Inheritance by the Unintended Child: The Impact of Knowledge Transfer on Spin-out Generation, Development and Performance

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ABSTRACT

This paper examines the role of knowledge as a driver of an organization's formation, and as a subsequent source of its competitive advantage. We investigate the un-intentional knowledge transfer from an incumbent to a spin-out (an entrepreneurial venture by an ex-employee), and the impact of inherited knowledge on spin-out development and performance. Using data from the disk drive industry, we show that incumbent knowledge capabilities, related to technology and market pioneering, predict spin-out formation. Parent's capabilities at the time of spin-out founding positively affect spin-out knowledge capabilities, and result in spin-outs having higher probabilities of survival relative to other entrants.

Where do entrepreneurial entrants come from? And, how does origin impact entrant performance? While studies of innovation and market evolution emphasizes the role of entrants as agents of structural market transformations (Gort & Klepper, 1982; Tushman & Anderson, 1986), the origin of entrepreneurial ventures has garnered little attention (Klepper & Simons, 2000). Studies have related new firm formation to market structure (Geroski 1995), technology (Gort and Klepper, 1982; Shane 2000), and population dynamics (Hannan & Freeman, 1987), but there has been little research addressing their origin, or the implications of genealogy. This is a serious gap in the literature since entrepreneurial source may impact evolutionary churn by influencing entrant capabilities. Venture origin determines heterogeneity in entrant capabilities (Carroll, Bigelow, Seidel and Tsai 1996; Klepper & Simons 2000) and initial endowments not only help new ventures withstand competitive pressures during their especially vulnerable initial years, but also imprint on their subsequent behavior and performance (Stinchcombe 1965).

This paper investigates the phenomenon of *spin-outs*, defined as entrepreneurial startups founded by employees of incumbent firms that operate in the same industry as the parent[1]. As opposed to "spin-offs" of incumbent firms that are *intentionally* created, we focus on spin-outs and the *unintentional* transfer of knowledge. Anecdotal evidence suggests that spin-outs are at the forefront of innovation and have powerful impacts on the market (Bhide, 2000). For example, in the semiconductor industry[2], generation after generation of employees left their parent company to launch the next entrant. Similar phenomena have been noted in the disk drive (Christensen, 1993), laser (Klepper & Sleeper, 2000) and information technology industries (Propson, 2000). Spin-outs are thus organizational products in that their genesis is from within incumbents, who provide employees with the skills and credibility needed to start their own

[1] Although systematic empirical studies on high technology start-ups are few, the terminology related to this organizational form is often confusing. The term 'spin-offs' has been used to refer to new firms that result from employee entrepreneurship (Dahlstrand, 1997; Klepper & Sleeper, 2000) and those that result fromcorporate restructuring (Allen 2001). To mitigate this confusion, we use the term "spin-out" which has been coined and used in popular magazines (e.g. *Business Week*). Moreover, in our sample, we find that there are no ownership positions by parents in these entrepreneurial ventures, thus making spin-outs independent from their parents.

[2] Fairchild Semiconductor, itself a progeny of Shockley Labs, has spawned so many entrepreneurial ventures that the progenies are termed Fairchildren. Some notable ones are Intel, AMD, LSI Logic and National Semiconductor. These in turn spawned Cypress, Zilog, and Sierra Semiconductor.

ventures (Cooper, 1985; Stinchcombe, 1965). In the milieu of existing studies that distinguish between new *de novo* and diversifying *de alio* entrants (Carroll et. al., 1996), we differentiate spin-outs as a special type of *de novo* in that they enjoy the benefit of parental knowledge that other *de novos* do not, while not being impeded by organizational baggage that *de alios* carry (Barnett &Carroll 1995).

We adopt a knowledge-based perspective of the firm (Grant 1996; Spender 1996). This view espouses that organizations comprise both knowledge-exchanging and knowledge-producing subsystems (Schulz 2001), and that heterogeneity in firm performance is caused by the creation and application of privately held, tacit knowledge (Eisenhardt & Martin 2000; Teece, Pisano & Schuen 1997). For new technology ventures (Zahra, Ireland & Hitt 2000), a combination of inside-out technological capabilities and outside-in market pioneering capabilities is critical to competitive advantage (Teece 1986; Moorman & Slotegraaf 1999). In this context, we place spin-outs as organizations whose very basis of creation is to exploit parental knowledge. We develop our story along three themes. First, we investigate why certain incumbent firms are likely to be 'entrepreneurial hotbeds' (Burton, Sorensen, & Beckman 2001), and examine how knowledge levels affect likelihood of spin-out generation. In the process, we address why incumbents are often unable to exploit their own knowledge, and also fail to retain employees who leave to exploit the very same opportunities that the parent companies decide to forego. Further, we explore the inter-relationship between scientific and business knowledge domains. Second, we investigate whether genealogy matters in capability accumulation. Do smarter parents create smarter children? Third, we explore how organizational outcomes, namely knowledge and survival, are impacted by venture origin.

The empirical setting of our study is the rigid disk drive industry, which has been analogized as the "fruit fly of industries" in reference to the rapid pace of technological change, and evolution. This is a particularly interesting and appropriate setting because of the number of entrants in the period studied and the high percentage of spin-outs in the sample. The data are longitudinal, based on published lists of industry reports, and considerable enough to allow us to construct the genealogy of parent-progeny relationships and analyze incumbent knowledge affected spin-out formation and evolution.

Our paper is related to and builds on a number of theoretical streams of research. First, we draw on the economic and sociological literature on knowledge spillovers and inter-organizational mobility of managers, and develop a strategic management view of the impact of knowledge spillovers on new venture formation and performance. While economic literature focuses on how externalities of knowledge spillovers that occur through employee mobility results in R&D under-investment (Moen, 2001; Zucker, Darby & Brewer, 1998), the sociological approach investigates knowledge diffusion and the inter-organizational social structure created by executive migration (Aldrich & Pfeffer, 1976; Boeker, 1997). Both streams of literature have tended to focus on large, existing organizations and with the exception of some recent research (Burton et. al. 1999; Gunz & Jalland, 1996; Higgins & Gulati, 2000; Shane & Khurana, 1999) have ignored new ventures. The lack of a strategic management perspective on knowledge spillovers and new ventures is surprising[3]. We address this theoretical shortcoming by linking human capital to new venture formation.

Second, we contribute to emerging strategy research on firm capabilities and recent focus on value creation (Moran & Ghoshal 1999). While competitive strategy has traditionally focused more on isolating mechanisms and rent appropriation (Rumelt 1984), dynamic capability scholars tend to emphasize rent creation (Eisenhardt & Martin 2000; Teece et. al., 1997). What is not readily apparent is the value of a syncretic approach, and the combinatorial nature of the capabilities involved in pursuing these strategies. Building on Teece's (1986) argument that profiting from R&D capabilities (value-creation) requires successful technology commercialization (value-appropriation), we investigate the combinatorial aspect of resource deployment, drawing attention to the view that the organization of capabilities may be as

[3] For instance, organizational identity, in studies that relate socio-structural aspects of career affiliations (e.g. Burton et.al, 1999) to start-up performance, may be viewed as essentially a surrogate for a firm's competitive positioning, which from the strategic, resource-based view of the firm is attributable to a firm's knowledge based capabilities.

important a source of performance heterogeneity as capabilities themselves (Leiponen 1999). We further argue that for co-specialized assets, where the value of any one asset is dependent on the level of the other (Teece 1986), high levels of knowledge along only a single dimension could be detrimental to a firm.

Third, our study contributes to literature on the effect of pre-entry experience on firm performance. Existing studies typically assume that incumbency, and the ability to transfer and leverage knowledge across various business units of the firm (Teece & Pisano, 1994) bestow a benefit of "dominance by birthright" on *de alios* (Barnett & Carroll, 1995; Carroll et. al., 1996; Klepper & Simons, 2000). However, to assume that de novos are a homogeneous lot that start off with empty resource slates may be both presumptuous and erroneous. In contrast to existing literature, we distinguish spin-outs as a special class of firms and investigate how genetic links to incumbents and venture origin combine to create competitive advantage.

Finally, although there is growing excitement in the management literature about organizational learning and knowledge related issues, our understanding of how new ventures learn is very limited (Zahra et. al. 2000). Knowledge, in the form of rules, routines and procedures, can transfer across firm boundaries. Similar to reproduction and transmission of biological genes, the cognitive dimensions of competency can be transferred across organizations (Winter 1991; Boeker 1997). However, as Huber (1991) notes, there are no systematic linkages between inherited learning and performance. Also, research indicates that knowledge is sticky and difficult to transfer (Szulanski 2000). What is not known is whether various modes of knowledge transfers, such as that achieved through grafting by recruitment of personnel have different outcomes relative to when inherited knowledge is transferred directly through employee-turned-founders, issues that we examine in this paper.

THEORY DEVELOPMENT AND HYPOTHESES

THEME 1: Parental Knowledge and Spin-Out Generation

By virtue of being difficult to codify, imitate or transfer, tacit knowledge is argued to be the most critical competitive asset that a firm possesses (Grant 1996; Teece et. al.1997). Integral to complex scientific or business process skills, tacit knowledge is usually embedded in a firm's uncodified routines (Leibeskind, 1996), social context (Nelson and Winter 1982), and *human capital* (Augustine & Wilson 1994; Lepak & Snell 1999). In fact, as Teece (1988) argues, a complex part of technology relates to its "softer" side. This goes beyond codification in scientific papers, formulae, technical specification, blueprints or hardware, and refers to information held in the form of tacit, non-articulable knowledge and competence assets by individuals (Kogut & Zander 1992). Human capital thus represents a unique organizational resource that enables value creation (Hitt et. al. 2001; Lepak & Snell 1999).

