Knowledge Transfer Through Inheritance: Spin-out Generation, Development and Survival

Rajshree Agarwal*
Dept. of Business Administration
University of Illinois at Urbana Champaign
350 Wohlers Hall, 1206 S. Sixth St.
Champaign, IL 61820
Email: agarwalr@uiuc.edu

Raj Echambadi
Dept. of Marketing
College of Business Administration
University of Central Florida
P.O. Box 161400
Orlando, Fl 32816-1400
Email: rechambadi@bus.ucf.edu

April M. Franco
Dept. of Economics
W210 John Pappajohn Business Building
The University of Iowa
Iowa City, IA 52242-1000
Email: afranco@blue.weeg.uiowa.edu

MB Sarkar
Dept. of Management
College of Business Administration
University of Central Florida
P.O. Box 161400
Orlando, Fl 32816-1400
Email: msarkar@bus.ucf.edu

All authors contributed equally. The names are arranged in alphabetical order

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* Contact Author.

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ABSTRACT

This paper examines the role of inherited knowledge in an organization's formation and as a subsequent source of its competitive advantage. We investigate how knowledge inherited from an industry incumbent by a "spin-out" (an entrepreneurial venture by an ex-employee) influences the spin-out's development and performance. Using data from the disk drive industry from 1977 to 1997, we show that the incumbent's capabilities related to technology and market pioneering predict spin-out formation by its employees. Results show that incumbents with both strong technological *and* market pioneering know-how generate fewer spin-outs than firms with strengths in only one area. The incumbent's capabilities at the time of spin-out founding positively affects the spin-out's knowledge capabilities and result in spin-outs having higher probabilities of survival relative to other industry entrants.

Organizational researchers have long considered the effects of historical antecedents on industry entrants' heterogeneity. For diversifying firms, there is evidence that pre-entry experience influences a firm's resources and capabilities and, therefore, its performance in new product markets (Carroll, Bigelow, Seidal &Tsai, 1996; Klepper & Simons, 2000). While not much is known about the birth and development of capabilities in new ventures (Helfat & Lieberman, 2002; Zahra, Ireland, & Hitt, 2000), research suggests that routines and resources transfer from old to new organizations with personnel migration (Aldrich & Pfeffer, 1976; Almeida & Kogut, 1999; Pfeffer & Leblebici, 1973). Findings indicate that previous employment affiliations influence not only new venture formation (Burton, Sørensen, & Beckman, 2002; Shane & Khurana, 1999) but also product-market strategies (Boeker, 1997) and firm survival (Bruderl, Preisendorfer, & Ziegler, 1992; Phillips, 2002). However, despite past work suggesting that historical ties between an incumbent and a new entrant manifest themselves through knowledge diffusion, some gaps remain.

First, while emerging research speculates that new ventures exploit knowledge they inherit from their founders' past employer (Klepper & Sleeper, 2000; Phillips, 2002), we lack an explicit theoretical and empirical *knowledge* connection linking pre-entry affiliation with new venture creation, capability formation, and survival. For example, past literature has conceptualized parent-progeny transfer of routines as a function of the relative position of the employee and has assumed that an underlying process of knowledge transfer occurs, *without* explicitly testing for such inheritance (see Phillips, 2002). Therefore, it is unclear whether knowledge is in fact inherited and how pre-entry affiliation shapes a start-up's knowledge endowments. Second, as noted by Huber (1991), there is little research that has systematically linked inherited knowledge to firm performance. Therefore, it is unclear whether initial endowments from inheritance have long-term effects on a firm's evolution and performance.

This paper addresses each of these gaps by developing and testing a framework linking knowledge inheritance to the formation, development, and life chances of a *spin-out* -- defined as an entrepreneurial new venture (the progeny) founded by former employees of an incumbent

firm (the parent) which competes in the same industry as the parent and has no equity relationships with any industry incumbent. Such spin-outs are legion in high-technology industries such as semi-conductor (Braun & MacDonald, 1978; Dosi, 1984), disk drive (Christensen, 1993), and laser (Klepper & Sleeper, 2000) manufacturers, as well as in the legal services (Phillips, 2002) industry, where generation after generation of executives have left their employers to launch new entrants. Tending to operate at the forefront of innovation, they often commercialize technology that their parents had developed but chosen to either ignore or underexploit (Bhide, 2000; Christensen, 1993; 1997). Spin-outs therefore pose a special threat to incumbents, who not only risk losing proprietary knowledge but also run the danger of being upstaged by knowledge that they themselves have created. We analyze how inherited knowledge from parent firms affected spin-outs' formation and evolution using data on the rigid disk drive industry, which has been called the "fruit fly of industries" due to its rapid technological changes (Christensen, 1993). A significant percentage of new entrants in this industry were spin-outs, thus making it a particularly appropriate setting for our study.