Theories of human capital (Becker 1964) suggest that employees acquire three types of human capital from their employer firm: technological capital, or scientific knowledge; social capital, or personal contacts and network ties (Yli-Renko, Autio & Sapienza 2001) and cultural capital, or the value society places on symbols of prestige (Long, Powers, Barnett & White 1998). Human capital however is distinct from tangible assets in that a firm's deliberate actions only have limited effectiveness in preventing knowledge expropriation. First, knowledge is inherently mobile since it resides in the heads of individuals (Grant 1996). Personnel are under limited organizational control and free to quit at will (Coff 1997). Second, there is a public good aspect to knowledge (Arrow 1962). Since an item of knowledge is usable by multiple individuals and organizations without diminishing its productivity for any one user, it becomes difficult for any one firm to detect its expropriation. Further, as Liebeskind (1996) argues, market mechanisms have only limited effectiveness in protecting knowledge. The voluntary turnover of experts who possess critical know-how is a significant threat to technology firms that have substantive portions of their R&D capital embodied in their employees (Zucker et. al., 1998). In fact, the uncertainty and costs associated with knowledge protection have prompted Stinchcombe and Heimer (1988) to refer to technology rich firms as 'precarious monopolies.'

Given that spin-outs are new entrants that capitalize on knowledge acquired by founders during their tenure at an incumbent firm, two issues need clarification before we move onto our genealogical framework. First, why do incumbents fail to capitalize on new market opportunities, when after all, they do possess the initial advantage regarding the focal knowledge? Second, why does an incumbent fail to retain employees who may leave to start their own ventures?

Research suggests that certain inertial incumbent properties impede their ability to realize full value of their knowledge. According to Moran and Ghoshal (1999), a firm often fails to realize its full potential due to various constraints on its ability to deploy resources and exploit the inherent value in its knowledge assets. This resonates with organizational learning arguments that describe various incumbent pathologies ascribed to learning traps (March, 1991; Levinthal & March 1993;) that serve to constrain and localize search in proximate areas (Ahuja & Lampert 2001; Cyert & March 1963). Risk averseness in high-performing organizations (Greve 1998), along with organizational inertia (Hannan & Freeman 1984), inhibit experimentation, and lead to situations where organizations either fail to uncover innovative solutions, or fail to act on solutions that they do uncover (Greve & Taylor 2000).

In addition, goals, expectations, and risk averseness of top managers may diverge significantly from those of other professionals in the firm. While top management typically emphasize goals salient to external stakeholders who provide critical resources to the organization (Audia & Greve 2001; Greve 1998), scientific personnel in control of critical R&D and product development processes are more likely to be driven by aspirations linked closely to the performance of their sub-unit or the specific technology that they are working on. For example, Christensen (1993) shows how a firm's dependence on existing customers hampered efforts to re-orient market strategies, and additionally frustrated engineers who did not see their technological inventions being commercialized. These differences in perspectives can increase incumbent reticence to engage in slack search (Nohria & Gulati 1996).

Further, employment contracts only place limited restrictions on an employee's freedom to leave a firm. While firms can increase employee exit costs by imposing 'golden handcuffs,' or creating incentives for them to stay long term by deferring the timing of payments for employee knowledge (Liebeskind, 1996), these mechanisms are subject to agency costs. Problems of moral hazard (Wiggins 1995), and information asymmetries (Anton & Yao 1995) create contractual problems that make it lucrative for the employee to develop the discovery in her own entrepreneurial venture rather than by staying with her employer[4].

Organizations are thus imperfect and permeable repositories of knowledge. An incumbent's inertia and resultant inability to fully exploit its know-how, combined with contractual failures to prevent employees from leaving leads to potential situations where spin-outs may form with the raison d'être of exploiting the incumbent's technological breakthroughs in the market. However, what is not clear is what makes certain firms prone to becoming entrepreneurial hothouses? We now turn to this question.

Technological Know-how

Employees of firms that are technological leaders and are operating at the frontier of science are likely to be better informed on contemporaneous breakthroughs, and thus possess more *technological knowledge capital* compared to their counterparts at less sophisticated firms. Note that research workers not only sell their skills, but simultaneous purchase the opportunity to augment those skills (Rosen 1972). As a result, employees at advanced firms end up with a larger stock of knowledge assets. Most professionals start their careers as apprentices after completing their educational requirements, and continue to gain significant tacit knowledge through experiential learning (Hitt et. al. 2001). In fact, scientists are sometimes willing to undergo short-term financial sacrifices and work at lower wages for firms that are on the technological frontier[5] (Franco & Filson, 2000). Their individual intellectual capital increases, as does their likelihood of recognizing opportunities to translate knowledge into value, by being in an environment where they are exposed to stronger flows of new, and higher quality information (Burton et. al., 2001; Shane, 1999). Being more knowledgeable, employees at such firms are advantaged over their colleagues in other firms by being better placed to appropriate part of the economic returns

[4] The problem is further exacerbated due to some states, such as California—a hot-house for much of the activity in semi-conductors, disk drives, and computer related industries—not enforcing non-competing clauses in labor contracts.
[5] Noyce accepted lower pay to work at Shockley, the leading maker of semi-conductors at the time. Noyce later left to start up Fairchild.

that flow from their employer's R&D investments (Zucker, Darby & Brewer 1998). In brief, since employees of firms at the cutting edge of scientific know-how accumulate more technical knowledge, entrepreneurial probability is simultaneously enhanced.

Career experiences also impact *social and cultural capital* (Burton et. al., 2001). The place of employment influences positions in social structure and thus access to opportunities and resources (Granovetter 1985). Mobilizing financial and other legitimacy building resources is critical for start-ups (Stinchcombe 1965). However, as emerging literature on venture capitalists indicates, information asymmetries make it difficult to assess the quality of a new venture, especially in new, unproven arenas (Gompers & Lerner 1999; Shane & Stuart 2002). Externally observable attributes serve as quality surrogates of the prospective founder (Stuart, Hoang & Hybels 1999). Recent technological accomplishments, prominence of the scientist's associates, and an employer's reputation help reduce perceived uncertainty. Accordingly, affiliation with a technologically advanced firm is likely to enhance expectations concerning the venture's probability of survival, and thus likelihood of founding (Shane & Khurana 2001). Venture capitalists are likely to make direct associations between the parent's R&D capital and the intellectual human capital of the founder (Fried & Hisrich, 1994), and be more willing to back ventures where the founder's employer is a technological leader.

Higher level of know-how is likely to reduce perceived entry and survival barriers, and thus increase an employee's confidence of venturing out, which in turn leads to increased action propensity (Eisenhardt 1989). Research on individual risk-taking behavior suggests that difference in organizational and individual goals may spur individual action (Greve 1998). Even as an incumbent's improved performance and growing stature as a technological leader may increase its risk averseness, an individual employee's motivation to undertake risk may increase. According to prospect theory, individual risk-taking seems to increase when people fail to attain a goal or aspiration level (Kahneman & Tversky 1979). It is plausible that the personal aspiration levels of scientists increase with their association with technological breakthroughs. However, if the employer firm exhibits behavioral inertia, and fails to exploit new knowledge in the marketplace, the scientist is likely to experience a growing gap between aspiration and current career status. The growing gap is likely to exacerbate employee frustration and trigger risk-taking behavior, which in this context, is to found a new venture (Lant & Montgomery 1987). Inventions, particularly those that are substantial and path breaking, are thus likely to lead to spin-out formation. Although an employer firm may attempt to re-contract with an employee, venture capitalists are likely to succeed in outbidding incumbents especially for less risk-averse employees (Bankman & Gilson 1999). This implies that firms on the cutting edge of technology are also more likely to be fertile breeding grounds for entrepreneurial ventures.

> *H_1: The probability of spin-out generation is positively related to the technological know-how of a firm*

Market Pioneering Know-how

In the final analysis, irrespective of scientific knowledge and investor backing, a prospective founder needs not only to establish the new venture, but also execute a set of integrated marketing decisions and actions that will enable it to meet the value requirements of a new segment of customers (Slater & Olson 2001). Executing a coherent marketing strategy involves market segmentation, targeting, and positioning based on product, price, distribution and promotion (Kotler 1994). Being an early mover in commercializing new technology requires complex marketing skills that are qualitatively different from those required by late entrants (Bowman & Gatignon 1995; Kalyanaram, Robinson & Urban 1995). To do so effectively requires high levels of marketing orientation which in turn involves innovative behavior, superior skills in understanding and satisfying new customers, and cross-functional integration for proper execution (Jaworski & Kohli 1993; Narver & Slater 1990). In short, an organization needs to be able to deploy its market pioneering resources effectively. As Mosakowski (1998) argues, being able to assess the value of its resources, and creatively combine them in ways that lead to novel, rent generating competitive market outcomes is an intangible firm asset. Similarly, market pioneering know-how enables a firm to translate its technological know-how into commercial 'killer' applications and develop nascent market ahead of most competition.

Importantly, these market creating and pioneering capabilities are *endogenous* to firm behavior, in that firms can develop best practices and related organizational routines based on experiential learning from their past actions. By accumulating and developing certain rule-like responses, interpretive schemas, and outcome evaluations (Greve & Taylor 2000), firms can develop certain decision heuristics that enhances their market pioneering capabilities. For example, prospector organizations who achieve growth by entering new markets and regularly expanding their product offerings may engage in higher levels of market oriented behavior, and in the process develop distinctive competencies in pioneering new market segments (Matsuno & Mentzer 2000; Slater & Olson 2001; Conant, Mokwa & Varadarajan 1990).

Moreover, such strategic orientations get embedded in a firm's structure and social processes (Meyer & Rowan 1977), and percolates down to individual employees. Socialization builds a collective consciousness of the organization (Becker 1964), and helps employees internalize the organization's values, norms, and culture (Inzerille & Rosen, 1983; Meek 1988). Further, it helps employees develop action repertoires to confront dynamic and amorphous problems. Thus, past organizational pioneering adventures may provide prospective founders with procedural and declarative knowledge (Burton et. al., 2001; Moorman & Miner 1997). 'Hall talk' and stories of past market pioneering successes provide psychological support for the entrepreneurial act (Cooper & Folta 2000).

It may be argued that a parent's past marketing aggressiveness might deplete the set of remaining marketing opportunities, thus making it more difficult for a spin-out to find an unoccupied market niche. However, in industries where rapid innovation leads to technological discontinuities, new technical sub-fields emerge (Mitchell 1989). Drawing on new knowledge bases, these emerging segments create new opportunities for entrants. Therefore, incumbents' past market aggressiveness may not preempt contemporaneous entrant opportunity. In addition, as discussed in relation to technological knowledge, affiliation with an employer that has a reputation of aggressive market pioneering behavior based on its past performance could serve to legitimate the prospective founder's ventures chances of success in the eyes of the investor community. The past history of the employer firm can also set aspiration levels for its members (Cyert & March 1963), and influence their risk-taking behavior (Lant 1992). Therefore,

> *H_2: The probability of spin-out generation is positively related to the market pioneering know-how of a firm*

We have argued thus far that spin-out formation is positively related to an incumbent's technological or market pioneering capabilities. On the one hand, an incumbent's technological prowess provides scientific knowledge, social, and cultural capital to its employees. These serve to facilitate resource acquisition from external stakeholders, while encouraging risk-taking behavior by the prospective founder. On the other hand, an employer's market-pioneering prowess nurtures entrepreneurial mind-sets in its employees. By providing tactical and strategic knowledge surrounding commercializing of new technology, an incumbent's past market pioneering successes can encourage employee entrepreneurship This poses a serious conundrum. Spin-out formation is clearly a sub-optimal outcome for the incumbent firm, since it implies loss of some returns on their R&D investment. It is intriguing that enhanced capabilities may jeopardize firms. Assuming that spin-outs are of serious concern to parents, are incumbent firms then better off in not developing capabilities? What happens to "dual drive" firms that are leaders in both domains? Are they worse off than firms that are high on either of the two capabilities?

To investigate this issue, it is necessary to understand the combinatorial nature of these two capabilities. To profit from innovation, a firm requires *both* technology and market creating capabilities (Teece 1986; Griffin & Hauser 1996). Implicit in the observation that "firm capabilities may not be valuable as single assets" (Moorman & Slotegraaf 1999, p. 239) is the notion that these are co-specialized assets (Teece 1986) where the value of any one asset is dependent on the level of the other. When both capabilities are well developed, firms maximize the benefits from its product development process, since marketing and technological know-how feed into one another (Cohen & Levinthal 1990). While technological capabilities enable firms to fully exploit market opportunities (Cohen & Levinthal 1990), market pioneering know-how enables firms to appropriate the potential stream of rents from their technological breakthroughs

(Teece 1986). If a profusion of resource in one domain of knowledge co-exists with scarcity in the other domain, the firm is unable to make optimal use of existing competencies. However, when a firm engages in simultaneous value creation and appropriation, technological know-how can be put to good use by market pioneering know-how. Their complementary nature creates a valuable synergy that increases a firm's effectiveness and efficiency.

Further, the inherent difficulty of developing these two capabilities simultaneously implies that dual drive firms are likely to inhibit competitive imitation and enjoy superior performance (Grant 1991). By strategically investing in both capabilities, incumbent firms can increase the disincentives to employees leaving to form their own ventures. Typically, this may be achieved through employee compensation policies that reward innovations, and through a capital budgeting process that allow resource flows to exploratory projects[6]. Accordingly, through firm choices relating to the trade-off between exploration and appropriation, dual capabilities can accumulate and develop over time. For instance, when an employee makes an invention, she raises the level of technological knowledge resources. Where the company deploys its commercializing capability to explore new market possibilities, it essentially compensates the employee as an "intrapreneur". First, by responding to opportunities in the environment and becoming entrepreneurial themselves, organizations remove employee aggravation and frustration that results when inventions do not find market place expression, and are "shelved" (Christensen 1993; Garvin 1983). Better job satisfaction and perceived prospects reduce chances of employee mobility when the organization is committed to taking emergent technological developments to market (Benkhoff 1997). Second, incumbent organizations that possess high-end technological capabilities *and* are committed to going to the market with them exhibit a 'willingness to cannibalize' and are likely to sustain leadership in dynamic markets (Kamien & Schwartz 1982). Third, pre-emptive early entry into new technical sub-fields serves to deter spin-out entry by raising entry barriers.

[6] 3M for instance, encourages researchers to spend up to 15 % of their time on projects that are of interest only to them (Moran & Ghoshal, 1999).

Double leadership may also motivate employees to leave the firm and start new ventures, and strengthen the confidence of entrepreneurs and investors. However, through a combination of incentives aimed at employee retention, and competitive deterrence, we believe that dual drive incumbents can reduce this incidence. In other words, abundance of underutilized knowledge can beget spin-outs, but spin-outs are deterred when the knowledge of a firm is put to good use[7].

H_3: The greater the level of both technological know-how and market pioneering know-how in an incumbent, the lesser is the likelihood of spin-out generation.

THEME 2: Knowledge Transfer through Spin-out Inheritance

Founding conditions, both environment and founder related, imprint on an organization (Stinchcombe 1965). This implies that certain conditions existing at the time of formation imprint the firm on various levels - structural, strategic, technology and routines, and culture (Sastry & Coen 2000) - and continue to have a long-term effect on a firm's actions and performance. One specific aspect of founding conditions relates to an organization's initial resource endowments. The basic argument is that founding endowments impact a firm's key strategic decisions related to costs, employee skills, and firm boundaries (Swaminathan 1996). As a result, differences in initial endowments may position firms on heterogeneous developmental paths, and thus impact long term competitive positioning (Shane & Stuart 2002)

Research indicates that founder human capital and technical knowledge which constitutes a start-up's initial resource endowment, has an imprinting effect on organizational outcomes (Stuart et. al., 1999; Eisenhardt & Schoonhoven, 1990). As elaborated earlier, when employees leave to start a new venture, they walk out with knowledge pertaining to the "softer" side of technology that goes beyond codified information.. The knowledge inherited from the parent firm at the time of founding thus constitutes a spin-out's inherited knowledge (Huber 1991). Inherited knowledge may have a sustained effect on the spin-out's knowledge capabilities over time due to endowment effect and learning. First, a firm's previous investments and current set of routines constrain future behavior, especially as learning tends to be local (Teece et.al., 1997).

[7] We would like to thank an anonymous reviewer for helping us putting this thought so succinctly.

Second, prior information creates knowledge corridors that trigger discovery and learning (Shane 2000). Third, path dependency in learning, as proposed by the theory of absorptive capacity, suggests that the knowledge stocks at founding leaves a long lasting imprint on a firm's future competitiveness. A firm's ability, efficiency and aspiration to learn, discover and acquire new knowledge depend on its level of prior related knowledge (Cohen & Levinthal, 1990). The initial stock of scientific and market knowledge thus impacts the absorptive capacity on a firm, since it affects its ability to recognize the value of new information, assimilate, and apply it to create new knowledge. Prior scientific and technological knowledge thus facilitates new knowledge creation. Accordingly, a spin-out's capability will depend on the initial stock of know-how that it inherits from its parent. Further, there will be a *within group variance* among spin-out firms' capabilities, with smart parents more likely to create smart progenies.

> *$H_{4a\text{-}b}$: The (a) technological and (b) market pioneering knowledge levels of a parent and its spin-out will be positively related.*

THEME 3: Spin-out Characteristics and Performance

Having argued that knowledge lies at the heart of spin-out formation whose raison d'être is to exploit and develop on its parent's underutilized know-how, and developed a genealogical knowledge based theory linking parents and spin-out, we now examine the relationship between organizational forms[8] and outcomes. We focus on two key organizational outcomes: firm knowledge and survival, and investigate whether genesis explains entrant heterogeneity. More specifically, we investigate whether there are any differences in the performance of 'spin-outs' relative to other entrants. Regarding entrant types, while literature typically makes a broad distinction between *de novo* ventures and *de alio* entrants (Carroll et. al, 1996; Shane, 2001), we adopt a finer-grained analysis based on pre-entry relationship with an incumbent, and entrepreneurial origin. On this basis, we find four types of entrants: spin-outs *de novos* with

[8] In classifying 'spin-outs' as an organizational form, we adopt an ecological view wherein organizations are identified as a member of a group of similar organizations on the basis of certain organizational characteristics (Romanelli 1991). The shared characteristic in this case is their genesis.

inherited knowledge, non-spin-out *de novo* firms, spin-offs from incumbent firms, and diversifying entrants from other industries.