Our paper contributes to the under-researched phenomenon of employee entrepreneurship (Klepper 2001). We offer a strategic management view of knowledge inheritance and its role in seeding the entrepreneurial process – a perspective that is quite distinct from dominant economic (Moen, 2001; Zucker, Darby & Brewer, 1998), and sociological perspectives (Aldrich & Pfeffer, 1976; Boeker, 1997) on knowledge spillovers. We also contribute to emerging ideas surrounding strategic entrepreneurship (Hitt et al., 2001) by adopting a symbiotic perspective of value-creation and value-appropriation. Finally, by suggesting that the organization of capabilities may be as important a source of performance heterogeneity as the capabilities themselves, our research advances understanding of the resource-base (Leiponen, 1999).

KNOWLEDGE TRANSFER AND THE SPIN-OUT PHENOMENON

Knowledge is not only the fountainhead of innovative firm entry (Schumpeter, 1934) but is also fundamental to a firm's evolution and growth (Spender, 1996). A critical competitive asset, tacit knowledge enables a firm to build new resource positions to take advantage of

changing conditions (Eisenhardt & Martin, 2000; Grant, 1996). The ability to reconfigure resources ahead of competitors is especially relevant in high-technology markets, where frequent technological disruptions create both opportunities in new subfields and threats of obsolescence (Mitchell, 1994; Cohen & Levinthal, 1990; Teece, Pisano, & Shuen, 1997). Underlying strategic renewal in such markets are investments in developing two key interrelated capabilities, namely, R&D and marketing (Daneels, 2002; Teece, 1986).

While *technological capabilities* reflect a firm's ability to generate new scientific discoveries and technological breakthroughs, *market pioneering capabilities* enable a firm to commercialize technological innovations ahead of competitors. The potential value created by a firm's R&D efforts can be unlocked and appropriated through marketing by understanding and satisfying new customer needs quickly (Jaworski & Kohli, 1993; Narver & Slater, 1990). Market pioneering not only involves complex marketing skills that are qualitatively different from those required by later entrants (Bowman & Gatignon, 1995) but is critical in markets with short product life cycles, where prices tend to drop sharply after an initial period of time (Hatch & Macher, 2002). The two capabilities are thus complementary in that a firm needs to create technological innovations as well as design "killer applications" that enable it to appropriate market value (Cohen & Levinthal, 1990; Moran & Ghoshal, 1999; Teece, 1986).

In the process of investing in such value-creating and appropriating capabilities, firms enhance their employees' capabilities too. As a firm utilizes its human capital to develop new know-how (Hitt et al., 2001; Lepak & Snell, 1999), its employees simultaneously acquire technological (scientific knowledge), social (personal contacts and network ties), and cultural (value placed by society on symbols of prestige) capital from their employers (Becker, 1964; Long et al., 1998; Yli-Renko, Autio, & Sapienza, 2001). Prior research suggests that an organization's tacit knowledge, which is integral to acquiring complex scientific or business process skills, is not only socially embedded in organizational routines (Liebeskind, 1996; Nelson & Winter, 1982) but also resides in individual employees and their skills (Hitt et al., 2001; Szulanski, 1996). A complex and critical part of technology relates to its "softer" side,

which goes beyond codified knowledge available in scientific papers, formulae, technical specifications, blueprints, or hardware and is often held by individual employees in the form of tacit knowledge and competence assets (Kogut & Zander, 1992; Teece, 1988). This recursive and interdependent relationship between a firm's tacit knowledge and its human capital (Lepak & Snell, 1999) implies that investments in R&D and marketing increase not only the organization's resource base but also its employees' human capital.

Unlike tangible assets, however, personnel are under limited organizational control, and free to quit at will (Coff, 1997). Human capital is mobile and, therefore, so is the knowledge that employees possess (Aldrich & Pfeffer, 1976; Boeker, 1997). The impediments to spillovers are further lowered in some states such as California that do not enforce non-compete clauses. Further, market mechanisms are generally ineffective in protecting knowledge spillovers caused by employee mobility. While firms can increase employees' exit costs and impose "golden handcuffs" (Liebeskind, 1996), these incentive mechanisms are subject to agency costs. Problems of moral hazard (Wiggins, 1995) and information asymmetries (Anton & Yao, 1995) create contractual problems between employees and their employers. As a result, incentives provided by incumbent firms to lock in their employees (and their knowledge) may not be effective because the potential rewards are greater in entrepreneurial ventures.

Due to the uncertainties and costs of protecting knowledge, technology-rich firms have been referred to as "precarious monopolies" (Stinchcombe & Heimer, 1988). By forming their own entrepreneurial ventures, employees can expropriate the outputs of their previous employer's investments in capability development. Organizations thus often emerge from other organizations (Stinchcombe, 1965), as employees leave to found new spin-out organizations using knowledge gained as a result of employment with the industry incumbent.