Entrant Capabilities

On the one hand, there is growing recognition that competitive success arises from knowledge and intellectual assets (Grant 1996; Spender 1996). On the other, an intriguing finding in organizational learning suggests that *organizations do not necessarily know all that they know* (Szulanski 2000). To resolve this conundrum, we need to distinguish knowledge that lies inert in some part of an organization from that which is active, and through learning processes transfers into a new setting and impacts firm behavior. Knowledge needs to be converted into capabilities that are deployed to meet the demands of the environment (Lane and Lubatkin 1998). Difficulties in affecting internal transfer of existing knowledge due to knowledge "stickiness" results in organizations not being able to exploit their know-how fully (von Hippel, 1994). The adoption of new technology or business processes requires not merely the presence of knowledge, but also involves a conscious process of reconstructing know-how, initial implementation, ramp-up, follow through and subsequent integration into routines (Szulanski 2000). Also, as Lane and Lubakin (1998) argue, learning the 'how and why' of knowledge requires a deeper interactive process than knowledge that is readily articulable and thus transferable through both passive and active observation.

While founders bring in inherited knowledge directly from their parents, other entrants can access incumbent knowledge through either employee transfer, in the case of incumbent sponsored spin-offs, or recruitment (Boeker 1997; DiMaggio & Powell 1983). Corporate spin-offs have the luxury of being embedded in a cooperative and continuing super-ordinate relationship with an incumbent, factors that have been empirically related with increased likelihood of knowledge transfers (Darr, Argote & Epple 1995; Baum & Ingram 1998). Other entrants, however, typically learn by doing or through grafting mechanisms such as hiring incumbent employees. Compared to these entrants, spin-outs have a knowledge advantage. Fundamentally, a person's know-how becomes more valuable when bundled with complementary know-how of another. Typically, multiple employees from diverse backgrounds leave together to start a new firm, thus increasing the potential value of a single person's know-how by bundling with that of others. Founder teams are thus likely to have an edge over discrete instances of employees that are hired for numerous reasons[9]. First, agency problems and competitive incentive structures within organizations create certain exchange dynamics within internal knowledge markets that discourage employees from knowledge sharing (Davenport & Prusak 1998). Since power within the organization depends on non-replicated knowledge, an employee prefers not to lose her knowledge monopoly (Pettigrew 1972). This increases the stickiness of knowledge transfers. Spin-out founders, however, are unencumbered by such issues of opportunism, and have an incentive to share their knowledge and transfer it into best practices within their organization so as to appropriate the fullest entrepreneurial rents stemming from their knowledge.

Second, the general management role of the entrepreneur founder enables them to take a more holistic picture, while specialist employees with functional affiliations may be limited in both their ability and motivation to transfer relevant knowledge across different departments of the organization (Fisher, Maltz & Jaworski 1997). Acting as knowledge brokers between functional domains (Burt 1992), founders can not only integrate knowledge across functional areas to create greater value, but are also in a better position to change employee expectations, and thus increase the likelihood of them adopting a new practice (Lenox & King 2001). By being in a more influential position to bring about progressive routinization of best practices, founders have an advantage over employees in effecting knowledge transfers from incumbents.

Third, relative to entrants diversifying from other industries that may benefit from prior affiliations, spin-out firms are not constrained by vested interests that try to preserve status quo (Haveman 1992). Parental authority and clearance on strategic issues may create organizational

[9] The information on founding teams in our data indicate that the mean and standard deviation of the number of ex-employee founders per spin-out is 2.47and 1.5 respectively. This indicates that on average, groups of ex-employees became founders of such entrepreneurial ventures. Further, the backgrounds of the founders revealed significant diversity of functional expertise in the founding team.

inertia in diversifying entrants, thus giving spin-outs a learning advantage in dynamic environments (Carroll et. al. 1996) since they are better able to move quickly and decisively to deploy new knowledge routines (Henderson 1993; Rosenbloom & Christensen 1994). Further, as opposed to employees that need to adapt to an existing organizational culture, spin-out founders are in a position to imprint their own blueprint on their organizations and create a learning oriented culture. Accordingly, spin-outs are likely to possess a knowledge advantage.

$H_{5a\text{-}b}$: Spin-outs will have higher levels of a) technological know-how and b) market pioneering know-how relative to other de novo and other de alio entrants.

Entrant Survival

While most *de novos* may be resource disadvantaged relative to *de alios* who have access to parental resources and enter with adequate capital, personnel, and distribution facilities (Mitchell 1994), *de novos* tend to be more flexible in their organizational and political structures (Henderson 1993; Rosenbloom and Christensen 1994). We now argue that spin-outs, by virtue of their inherited knowledge capabilities and entrepreneurial flexibility in combining and exchanging resources, are doubly advantaged.

Inherited knowledge and insider status in the industry advantages spin-outs over both other *de novos* and firms diversifying from other industries. Having imbibed experiential learning with regard to reliable routines from the parent, spin-outs are less likely to face the costs of a pure trial and error. In addition to the knowledge along the technological and market pioneering dimensions, spin-outs may also inherit other relevant knowledge and social capital.

Regarding the performance of spin-outs vis-à-vis incumbent backed spin-off entrants, the issue is less clear. In addition to deep parental pockets, spin-offs also have the benefit of a continuing linkage with the parent. However, spin-outs are advantaged over corporate spin-offs (and diversifying entrants as well) because of their entrepreneurial origin, which the entrepreneurship literature argues is an important source of resource differences, strategies and performance (Knight 1989; Shrader and Simon 1997). Greater autonomy, lack of bureaucratic inertia, and simple structures enables entrepreneurial spin-outs to creatively combine and exchange resources quicker in response to market needs as compared to corporate sponsored entrants (Fast 1981). Spin-offs frequently suffer from conflicting signals, and role confusion due to vested interests in the parent organizations (Haveman 1992). Accordingly, their managers have to balance a variety of political and corporate objectives that pull them in different directions (Fast 1981). Further, in many cases, sponsors in parent firms have formal authority to oversee *de alio* behavior. Carroll et. al. (1997) argue that this mandates formally developed plans for future action, which increases organizational inertia. Whereas managers of a spin-off are likely to be evaluated on the basis of how closely they adhere to a plan vetted by their parent, spin-out founders are motivated by the ends achieved because they are compensated on venture performance (Weiss 1981). Furthermore, Knight (1989) points to a self-selection issue that makes independent ventures likely to attract more entrepreneurial managers in the first place. Accordingly, in hyper-competitive environments, spin-outs are likely to outperform spin-offs.

> *H_6: The likelihood of survival will be greater for spin-out entrants than for non spin-out entrants.*

METHOD

Data and Measurement

Description of Data: We test our hypotheses using data from the rigid disk drive industry. Disk drives are magnetic information storage devices used with computers. After IBM introduced the 14-inch Winchester—the first completely sealed and removable disk drive—in 1973, the disk drive industry experienced numerous innovations in the 20-year period considered in our study. While architectural innovations resulted in five new diameters subsequent to the 14" drive, several modular and incremental innovations resulted in dramatic increases in the storage capacities of the disk drives[10]. Spin-outs, which constituted approximately 25% of entrants, represent an important mechanism of knowledge diffusion and technology transfer in this industry[11], making the disk-drive industry an appropriate setting for our study.

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[10] We refer interested readers to Christensen (1993, 1997) for detailed histories of the rigid disk drive.
[11] The legal environment within the disk drive industry, not atypical for most high tech industries, did not create significant hurdles for employee mobility, in part because most of the disk drive manufacturers are in California, which does not enforce non-competing clauses in labor contracts.

Availability of historical data is a chief constraint to studies such as ours. To maintain accuracy, particularly on firms' early histories, we collected data from sources that documented facts *at the time of occurrence* and tracked information on important historical events in the industry for *all* firms entering and exiting the market. As have a number of past studies (Christensen 1993; King and Tucci, 2002; Lerner 1997), we used information compiled from the *Disk/Trend Report* - a market research publication that has covered the disk drive industry since 1977. The data were supplemented by company press reports and news releases, and other data sources including scientific journals, books, articles, chronologies, and directories (e.g. the *Directory of Corporate Affiliations*, and the *International Directory of Company Histories.*) We constructed the genealogy of the firms and determined parent-progeny relationships based on background information of founders of new firms. To minimize potential data-entry errors or bias, the data were developed independently by three research assistants who had no knowledge of the research questions. The databases were then compared to reconcile discrepancies, rectify mistakes, and ensure accuracy. The entire exercise was checked and overseen by two researchers with intimate knowledge and record of academic publication in related research areas.

The final database contains the entire census of firms in the industry during the 1977-1997 period and includes detailed information on introduction dates of the new diameters in the industry, product characteristics, and annual sales of disk drives[12]. In addition to 39 incumbents that entered between 1973 and 1976, there were 153 new entrants, of which 40 were spin-outs. Checks ensured that there were no formal connections between the parents and the spin-outs. The mean number of ex-employee founders per spin-out is 2.47 (s.d. = 1.5), indicating that on average, groups of ex-employees became founders of spin-outs. The founders of the spin-outs were all senior level employees of the parent firms with several years of industry experience. 72% of the founders were either research engineers or in production operations, with the rest either in marketing or finance. Further, each spin-out had at least one founder that had

[12] Sales information is available by firm at an aggregate disk-drive level, and not at the individual diameter level.

engineering or operational experience. Since every productive firm, regardless of size, is included for their span of existence in the market, our sample does not suffer from survival bias for the period under analysis.