Knowledge Capabilities and Spin-out Generation

Abundant Knowledge: Anecdotal evidence suggests that some firms seem to be "entrepreneurial hotbeds" in spawning progeny (Burton et al., 2002). What these firms seem to have in common is an abundance of knowledge. There are two reasons why firms with abundant

knowledge would be associated with a higher *potential* for spin-out generation. First, the place of employment may influence an employee's ability to perceive a prospect. Since exploiting an opportunity is endogenous to discovering it (Shane, 2000), and knowledge asymmetry lies at the heart of entrepreneurship (Venkataraman, 1997), possessing unique and idiosyncratic information is a source of advantage since it enables one to spot potential opportunities ahead of others. Working with firms that are at the cutting-edge helps create a "knowledge corridor" that facilitates opportunity recognition (Hayek, 1945; Venkataraman, 1997). The stock of prior knowledge has an influence on one's ability to understand, infer and creatively extend new knowledge to new frontiers in a way that those lacking prior information cannot replicate (Roberts, 1991). In the context of technological innovations, for example, Shane (2000) noted that prior information triggers the discovery of a new entrepreneurial opportunity. Further, the quality of research discussions and social interactions are likely to be substantively different in a premier research institution than in others. Scientists have been known to undergo short-term financial sacrifices to apprentice for firms that are on the technological frontier in order to enhance their knowledge (Franco & Filson, 2000; Hitt et al., 2001).

Similarly, by accumulating and developing rule-like responses, interpretive schemas, and outcome evaluations (Greve & Taylor, 2000), firms can develop decision heuristics that enhance their market pioneering knowledge. For example, prospector organizations that achieve growth by entering new markets and frequently expanding 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). As employees internalize the organization's culture (Inzerille & Rosen, 1983; Meek 1988), such strategic orientations may provide prospective founders with procedural and declarative knowledge related to assessing market needs and identifying new market opportunities earlier than competitors. Thus, employees of firms with greater knowledge capabilities are more likely to perceive the next generation of technologies and markets earlier than their counterparts in firms that lag behind.

Second, raising venture capital for an entrepreneurial venture is fraught with information asymmetry between the entrepreneur and the venture capitalist, causing problems of moral hazard and adverse selection. (Brav & Gompers, 1997). The newer the technology and more nascent the market, the greater the information asymmetry and associated uncertainty about the venture's prospects. In such situations, investors depend on certification cues to make quality judgments, and the prospective entrepreneur's institutional affiliation assumes heightened importance in assuring venture quality and mitigating concerns about the liabilities of newness (Gompers & Lerner, 2001; Shane & Khurana, 1999; Stuart, Hoang, & Hybels, 1999). Past research indicates that employment affiliation with a marquee firm transfers status and thus has a legitimizing effect (Podolny, 1994; Stuart et al., 1999). Accordingly, employees of well-reputed firms benefit from enhanced social capital in the form of reputation, networks, role models, and "entrepreneurial capital" (Aldrich, Renzulli & Langton, 1998). Research findings indicate that entrepreneurs' prior jobs influence perceptions of their skills and trustworthiness (Davis, 1991; Eisenhardt & Schoonhoven, 1996). Further, innovations in emerging areas of technology have been perceived to be more important when affiliated with high-status organizations (Podolny & Stuart, 1995). In the absence of unambiguous measures of quality, institutional affiliations may thus serve an endorsement role and influence perceptions relating to the quality and promise of a proposed entrepreneurial venture. These, in turn, help to mobilize the financial and other resources necessary to undertake an entrepreneurial venture (Burton et al., 2002; Higgins & Gulati, 2003). As a result, the place of prior employment can influence access not only to opportunities but also resources (Granovetter, 1985), since investors are likely to be more willing to back ventures in which the founder's employer is a technological or marketing leader.

Thus, employees at firms with better capabilities have a higher *potential* to create new ventures due to both opportunity recognition and investor confidence, but whether they *realize* these opportunities and commit to leaving employment to start-up a new venture is likely to depend on how well their employer firm uses the abundance of knowledge it generates.

Underutilization of Abundant Knowledge: When an organization's strategy for acquiring knowledge emphasizes either technological know-how or market pioneering know-how and ignores the other, many identified but unexploited opportunities result. In such situations, employees may be more likely to leave and start their own ventures. Research on individual risk-taking behavior suggests that individual action may be spurred by divergence between organizational and individual goals (Greve, 1998). While top management tends to emphasize goals that are salient to external stakeholders who provide critical resources to the organization, employee aspirations could be different. Christensen (1993) showed how a firm's dependence on existing customers both hampered efforts to reorient market strategies and frustrated engineers whose technological inventions were not commercialized. When incumbent firms develop promising technological inventions but fail to marshal the resources needed to take the technologies to market, their behavioral inertia and inaction may result in a growing gap between employees' aspirations and their current situation (Kahneman & Tversky, 1979). Similarly, as organizations develop their "scouting" and "prospecting" abilities, they may uncover new opportunities, and firms with superior market pioneering know-how will be able to home in on these better. Some of these opportunities may require the firms to develop technologies or venture in directions that they are not willing to go, causing again a divergence between the professional personnel and top management. Thus, if firms do not simultaneously develop their technological *and* market pioneering know-how, they create frustration among employees, who perceive their organizations as systematically missing out on either value-creating or value-appropriating opportunities.

Further, an incumbent's unwillingness to pursue certain technologies may also cause employees to perceive reduced entry and survival barriers for their own ventures. Thus, undeveloped technologies or new market opportunities, particularly those that are substantial and path breaking, increase employees' confidence in venturing out and their entrepreneurial propensity (Eisenhardt, 1989). Underexploitation causes some employees to act on the potential created by the abundant opportunities by leaving and starting their own firm. Therefore,

H_1: The probability of spin-out generation is likely to be higher when a firm possesses higher levels of either (a) technological or (b) market pioneering know-how.

Simultaneous Creation and Appropriation of Knowledge: The complementary nature of technological and market pioneering know-how (Griffin & Hauser, 1996; Teece, 1986) not only creates a valuable synergy that increases a firm's effectiveness but also inhibits competitive imitation (Grant, 1991). First, by responding to opportunities, organizations prevent aggravation and frustration among employees from their "shelved" inventions (Christensen, 1993; Garvin, 1983). Better job satisfaction and increased prospects reduce the chances of employees leaving (Benkhoff, 1997). Second, incumbent organizations that possess both high-end technological *and* market pioneering know-how exhibit a "willingness to cannibalize" (Chandy & Tellis, 1998; Kamien & Schwartz, 1982). Their preemptive entry into new technical subfields deters spin-out formation by raising entry barriers. In essence, these organizations commit themselves to preventing the underexploitation of their knowledge resources. Through a combination of incentives aimed at employee retention and competitive deterrence, incumbents with high capabilities in both areas can reduce the incidence of spin-out generation. In other words, an abundance of underutilized knowledge can beget spin-outs, but spin-outs are deterred when the knowledge of a firm is put to good use.[1] Thus,

H_2: 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.

Spin-out's Knowledge Inheritance

The knowledge that a spin-out inherits from the incumbent firm that employed its founders should have an imprinting effect of the spin-out. Organizational sociologists have theorized about the interorganizational transfer of rules, routines, and resources (Brittain & Freeman, 1980; Hannan & Freeman, 1986). This literature posits that, similar to the reproduction and transmission of biological genes, organizational blueprints transfer through the career experiences of founders (Winter, 1991). Applying the transfer of resources to the domain of organizational speciation, it is plausible that progeny inherit knowledge-based resources from

[1] We would like to thank an anonymous reviewer for helping us articulate this thought.

their parents (Phillips, 2002). When employees leave to start a new venture, they walk out with tacit knowledge that goes beyond codified information. Parental know-how at the time of spin-out inception thus represents knowledge that potentially can be inherited by the spin-out. Moreover, the knowledge inherited from the parent may have a long term effect on the spin-out's knowledge capabilities.

Founding conditions, related to both the environment and the founder are imprinted on a new organization (Stinchcombe, 1965) and have an impact on the organization at various levels—structure, strategy, technology, and routines—and have long-term consequences for a firm's actions and performance (Baum, Calabrese, & Silverman, 2000; Eisenhardt & Schoonhoven, 1991; Sastry & Coen, 2000; Shane & Stuart, 2002). Moreover, an organization's absorptive capacity—its ability, efficiency, and aspiration to learn, discover, and acquire new knowledge—is also linked to its level of prior related knowledge (Cohen & Levinthal, 1990). This implies that the knowledge inherited by its founders from a parent organization positions a spin-out on a developmental path that affects its long-term competitive positioning. Thus, the parent's knowledge at the time of spin-out inception is related to the spin-out's knowledge over time. Further, the same arguments also relate to the *within-group variance* among spin-outs' capabilities. Smart parents are more likely to create smart progenies. Starting with a good model can have an impact on subsequent firm performance (Cyert, Kumar, & Williams, 1993), and superior endowments at birth result in long-term robust performance. Thus,

> *H_3: The levels of the spin-out firm's (a) technological and (b) market pioneering know-how over time will be positively related to the level of its parent's (a) technological and (b) market pioneering know-how at the time of the spin-out's inception.*

Spin-out Knowledge Capabilities and Survival

Due to inherited knowledge and entrepreneurial origin, spin-outs may differ in their knowledge and survival probabilities vis-à-vis other entrants. We follow Helfat and Lieberman's (2002) distinction between entrants, as opposed to the coarse-grained distinction between *de novo* and *de alio* entrants based on pre-entry experience (Carroll et al. 1996; Klepper & Simons, 1996). Among *de novo* entrants representing new start-ups, we distinguish between spin-outs and

non-spin-out *de novo* entrants, since spin-outs inherit knowledge from an industry incumbent.[2] Among *de alio* entrants, we distinguish between diversifying entrants and incumbent-backed ventures. Diversifying entrants are established firms in other industries that enter the focal industry, while incumbent-backed ventures represent separate legal entities with incumbent ties (e.g., subsidiaries, joint ventures, franchisees, spin-offs).[3]