Operationalization of Constructs: Table 1 provides rationale behind inclusion and operationalization of our variables. The descriptive statistics and correlation matrix are presented in Table 2. Market pioneering and technological know-how are described below.

[Insert Table 1 here]

[Insert Table 2 here]

Market Pioneering Know-how: All the major architectural innovations in this industry catered to new markets. Five such innovations, namely the 8", 5.25", 3.75", 2.5", and 1.8" drives, were introduced between 1977-1997. The market pioneering know-how variable captures the early mover know-how associated with bringing an innovation to market[13]. We operationalize this variable as the number of times a firm introduced a drive of a new diameter within the first year of the diameter's introduction into the market as a proportion of the total number of opportunities available to the firm to do so[14]. Since there were five distinct diameters introduced in the period under study, the market pioneering know-how of a firm varies over time and across firms[15].

Technological Know-how: The outcome of all modular and incremental innovations is manifested in the 'areal density,' defined as the megabytes of information that can be stored per square inch of a particular drive, indicates the technological expertise of a firm. Areal density enables cross-diameter comparisons, and is an important measure of product performance.

[13] Our operationalization of market pioneering is broader than that of Golder and Tellis (1993), since more than one firm may be identified as a pioneer in a market segment given that our measure is based on the year rather than the order of first entry.

[14] While this operationalization is the most intuitively appealing, we experimented with alternative measures that included the absolute number of times a firm could be considered an early mover, the negative of the number and proportion of missed pioneering opportunities, and an ordinal rank measure of market pioneering. All such operationalizations yielded similar substantive results.

[15] For each firm operating in the market at the time of a new diameter's introduction, the denominator of the variable is increased by 1, and the numerator increases by 1 only if the firm was an early mover for that diameter. For firms that entered between two consecutive diameter introductions, the market pioneering know-how variable takes the value of zero till the year of the next diameter introduction. Treating the variable as missing for these firm-years did not change the results.

Figure 1 shows the rapid technological progress over the years within and across the diameters[16]. We operationalize a firm's technological capabilities as its relative proximity to the technological frontier in each diameter at any point of time. Measuring firm's technological capabilities in comparison to the 'best' drive in the market circumvents problems related to cumulative and absolute increases in technological know-how over time, since it is a *relative* time varying measure that reflects a firm's competitive positioning on technology. The measure is operationalized as the average of the firm's diameter specific relative technological position across all the diameters it produced that year[17].

[Insert Figure 1 here]

Estimation Methodology

For hypotheses (H_1-H_3) pertaining to Theme 1, we use negative binomial regression to model the number of spin-outs generated in any given year. The discrete probability function is commonly specified as a Poisson process, which restricts the mean and variance of the distribution to be equal. The negative binomial model relaxes this assumption and contains an additional parameter for unobserved heterogeneity[18]. The results are robust to alternative specifications, including probit, logistic, and Poisson models.

For hypotheses $H_{4a\text{-}b}$ and $H_{5a\text{-}b}$, seemingly unrelated regression models (SUR) are used to account for potential correlations of the errors across the technological and market pioneering

[16] The hi-areal curve represents the highest areal density across all drives produced in a particular year. Note that both 14 and 8 inch diameters experienced a withdrawal during this period. The dominance of newer diameters over time is evident by the fact that the highest areal density of the 14 inch drive is overshadowed by areal densities of 5.25 inch drives in 1987, which is subsequently overtaken by the 3.5 inch in 1988 and the 2.5 inch in 1997.

[17] More specifically, we follow a two step procedure. We first divide the areal density of the best drive produced by a firm in a given diameter in a particular year by the highest areal density in that diameter available in the market that year to obtain the firm's diameter specific relative technological position. We then average this measure across all diameters produced by the firm to obtain a measure of the firm's average relative technological know-how in that year. Note that we focus on the *average* relative technological know-how across all drives rather than the relative position of the firm in its best drive because a firm typically competes in more than one diameter with the other firms in the market, and we are interested in capturing its technological know-how across its product lines. This gives us a conservative estimate of technological know-how since a firm that continues to produce only in the older diameters will benefit from other firms dropping the diameters that are leveling off and producing in markets that are advancing their technological frontier more quickly.

[18] The negative binomial also loosens the deterministic specification of Poisson by including, in the parameter λ that models the expected probability, a stochastic term that follows a gamma distribution, (var $(y_i/x_i) = \phi_i\ (1 + \delta\phi_i)$), such that the negative binomial collapses to a poisson as δ approaches zero.

know-how equations. Due to the complexity of the error variance-covariance matrix when both cross equation and auto-correlation constraints are introduced, existing software packages do not accommodate panel-based SUR models, the ideal given the nature of our data. In the absence of such methods, we tested the hypotheses using both random effects panel regression and SUR models separately, and the results are largely similar. We report the SUR results, which we believe are more appropriate, since SUR allows for a) separate variances and b) contemporaneous correlation of the error terms of each equation in contrast to panel models that assume homogeneous distribution of the error terms for various cross sections, thus leading to more efficient estimates (Mckenzie and Thompson, 1997).

Finally, hazard rate analysis is used to test hypothesis H_6 pertaining to survival. Several discrete and continuous time models are available for the estimation of hazard rates (Allison, 1995). Following earlier studies (Henderson, 1999), we used a multiple spells formulation with a complementary log-log specification that allows for incorporation of time-varying covariates[19]. The results are robust to alternative model specifications, which include probit, logistic, and parametric and semi-parametric duration data models.

RESULTS

The hypotheses in Theme 1 relate firm know-how to spin-out generation. Accordingly, the observations pertain to a firm being a potential parent in every single year after their entry, or after 1976 for firms that entered prior to this date[20]. The results of the tests of hypotheses 1-3 are shown in Table 3. Recall that H_3 proposes a contingent relationship. Since the evaluation of main effects change in the presence of an interaction term (Aiken & West, 1991), we estimate the model in two stages. In stage 1,as reported in Model 3a, the main effects of technological know-how and market pioneering know-how on spin-out generation, along with control variables are

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[19] Although a firm may fail at any point within a given year, the data on failure are updated only annually. A multiple spells, complementary log-log formulation allows continuous-time hazard rates to be obtained from discrete time failure data. See Allison (1995).

[20] Since there was only one foreign firm that generated a spin-out, the foreign firm dummy is not included in the spin-generation hypotheses testing.

entered. In stage 2, as shown in model 3b, we enter and estimate the multiplicative interaction term between technological know-how and market pioneering know-how.

[Insert Table 3 here]

Results from model 3a reveal that the probability of generating a spin-out in the following period is positively related to both technological know-how and market pioneering know-how of the firm, thereby supporting H_1 and H_2. Among firm specific control variables, while age of the firm does not affect the likelihood of spin-out generation, larger firms are more likely to generate spin-outs. A firm with higher than the average level of product diversity is less likely to generate a spin-out. The only significant industry level control variables relate to the linear and squared terms of competitive density. Model 3b shows that the interaction between the two types of know-how negatively impacts the probability of generating a spin-out, thereby supporting H_3. Thus, our results strongly support each of the three hypotheses in Theme 1.

Table 4 presents test results pertaining to Theme 2, which relates parent know-how levels to that of spin-outs. Using firm-year observations pertaining to spin-out firms, models 4a and 4b report results related to the impact of parental knowledge on technological and market pioneering knowledge of their spin-outs. Results from model 4a (model 4b) show that parent technological (market pioneering) know-how measured in the year preceding spin-out entry is strongly significant in predicting a spin-out's technological (market pioneering) know-how, thereby supporting H_{4a} and $H_{4b.}$ Among the control variables, age is significant for both equations, though it is seen to first decrease and then increase spin-out technological know-how, while it has the opposite effect on market pioneering know-how. Firm sales are positively related to spin-out market pioneering know-how, but not technological know-how. Among the industry control variables, only industry sales matters in model 4b, indicating that higher industry sales result in lower levels of market pioneering know-how of spin-outs.

In order to ascertain whether the effect of parental know-how on spin-outs persisted over time, we estimated an interaction term of both types of parent know-how with age in models 4c and 4d[21]. As model 4c shows, while the main effects of age and age^2 remain unchanged, the interaction coefficients of parent technological know-how with spin-out age and age^2 are positive and negative respectively. The results indicate that the effect of parent technological know-how on spin-out technological know-how is sustained over the entire life-span of the spin-outs[22]. Model 4d reports a positive and significant interaction between parent market pioneering know-how and age, indicating the sustained effect on parent know-how on spin-out know-how on this dimension as well.

[Insert Table 4 about here]

In Table 5, we report the results for hypotheses H_{5a-b} using all firm-year observations for the post-1977 entrants in the industry. Models 5a and 5b report the effects of the various types of entrants (spin-out, spin-off, and diversified entrants) on the technological and market pioneering capabilities of the entrants. Model 5a shows that spin-outs, along with spin-offs, have a higher level of technological know-how when compared to the other type of entrants. Therefore, H_{5a} is supported. The coefficient of diversifying entrants is negative and significant indicating the technological know-how of diversified firms is lower than the control group, which comprises of the non-related *de novo* entrants. Model 5b reveals that spin-outs possess higher levels of market pioneering know-how than both spin-offs and non related *de novo* entrants, supporting H_{5b}. Diversified firms have lower levels of market pioneering know-how compared to the control group. The coefficient of foreign firms is positive and significant for market pioneering know-how. Age of the firm does not affect technological know-how, though it is seen to first increase and then decrease market pioneering know-how. Also, industry sales have a negative relationship with market pioneering know-how of entrants.