Entrant Knowledge Capabilities: Among the four entrant categories, both incumbent-backed ventures and spin-outs benefit from direct knowledge transfer from an incumbent. Just as spin-outs inherit knowledge from the parent firm through founders, incumbent-backed ventures obtain knowledge through a cooperative relationship with the incumbent at birth, and perhaps on a continuing basis. Thus, given the links to incumbent firms, knowledge difference between these two groups is an empirical issue. Diversifying and non-spin-out *de novo* entrants, however, learn either by doing or by indirect grafting mechanisms such as recruiting employees who work in the industry (Boeker, 1997; DiMaggio & Powell, 1983). Compared with these two types of entrants, spin-outs should have an advantage because the knowledge brought in by ex-employee founders will be less vulnerable to the problem of "stickiness" and will therefore be more effectively transferred internally within the organization (Szulanski, 1996).

The adoption of complex technology and business processes involves a conscious process of reconstruction, diffusion, and integration into new routines within an organization. Stickiness, reflects difficulties encountered by organizations in effecting internal transfer of knowledge. This causes knowledge, particularly the tacit component, to lie inert in some part of the organization - acquired, yet not readily accessible or retrievable, and therefore not deployable and convertible into value when required (Whitehead, 1929). As a result, "organizations may not necessarily know all that they know" (Szulanski, 2000, p. 10) and thus fall short of fully exploiting their know-how (von Hippel, 1994).

[2] We refrain from using the term "entrepreneurial spin-offs" used by Helfat and Lieberman (2002) and Klepper (2001, 2002) to avoid confusion with the term "spin-off" as defined in the finance literature.

[3] As Helfat and Lieberman (2002) elaborated, incumbent-backed ventures are hybrids between diversifying and *de novo* entrants that are set up by established firms. While the established firm may have a financial stake or representation on the board of directors, these are nonetheless new companies and separate legal entities.

The directness of knowledge transfer through employee-founders reduces stickiness and increases a firm's ability to integrate and successfully acquire knowledge. First, the general management role of entrepreneurial founders enables them to adopt a holistic picture. Employees may be limited in their ability and motivation to transfer relevant resources across different departments of the organization, leading to an under-use of knowledge. Fisher, Maltz and Jaworski (1997) found that functional identification may actually decrease information dissemination through the organization. Acting as knowledge brokers between functional domains and various employees, founders on the other hand can increase the likelihood of employees adopting a new practice (Lenox & King, 2003). By being in a more influential position to bring about progressive routinization of best practices, founders have an advantage over other lower-level employees in effecting the knowledge transfers. Second, founders have the incentives and motivation to share their knowledge and transform it into best practices so as to appropriate full benefits from their know-how, while agency problems and competitive incentive structures in organizations can create certain exchange dynamics in internal knowledge markets that may discourage employees from sharing knowledge (Davenport & Prusak, 1998). Since power in the organization depends on having non-replicated knowledge, employees may prefer not to lose their knowledge monopoly. Founders face no such divergence between their own and the organization's goals, causing useful knowledge to be disseminated within the organization more easily.

Further, founding teams of spin-outs are likely to have a knowledge advantage over employees hired individually into new firms. Typically, multiple employees from diverse backgrounds (and often from different incumbents) come together to start a new firm, thus creating synergy and increasing the potential value of their combined know how (Dess & Shaw, 2001). Armed with insider knowledge, these prospective entrepreneurs are likely to conduct an active search for specific pockets of complementary knowledge in their employing firm or their social networks in the industry to create synergy among the individual components of know-how. Accordingly,

H_4: Spin-outs will have higher levels of (a) technological know-how and (b) market pioneering know-how relative to both non-spin-out de novo and diversifying entrants.

Entrant Survival: Spin-outs, as an organizational form, may also be advantaged over other types of entrants on a key dimension of performance, namely, survival. Spin-outs represent employee entrepreneurship with both inside knowledge of the industry and entrepreneurial origin, which is argued to be an important source of resource differences, strategies, and performance (Knight, 1989; Shrader & Simon, 1997). Both these dimensions, we posit, create survival advantages for spin-outs when compared with the other three entrant groups.

Spin-out firms share their entrepreneurial origin roots with non-spin-out *de novo* entrants, but, additionally, have the benefit of insider status, which means that their initial resource endowments are likely to be superior to other *de novo* firms. In addition to having technological and marketing knowledge, spin-out founders are likely to benefit from their employer's contacts, and network ties (Higgins & Gulati, 2003; Yli-Renko et al., 2001). Further, spin-outs are likely to bring in routines and processes and links with customers that enable them to better overcome liabilities of newness (Phillips, 2002). Further, as Shane & Stuart (2002) found, founders' social capital is positively related to survival. Thus, consistent with the findings of Phillips (2002), we expect spin-out firms should be advantaged over other *de novo* entrants in terms of survival.

Compared with incumbent-backed ventures, spin-outs lack parental support. Thus, it may seem that the former is advantaged because parental backing cushions incumbent-backed ventures from the liability of newness. But this advantage may be mitigated by the characteristics of employees that venture out on their own. Underutilization of knowledge resources by incumbents may set into play certain self-selection processes whereby a certain type of employee may tend to undertake the entrepreneurial act. Research reveals that an entrepreneurial mindset may be distinct from a managerial one (McGrath and MacMillan 2000). Entrepreneurs tend to have a higher risk-taking propensity, low uncertainty avoidance, and a preference for innovative behavior (Carland, Carland, & Stewart, 1996; Drucker, 1995). In other words, these are traits that are consistent with the requirements of high-technology markets (Moriarty & Kosnik, 1989).

Further, expectations of success are linked to the choice of undertaking an entrepreneurial venture, and individuals' expectations of success through entrepreneurship are related to their assessment of personal capabilities, to accessible resources and earlier investments in relevant resources (Blumberg & Pfann, 2001). Therefore, as incumbents fail to utilize opportunities, it is those employees with entrepreneurial capital and ability that are likely to depart and form spin-outs. Spin-outs, manned by personnel with greater entrepreneurial zeal and ability than other entrants, may thus ultimately fare better than incumbent-backed ventures.

Finally, relative to diversifying entrants, spin-out firms are advantaged in terms of both their founders' access to industry-related information and their entrepreneurial origin. While diversifying entrants may have access to resources and capital, these resources may not be as directly related to the focal industry as the resources garnered by spin-out firms through their own networks and social capital. Further, higher autonomy, lack of bureaucratic inertia, and simple structures enable entrepreneurial spin-outs to creatively combine and exchange resources more quickly than diversifying entrants.[4] Diversifying entrants frequently suffer from conflicting signals and role confusion due to vested interests in the established organization (Haveman, 1992), and their managers may have to balance a variety of political and corporate objectives that pull them in different directions. Corporate authority and the need to obtain clearance on strategic decisions may create organizational inertia in diversifying entrants, giving spin-outs a learning advantage in dynamic environments (Carroll et al., 1996), since they can move more quickly and decisively to deploy new knowledge routines (Rosenbloom & Christensen, 1994). Finally, while managers of diversifying entrants are likely to be evaluated on the basis of how closely they adhere to a plan vetted by corporate headquarters, spin-out founders are motivated by the ends achieved, because their livelihood is tied to the venture's performance. Thus, relative to diversifying entrants too, spin-out firms should be advantaged in terms of survival. Therefore,

> *H_5: The likelihood of survival will be greater for spin-out entrants than for all other types of entrants.*

[4] These constraints are also applicable to incumbent-backed ventures, to the extent that they have continued parental ties (through an incumbent's equity stake or representation on the board of directors).

METHODOLOGY

We tested our hypotheses using data from the rigid disk drive industry from 1977 to 1997. Disk drives are magnetic information storage devices used in computers. Analogized as the "fruit fly of industries," the industry is a particularly appropriate setting due to the rapid pace of technological evolution detailed below and the large number of entrants, of which a high percentage were spin-outs (See Christensen, 1993, 1997 for a detailed industry history).

The availability of longitudinal 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 about firms and the industry *at the time of occurrence* and tracked information on important historical events in the industry for *all* firms entering and exiting the market. As in a number of past studies (Christensen 1993; King & 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. We identified the existence and type of pre-entry affiliation of all entering firms, and in particular determined parent-progeny relationships for spin-outs, based on background information on the founders of new firms from the *Disk/Trend Report,* supplemented by company press reports and news releases and various technological sources, scientific journals, books, articles in periodicals, chronologies, and directories (e.g., the *Directory of Corporate Affiliations* and the *International Directory of Company Histories).* The database includes all firms in the industry during the 1977-1997 period with information on the introduction times of new products within the industry, product characteristics, and annual sales of disk drives.[5] Since every productive firm, regardless of size, is included for its span of existence in the market, our sample does not suffer from a survival bias.

Pace of Technological Change in the Disk Drive Industry

In 1973, IBM pioneered the 14-inch Winchester, the first completely sealed and removable disk drive, and the disk drive industry experienced numerous innovations in the

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

following 20-year period. Architectural innovations resulted in five new diameters after the 14-inch drive and created new submarkets (the 8-inch in 1979, the 5.25-inch in 1980, the 3.75-inch in 1983, the 2.5-inch in 1988, and the 1.8-inch in 1991). In addition to these disruptive innovations, within each diameter, several modular and incremental innovations resulted in dramatic increases in "areal density," defined as the megabytes of information that can be stored per square inch of a particular drive. Enabling cross-diameter comparisons, areal density is generally used as an industry standard to determine a drive's technological advancement. It is the main product performance measure, and represents a combination of the technologies—access speed, head technology, and recording technology. Research groups within disk drive firms report increasing storage capacity as the key challenge and focus of their technological activities. Figure 1 shows the rapid technological evolution in the industry over the years, within and across diameters. The diameter-specific curves represent the highest density drive produced in the industry within each diameter in a given year and thus the technology frontier specific to the particular diameter. The highest-areal-density curve represents the highest density drive produced in the industry in a particular year across all diameters. Both 14-inch and 8-inch diameters experienced a withdrawal from the market 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 was overshadowed by that of the 5.25-inch drive in 1987, which in turn was overtaken by the 3.5-inch in 1988, and the 2.5-inch in 1997.