[Insert Table 5 about here]

[21] We thank an anonymous reviewer for this suggestion.
[22] The coefficient estimates reveal that the effect of parent technological know-how on spin-out technological know-how dissipates around age 15. 96 percent of the firm-year observations occur for ages less than 12, and only one spin-out crossed the age of 15 by the end of the sample period.

To test whether spin-outs maintain a higher level of know-how over time vis-à-vis other entrants, we estimated an interaction of the spin-out variable with age. Results from model 5c reveal although there is a decline in relative advantage, spin-outs have higher levels of technological know-how over the observed life span of all entrants. On the market pioneering know-how dimension, however, results show that spin-outs do not experience any decline in their advantage.

Table 6 reports the results from the hazard rate analysis, and shows that spin-outs indeed have a higher probability of survival relative to all other types of entrants, thereby providing support for H_6. Higher technological know-how also increases the probability of survival, but market pioneering know-how is not seen to affect the probability of survival[23]. As would be expected, firm size increases the probability of survival. The level of industry sales seems to affect survival adversely, but the growth of industry sales proves beneficial to the probability of survival. The number of firms competing in the market is significant and the signs on the quadratic specification are consistent with the organizational ecology literature. Further, survival also seems to be aided by increases in industry level technological know-how. Interestingly, parent presence in the same diameter does not seem to affect spin-out survival.

DISCUSSION AND CONCLUSION

In trying to understand the impact of entry on market evolution, researchers have suggested that the origin of new firms may explain heterogeneity in their capabilities, and thus post-entry performance. This paper explores one such type of entrant, namely 'spin-outs,' or entrepreneurial ventures founded by former employees of incumbent firms. Adopting a knowledge perspective, we focus on two kinds of knowledge: *technological* and *market-pioneering* to analyze (a) how knowledge levels of incumbent companies affect the likelihood of generating spin-outs, (b) how parent knowledge levels at time of spin-out inception affect spin-

[23] While not a hypothesized relationship, the insignificance of market-pioneering in explaining survival is interesting. This may relate to earlier findings by Golder and Tellis (1993) that market pioneering by itself may not lead to sustained competitive advantage. Future research could perhaps investigate possible conditioning aspects of market pioneering with technological know-how and other relevant variables.

out knowledge levels, and (c) the knowledge levels of spin-outs and their survival chances relative to other entrants into the industry.

Our findings indicate that knowledge lies at the core of spin-out formation and development. While existing studies have related new firm formation to an industry's structural and evolutionary characteristics, we suggested that incumbent knowledge might lie at the heart of new venture formation. The empirical results support our hypotheses, indicating that as knowledge levels of parents increase, so do their likelihood of generating spin-outs. Since knowledge levels matter after controlling for firm size, it appears that abundant knowledge, not just abundant people that may have access to knowledge, is positively related to spin-out generation. However, when a firm has high levels of knowledge on both technological and market-pioneering dimensions, the likelihood of spin-out generation is attenuated. This supports the idea that abundance of underutilized knowledge can cause spin-outs, whereas spin-out formation is dissuaded when a firm puts its abundant knowledge to good use. The finding that presence in a large number of market segments lower chances of spin-out formation further points to the possibility that such wide market presence may help reduce employee dissatisfaction and thus spin-out formation.

In support of the notion that knowledge may be inherited and that smarter parents create smarter children, we find that spin-outs created from parents with superior knowledge levels are also ones that have elevated levels of knowledge. Further, we find that effects of the inherited knowledge may persist for a number of years. In our examination of age and know-how interactions, we found some evidence that higher levels of parental technological know-how mitigates the negative effects of aging on spin-out technological know-how, and higher levels of market pioneering know-how benefits spin-outs increasingly as they age.

The inheritance of knowledge by spin-outs, while representing un-intentional knowledge transfer, results in them being technologically advantaged over every form of entrant except the incumbent-backed spin-off. On the market pioneering dimension, spin-outs have an unambiguous sustained advantage. These findings indicate that directness of founder knowledge facilitates the integration of the knowledge transferred when compared to knowledge grafted through employees. Finally, we find that spin-outs survive at a higher rate than any other form of entrant into the industry, thus supporting our notion that their entrepreneurial form and origin from incumbents endow spin-outs with greater motivation and capabilities. It is interesting to note, in this context, the inability of spin-offs to either gain market pioneering know-how, or more importantly, have higher probabilities of survival. These findings thus seem to indicate that spin-offs may be subject to organizational inertia and rigidities due to continued parental involvement, and thus highlight the role of entrepreneurial flexibility and access to knowledge.

The arguments and conclusions of this study inform theory on several fronts of scholarly research: entrepreneurship, strategy, and organizational learning. Existing entrepreneurship research has demonstrated that new firm formation is influenced by personality characteristics (Roberts 1991), market structure (Geroski 1995), technological attributes (Christensen 1993), and the nature of the technology regime (Shane 2001). This study provides evidence of yet another exciting factor that influences new venture formation: knowledge spillovers lie at the core of entrepreneurship and industry evolution. Knowledge spillovers have been treated either as an economic problem of designing appropriate incentive mechanisms, or as a sociological mode through which industries undergo isomorphic transformation. Our research points to its role in seeding the entrepreneurial process.

In addition, our findings provide discriminating evidence of the nature of the advantages conferred by the dual presence of entrepreneurial flexibility and pre-entry experience on new ventures. Existing research has indicated the value of prior experience in new market entry: decision-making structures, access to capital (Carroll et. al. 1996), direct distribution networks (Mitchell 1989), experiential learning, and fungible innovative capabilities (Klepper and Simons 2000). However, most of this research applies to diversifying *de alios* and points to the virtues of incumbency. Very little has been said about the advantages that enable resource-starved *de novos* to compete successfully, other than their flexibility (Tushman and Anderson 1986). Much has been said however of their vulnerabilities due to resource shortages (Carroll et. al. 1996). Our findings show how some *de novo* firms benefit from both the advantage of flexibility, and an additional undiscovered source: inherited knowledge. Ex-employees who engage in entrepreneurship to exploit knowledge learned while working with an incumbent firm have a sustainable source of competitive advantage.

From the perspective of firm strategy, our findings uncover an intriguing possibility that knowledge may be a double-edged sword, with deleterious organizational consequences in certain situations. Till now, the notion of knowledge-based capabilities has assumed the status of universal goodness. Other then the 'capability-rigidity' paradox that highlights competency traps that constrain incumbent abilities to rejuvenate themselves (Leonard-Barton 1992; Ahuja and Lampert 2001), and some research that indicates that too much of slack resources may not yield economic benefits (Nohria and Gulati 1996), cautionary notes and discoveries related to the dark side of knowledge remain limited. Our research indicates that knowledge profusion, in certain circumstances, may result in sub-optimal outcomes for an incumbent. Our findings indicate that slack knowledge resources, which result from abundant, unutilized know-how, enhance the likelihood of employees leaving to found their own ventures. Not only does this mean a loss of human capital, and failure to appropriate full value of its investment in R&D and business processes, it also signifies an increase in competition for the incumbent.

Fortunately, our paper also points to a way out of the above predicament—rather than focusing on one dimension of know-how, firms will benefit from reduced future competition if they develop dual capabilities targeted towards both value creation and value appropriation. In doing so, our study also carries implications for emergent thinking on dynamic capabilities that questions strategy's traditional focus on rent appropriation, and proposes an equal emphasis on rent creation (Eisenhardt & Martin 2000; Moran & Ghoshal 1999). By questioning existing wisdom of concentrating on a single 'core' competency, our research suggests that the organization of capabilities may be as important as the capabilities themselves.

To the literature on organizational learning, we provide evidence of genealogical links between parents and progeny organizations. In other words, not only can knowledge be inherited, but there also seem to exist longer-term imprinting effects. Further, the quality of initial stock of knowledge inherited from a parent also seems to matter; progenies of smarter parents have higher knowledge levels relative to the others. We also find that spin-out organizations have higher levels of know-how, implying that the directness of knowledge transfer through founders results in a higher level of integration of knowledge for effective use relative to knowledge that is sought to be transferred through hiring of incumbent employees.

The limitations of our study, while precluding us from decisively answering some questions, also lead to avenues of future research. We find that while some firms specialize in advancing either scientific or marketing knowledge, others do both, thus raising issues for future exploration regarding knowledge development processes and decisions that lead firms on various knowledge paths. Also, while we establish a relationship between parental and progeny knowledge, we hope future research unravels endowment and learning effects so as to enable us to better understand whether spin-outs also learn faster and better than other entrants, or whether non spin-out entrants can ever play "catch-up." This is important given that age may lead to a firm losing its position relative to the technological frontier, even though it may have entered with cutting edge knowledge (Bahk and Gort, 1993; Jovanovic and Nyarko, 1996). Also, diminishing returns to learning may imply that the higher the stock of know-how, the lower is the rate of subsequent learning. Firms that have low stocks of know-how may be able to "learn" faster given the pre-existence of superior knowledge outside their boundaries, while firms with high stocks of knowledge face a harder task since their learning often requires new creation. These confounding effects make it difficult to make assertive statements on the presence (or lack thereof) of learning[24].

[24] Further, our measure of relative technological know-how limits our ability to address issues of learning. For instance, the relative scale and the upper limit of one implies that the measure would be biased against the market leader for the determination of learning effects. Even if the market leader made significant strides on the absolute scale of technological knowledge, the best case scenario facing this firm would be a zero change—no learning—on the relative scale in the following period. In the meantime, even modest increments on the absolute scale for firms that lag behind may result in gains on the relative scale.

Also, our overarching model of the phenomenon of spin-outs precluded finer grained analysis on the founders of these organizations. Research needs to address founder characteristics, and how their experiences impact on the new ventures they form. While all the founders held high positions in research, manufacturing and marketing at the incumbent firms, future research needs to address how variations in expertise levels, hierarchical positions and team characteristics influence the effectiveness of knowledge transfer, and whether there are "network" effects at play in the formation of founder teams. While we ensured the absence of formal ties between parents and progenies, we were unable to ascertain the absence or presence of informal ties. Future research needs to examine whether any informal ties exist, and if so, their effect on the transfer of knowledge between parent and progeny. Furthermore, an interesting extension of this research could look at the conditioning effect of variables such as size and lifecycle stage on spin-out formation and development. Finally, our findings lead to an intriguing set of questions for future research on the competitive dynamics and pressures that are unleashed by spin-outs? Does a spin-out adversely affect a parent's survival? What are incumbent strategies that can counter this competitive threat and mitigate the competitive pressures from spin-outs? Additional research focusing on these issues needs to be conducted to determine whether spin-out entrepreneurs have an advantage over parent firms with respect to discovering, recognizing or exploiting new opportunities.

Figure 1: Areal Density of Drives by Diameter

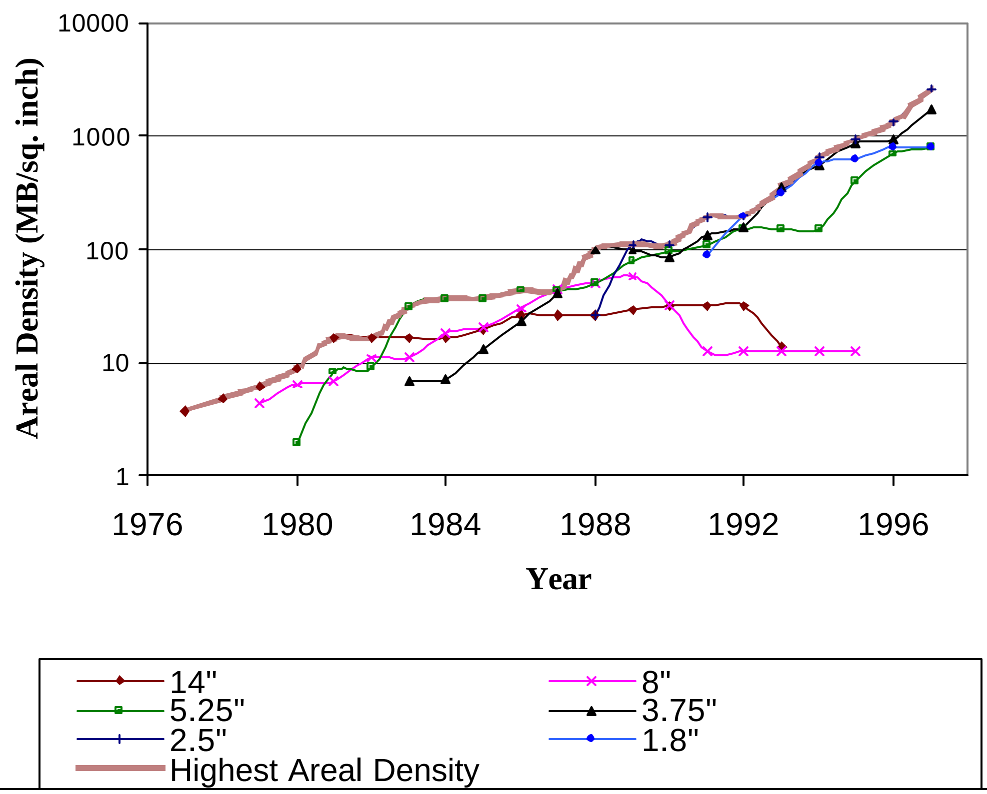

Table 1: Definition of Variables and Rationale

Variable Name	Variable Description	Rationale
Key Variables in Study		
Num. of Spin-outs Created	Number of spin-outs created in the following year due to employee(s) leaving in this period to form a new venture in the next period (0 if no spin-outs were generated)	Dependent variable for H1-H3
Survival	Dummy = 1 if firm survived to the following year (acquisitions treated as censored observations)	Dependent variable for H6
Technological Know-how	Firm's relative technological know-how in any year. Areal density (megabytes per square inch) of the firm's best drive in each diameter in each year is divided by the highest areal density observed for that diameter, and then averaged across diameters for the firm in each year.	Resource-based view argues that knowledge-based technological capabilities are critical to performance Explanatory variable for H_1-H_3 and H_6; Dependent variable for H_4-H_5
Market Pioneering Know-how	Number of times a firm introduced a drive of a new diameter within the first year of the diameter's introduction/ Total number of opportunities the firm had to do so	Measures the early-mover advantage of the firm Explanatory variable for H_1-H_3 and H_6; Dependent variable for H_4-H_5
Parent Tech. Know-how	Average relative technological know-how of the parent in the year preceding the spin-out's entry into the industry.	Measures parent firm technological capabilities. Explanatory variable for H_4-H_5
Parent Mkt. Pion. Knw-hw	Market pioneering know-how of the parent in the year preceding the spin-out's entry into the industry.	Measures parent firm market-pioneering capabilities. Explanatory variable for H_4-H_5
Spin-out	Dummy = 1 if one of the founders of a firm was an ex-employee of an incumbent firm in the year prior to spin-out formation.	Entrepreneurial ventures by ex-employees are different from other types of entry and represent technological transfer Explanatory variable for H_6
Firm Specific Control Variables		
Spin-off	Dummy = 1 if the firm was affiliated to an incumbent firm in the disk-drive industry (e.g. subsidiary, parent backing, joint venture, etc.)	Incumbent backed ventures are different from other entrants
Diversifying Entrant	Dummy = 1 if the firm existed in some other industry prior to entering the disk drive industry	Diversifying entrants are different from other entrants

Variable Name	Variable Description	Rationale
Firm Size	Logged value of all disk-drive sales of the firm per year, in millions of dollars	Larger firms may generate more spin-outs
Firm Growth	Growth in sales of the firm per year, in millions of dollars	In failing firms, employees may leave to start off on their own due to lack of employment opportunities
Foreign	Dummy = 1 if firm was a foreign firm. Note that since only one foreign firm generated a spin-out, this variable is not included in the hypotheses H_1-H_4 that pertain to spin-out formation/inheritance from parents	Foreign firms may be different from US due to institutional reasons.
Age, Age^2	Chronological age of firm since founding	Spin-out generation/survival affected non-linearly by firm age
Parent Presence	A dummy variable if parent was present in the diameter within which the spin-out first entered	Measures the impact of the parent's presence of spin-out performance and controls for potential deterrent effect
Firm Diversity	Number of diameters produced by the firm – average number of diameters produced by all firms in that year. Note that alternative operationalization as a proportion gives similar results	Measures firm diversity and scope of operations relative to the mean diversity and scope of operations in the industry
Incumbent 76	Dummy = 1 if firm entered prior to 1977	Controls for effects for firms that entered before the period under investigation
Industry Specific Control Variables		
Highest Areal	The highest areal density (information per square inch) of a drive across all the diameters produced in a given year: measure of the technological knowledge frontier in the industry in a given year	Knowledge accrual may be related to overall level of knowledge in the industry – absorptive capacity concept
Industry Sales	Sales of the industry per year, in millions of dollars	Represents resource munificence
Industry Growth	Growth in sales of the industry per year, in millions of dollars	Represents growth opportunities for firms
Nfirm, $Nfirm^2$	Number of firms in the industry per year	Non linear competitive density effects
Nentries	Number of firms entering the industry per year	Respresents possible extent of churn in the industry
Chronology Specific Control Variables		
Yre77-Yre97	Year Dummies for the entry year of the firm	Controls for founding conditions