[Insert Figure 1 here]

Types of Entrants in the Disk Drive Industry

In response to profit opportunities from such rapid technological dynamism and market growth, net market entry occurred for the first ten years of the period studied, followed by an industry shake-out in 1986. In addition to the 39 incumbents that entered between 1973 and 1976, there were 153 new entrants in the post-1977 period. Using the general definitions from Helfat and Lieberman (2002), entrants in the disk drive industry can be grouped into four different categories. Spin-outs, the first group of entrants, represent an important mechanism of

knowledge diffusion and technology transfer in this industry. We operationalized spin-outs as firms that were started by founders who were ex-employees of an incumbent firm in the year prior to the firm's formation. There were 40 spin-outs, constituting approximately 25% of all entrants in the period studied.[6] 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 founded spin-outs. The founders of the spin-outs were all senior-level employees of the parent firms with several years of industry experience. Seventy two percent 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 engineering or operational experience.

Incumbent-backed entrants, the second entrant group, are firms that were affiliated with an incumbent firm in the disk-drive industry, including subsidiaries, parent-sponsored ventures, and joint ventures. Diversifying entrants, the third entrant group, are firms that existed in some other industry prior to entering the disk drive industry. The final group, which is our control group, is non-spin-out, de novo entrants. These firms were ascertained to have no direct connection to the industry and were not diversifying entrants.

Operationalization of Constructs

For conciseness and ease of exposition, Table 1 provides information on variables included in the study (along with control variables), their measurement, and the rationale behind their inclusion. Descriptive statistics and correlation matrix are presented in Table 2. Operationalization of technological and market pioneering know-how variables are below.

[Insert Tables 1 & 2 here]

Technological Know-how: We measured a firm's technological capabilities, based on areal density, as the average of the firm's diameter-specific relative technological position across all

[6] Our definition of spin-outs is conservative—while there are 40 spin-outs based on our definition in the dataset, there are six additional firms that were started by former employees who had more than a year lapse between leaving an incumbent and founding the start-up. As detailed later, we conducted checks to ensure that the results regarding entrant characteristics and performance are robust to alternative definitions.

the diameters it produced in a particular year using the following two step procedure.[7] We first divided the areal density (A) of the best drive produced by a firm i in a given diameter j in a particular year t by the highest areal density in that diameter available in the market that year to obtain the firm's diameter-specific relative technological position (TK_{ijt}):

$$TK_{ijt} = \frac{A_{ijt}}{\max(A_{ijt})} \quad (1)$$

We then averaged this measure across all diameters (j = 1 to n) produced by the firm in a year to obtain a measure of the firm's average relative technological know-how (TK_{it}) in that year:

$$TK_{it} = \frac{\sum_{j} TK_{ijt}}{\sum j} \quad (2)$$

Measuring a firm's technological capabilities in comparison with 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. We focused 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 competed in more than one diameter with the other firms in the market, and we were interested in capturing its technological know-how across its product lines. Thus, the firm that is at the frontier in all diameters it produces will have technological know-how equal to one, a firm that is behind the frontier in any one diameter will have technological know-how less than one. This is a conservative measure in that firms that produce only older diameters will benefit from other firms dropping those older diameters, while firms that produce a wider range of diameters will have lower technological know-how because of higher competition in the newer diameters.

Market Pioneering Know-how: The five new diameter introductions created new submarkets, and we used these architectural innovations as the basis of our market pioneering know-how measure. The market pioneering know-how variable captures the early-mover know-how associated with bringing an innovation to market. Our operationalization of market pioneering is

[7] We note that while areal density is the best overall measure, it may not capture particular features when dealing with highly specialized hard drives (e.g., for VCRs). This may create underexploited business opportunities that may also give rise to spin-outs. We are grateful to an anonymous reviewer's insight on the issue.

broader than Golder and Tellis's measure (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. It is dynamic, however, because it recognizes the multiple market pioneering opportunities represented by the creation of submarkets, as opposed to only the opportunity of introducing the first (14-inch) diameter. As a result, our measure of the market pioneering know-how of a firm varies over time and across firms. We measured 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 industry divided by the total number of new diameter introductions in the industry since the year of entry for the firm. Mathematically, this implies that:

$$MPK_{it} = \begin{cases} \dfrac{\sum_{t=E_i}^{T} P_{it}}{\sum_{t=E_i}^{T} D_t} & \text{if } \sum_{t=E_i}^{T} D_t > 0 \\ 0 & \text{if } \sum_{t=E_i}^{T} D_t = 0 \end{cases} \qquad (3)$$

where E_i is the year of entry of the i^{th} firm, T is the current year of operation, P_{it} is a dummy variable that indicates whether the firm was an early mover when a new diameter was introduced ($P_{it} = 1$ if the firm was an early mover, and 0 otherwise), and D_t is a dummy variable that indicates whether there was a diameter introduction during that year ($D_t = 1$ if a diameter was introduced, and 0 otherwise). 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.[8] For firms that entered between two consecutive diameter introductions, the market pioneering know-how variable takes the value of zero until the year of the next diameter introduction. Treating the variable as