Table 2: Descriptive Statistics

	Variable	Mean	Std Dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	2
1	Number of Spin-outs Created	0.04	0.21	1.00																				
2	Survival	0.88	0.33	-0.01	1.00																			
3	Tech Know-how	0.44	0.23	0.03	0.09	1.00																		
4	Markt. Pion. Know-how	0.07	0.22	0.14	-0.01	0.11	1.00																	
5	Parent Tech Know-how	0.10	0.25	0.07	0.03	0.22	0.11	1.00																
6	Parent Markt. Pion. Know-how	0.32	0.46	-0.02	0.06	-0.13	0.07	0.11	1.00															
7	Spin-out	0.30	0.46	0.18	0.06	0.29	0.29	0.62	0.06	1.00														
8	Spin-off	0.03	0.18	-0.03	-0.06	0.03	-0.06	-0.08	-0.06	-0.12	1.00													
9	Diversifying Entrants	0.18	0.38	-0.04	0.04	0.03	-0.03	-0.20	0.03	-0.29	-0.01	1.00												
10	Foreign	0.23	0.42	-0.09	-0.05	-0.23	-0.09	-0.20	-0.09	-0.36	-0.10	-0.14	1.00											
11	Incumbent 76 Dummy	0.31	0.46	0.02	0.08	0.09	-0.07	-0.28	-0.24	-0.28	0.00	0.47	-0.37	1.00										
12	Age	6.19	5.84	-0.02	0.01	0.21	0.12	-0.15	-0.13	-0.11	-0.08	0.45	-0.21	0.47	1.00									
13	Parent presence	0.08	0.27	0.03	0.05	0.14	0.00	0.49	-0.12	0.45	-0.05	-0.14	-0.16	-0.20	-0.06	1.00								
14	Product Diversity	-0.01	0.97	0.01	0.13	0.16	0.10	-0.09	-0.06	-0.06	-0.06	0.47	-0.24	0.43	0.51	-0.01	1.00							
15	Firm Size	4.28	12.75	0.06	0.41	0.09	0.11	-0.21	-0.15	-0.08	-0.04	0.28	-0.17	0.36	0.38	-0.08	0.47	1.00						
16	Firm Growth	0.21	0.65	0.06	0.28	-0.01	0.09	0.07	0.12	0.10	0.00	-0.10	0.10	-0.19	-0.24	0.07	-0.02	0.36	1.00					
17	Industry Sales	16.33	0.67	-0.09	-0.14	0.04	0.01	0.11	0.09	0.05	-0.04	0.09	0.28	-0.32	0.35	0.05	0.00	-0.01	-0.19	1.00				
18	Industry growth	0.14	0.10	0.04	0.07	-0.10	0.05	-0.03	-0.03	0.01	0.04	0.03	-0.14	0.14	-0.24	0.00	0.00	0.00	0.17	-0.55	1.00			
19	Highest Areal	195.37	437.56	-0.06	0.02	0.09	-0.01	0.03	0.03	0.01	-0.05	-0.02	0.07	-0.10	0.31	-0.02	0.00	0.06	-0.09	0.48	-0.31	1.00		
20	Number of Firms	62.70	16.93	0.05	0.02	-0.11	0.09	0.02	0.02	0.05	0.06	0.09	-0.07	0.03	-0.24	0.05	0.00	-0.03	0.14	-0.17	0.58	-0.68	1.00	
21	Number of entries	7.97	4.48	0.10	0.05	-0.08	0.09	-0.01	0.00	0.03	0.03	0.02	-0.14	0.10	-0.24	0.01	0.00	-0.05	0.12	-0.45	0.52	-0.57	0.72	1.0

Table 3: Firm Know-how and Probability of Spin-out Generation[1]

Variable	Model 3a	Model 3b
Constant	-31.116	-37.520
	(23.675)	(23.808)
Technological Know-How	2.262**	3.457**
	(0.795)	(0.946)
Market Pioneering Know-How	1.256**	3.352**
	(0.507)	(1.033)
Technological Know-How *		-4.062**
Market Pioneering Know-How		(1.861)
Age	-0.126	-0.156
	(0.185)	(0.177)
Age ^{2}	0.001	0.002
	(0.006)	(0.006)
Firm Size	0.505**	0.446**
	(0.167)	(0.162)
Industry Sales	0.846	1.056
	(1.450)	(1.437)
Firm Growth	0.321	0.267
	(0.397)	(0.385)
Industry Growth	-3.654	-3.326
	(2.815)	(2.731)
Highest Areal	-0.019	-0.019
	(0.015)	(0.015)
Product Diversity	-0.477*	-0.566**
	(0.278)	(0.275)
Incumbent 76 Dummy	-0.856	-0.668
	(0.746)	(0.754)
Number of Firms	0.587*	0.661**
	(0.324)	(0.328)
Number of Firms ^{2}	-0.005*	-0.005**
	(0.002)	(0.002)
Number of Entrants	0.015	0.026
	(0.081)	(0.079)
Number of Observations	1180	1180
Log Likelihood	-101.93	-99.47

[1]The firm characteristics in this model relate to the firm becoming a potential parent.
Standard Errors are in parentheses; **Significant at the 5% level; * Significant at the 10% level

Table 4:Knowledge Transfer from Parent to Spin-out through Inheritance

Variable	Model 4a Spin-out Tech Know-how	Model 4b Spin-out Market Pion. Know-how	Model 4c Spin-out Tech Know-how	Model 4d Spin-out Market Pion. Know-how
Intercept	-0.137	2.348**	-0.214	2.622**
	(0.675)	(1.124)	(0.67)	(1.127)
Parent Technological Know-how	0.148**	-------	0.051	-------
	(0.045)		(0.080)	
Parent Market Pioneering Know-how	-------	0.106**	-------	-0.038
		(0.044)		(0.082)
Age	-0.035**	0.044**	-0.045**	0.027
	(0.009)	(0.015)	(0.012)	(0.017)
Age^2	0.002**	-0.002**	0.003**	-0.001
	(0.0005)	(0.0009)	(0.0007)	(0.001)
Parent Technological Know-how*Age	-------	-------	0.052**	-------
			(0.026)	
Parent Technological Know-how*Age^2	-------	-------	-0.004**	-------
			(0.002)	
Parent Market Pioneering*Age	-------	-------	-------	0.057**
				(0.029)
Parent Market Pioneering*Age^2	-------	-------	-------	-0.003
				(0.002)
Firm Size	-0.001	0.003*	-0.001	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Industry Sales	0.059	-0.131**	0.062*	-0.147**
	(0.038)	(0.063)	(0.038)	(0.063)
Industry Growth	0.090	0.042	0.088	0.042
	(0.148)	(0.131)	(0.148)	(0.248)
Highest Areal	-0.0002*	0.00006	-0.0002*	0.00007
	(0.0001)	(0.0002)	(0.0001)	(0.0002)
Number of Firms	-0.003	-0.009	-0.002	-0.009
	(0.009)	(0.016)	(0.010)	(0.016)
Number of $Firms^2$	0.0001	0.0001	-0.000003	0.0001
	(0.0007)	(0.0001)	(0.00007)	(0.0001)
Number of Entrants	0.000001	-0.003	0.00005	0.003
	(0.004)	(0.007)	(0.003)	(0.006)
Number of Observations	344		344	
System R^2	0.28		0.28	

Standard errors are in parentheses; ** 5% level; * 10% level. Year of entry dummies included but not reported.

Table 5: Technological and Market Pioneering Know-how of Entrants

Variables	Model 5a Tech Know-how	Model 5b: Market Pion. Know-how	Model 5c Tech Know-how	Model 5d: Market Pion. know-how
Intercept	0.704	2.636	0.206	2.041
	(0.462)	(0.674)	(0.446)	(0.655)
Spin-out	0.137**	0.165**	0.208**	0.137**
	(0.021)	(0.030)	(0.035)	(0.052)
Spin-off	0.129**	0.048	0.140**	0.043
	(0.045)	(0.066)	(0.046)	(0.067)
Foreign	-0.033	0.143**	-0.030	0.148**
	(0.023)	(0.034)	(0.023)	(0.034)
Diversifying Entrant	-0.127**	-0.108**	-0.120**	-0.087**
	(0.034)	(0.050)	(0.034)	(0.050)
Age	-0.004	0.058**	-0.0008	0.042**
	(0.006)	(0.009)	(0.009)	(0.014)
Age^2	0.0004	-0.003**	0.0002	-0.002
	(0.0004)	(0.0006)	(0.0008)	(0.001)
Spin-out*Age	-------	-------	-0.022*	0.019
			(0.001)	(0.019)
Spin-out*Age^2	-------	-------	0.001	-0.001
			(0.001)	(0.001)
Firm Size	-0.00005	0.0003	0.0001	0.0002
	(0.0006)	(0.001)	(0.0006)	(0.001)
Industry Sales	-0.015	-0.157**	0.013	-0.122*
	(0.027)	(0.039)	(0.026)	(0.038)
Industry Growth	-0.059	0.040	-0.062	0.032
	(0.109)	(0.159)	(0.109)	(0.161)
Highest Areal	-0.00001	0.000001	-0.000001	0.00001
	(0.00004)	(0.0001)	(0.00009)	(0.0001)
Number of firms	-0.001	-0.008	0.0002	-0.005
	(0.007)	(0.010)	(0.007)	(0.010)
Number of $firms^2$	0.000004	0.0001	-.000006	0.00008
	(0.00005)	(0.00008)	(0.00005)	(0.00008)
Number of Entrants	0.0006	-0.0007	-0.00005	0.0006
	(0.003)	(0.005)	(0.003)	(0.004)
Number of Observations	767		767	
System R^2 =	0.20		0.20	

standard errors are in parentheses; **Significant at the 5% level; * Significant at the 10% level
Year of entry dummies included by not reported

Table 6: Probability of Survival of Entrants

Variable	Model
	28.627**
	(12.945)
	0.70**
Spin-out	(0.309)
	-0.671
Spin-off	(0.523)
	-0.103
Diversifying Entrant	(0.428)
	0.839**
Technological Know-how	(0.420)
	-0.198
Market Pioneering Know-how	(0.350)
	0.397
Foreign Firm	(0.279)
	-0.108
Age	(0.164)
	0.013*
Age^2	(0.007)
	0.047**
Firm Size	(0.008)
	0.72
Parent Presence in Diameter of Entry	(0.48)
	0.003**
Highest Areal	(0.001)
	-2.344**
Industry Sales	(0.894)
	-0.886
Industry Growth	(1.466)
	0.321**
Number of firms	(0.089)
	-0.002**
Number of $firms^2$	(0.0006)
	-0.046
Number of Entrants	(0.043)
Number of observations	750
Log likelihood	-261.43

Year of entry dummies included but not reported
**Significant at 5 percent level
*Significant at 10 percent level

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