[8] As an example, consider a hypothetical firm X that entered the industry in 1979 producing a 8-inch drive, started production of the 5.25-inch drive in 1981 and of the 3.75-inch drive in 1983 and exited in 1987. Since 1979 was the first year that the 8-inch drive was produced, and firm X was an early mover in that diameter, its market pioneering know-how variable value in 1979 is 1. In 1980, the first year in which the 5.25-inch drive was produced, since the firm did not enter the submarket in its first year, the variable value for firm X is updated to become 0.5. This value remains unchanged until 1983, the year of the next diameter's introduction. Since firm X is an early mover in the 3.75-inch drive, the variable value is updated to become 0.67 and remains unchanged until the firm exits in 1987, as the next diameter introduction occurred in 1988.

missing for these firm-years did not change the results. Consistent with most of the work on first-mover advantages, we assumed no depreciation of market pioneering know-how. 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 (the number of times that the firm *did not* pioneer a diameter, divided by the number of new diameter introductions since year of firm entry), and an ordinal rank measure of market pioneering. All such operationalizations yielded similar substantive results.

Estimation Methodology

Hypotheses 1 and 2 relate to the probability of a firm generating a spin-out in a given year. We used all firm-year observations in the sample, since every firm is a potential parent in any given year. While there are several models available to analyze this phenomenon, we used hazard rate methodology to account for the fact that each firm is represented more than once in a data structure that includes firm-year as a unit of observation. The results are robust to alternative model specifications.[9] 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.[10]

Hypothesis 3, pertaining to spin-outs' knowledge was tested by restricting the sample to firm-year observations for only spin-out firms. Since our operationalization of spin-outs requires the firm to be founded within one year of the founder leaving the parent organization, we were able to use the parent's technological and market pioneering know-how in the year prior to the spin-out's entry in the hypotheses testing the inheritance of knowledge. The chief independent variables of interest - parent technological and market pioneering know-how - are time invariant,

[9] Since our dependent variable in H_1 and H_2 can also be considered as a count of spin-outs generated, we tested the hypotheses using random effect Poisson and negative binomial models and the results are available on request.

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

and the analyses tested their effect on the spin-out's technological know-how and market pioneering know-how over the spin-out's life span to check for long-term effects. To control for the effect of time, both entry-year dummies and spin-out age were included in the model. We tested hypothesis 4 for differences between spin-out and non-spin-out entrants' characteristics by including the firm-year observations of all entering firms.[11] For both hypotheses H3 and H4, seemingly unrelated regression models (SUR) were used to account for potential correlations of the errors across the technological and market pioneering know-how equations. Due to the complexity of the error variance-covariance matrix when both cross-equation and autocorrelation constraints are introduced, existing commercial software packages do not accommodate panel-based SUR models, the ideal model 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 were 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 & Thompson, 1997).[12] Finally, to test for differences between spin-out and non-spin-out entrant survival, we restricted the sample to all entrants. We used hazard rate methodology for the analysis of survival probabilities. To ensure the robustness of the results, we estimated additional model specifications, which included probit, logistic, and Cox proportional hazards models. The results were very similar across the different model specifications.

RESULTS

Hypotheses 1 and 2 relate incumbent firm know-how to spin-out generation. Accordingly, the observations pertain to a firm being a potential parent in every single year after its entry, or

[11] This restriction caused us to exclude firms that entered prior to 1976, since we lacked information on their founding characteristics.

[12] We conducted robustness checks to ensure the appropriateness of the distributional assumptions by testing the hypotheses using a logistic regression and conducting a SUR estimation of the logistic transformation of the dependent variable. The results are robust to these alternative specifications and are available on request.

after 1976 for firms that entered prior to this date.[13] The results of the tests of hypotheses 1 and 2 are shown in Table 3. Since H_2 proposed a contingent relationship, and the evaluation of main effects changes in the presence of an interaction term (Aiken & West, 1991), we estimated the model in two stages. In stage 1, as reported in model I, the main effects of technological know-how and market pioneering know-how on spin-out generation, along with control variables, are entered. In stage 2, as shown in model II, we enter and estimate the multiplicative interaction term between technological know-how and market pioneering know-how.

[Insert Table 3 here]

Results from models I and II reveal that the probability of generating a spin-out in the following period is positively related to the main effects of technological know-how and market pioneering know-how of the firm in the previous year, supporting H1. Among the firm-specific control variables, age of the firm does not affect the likelihood of spin-out generation, while larger-sized 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, as measured by the number of firms in the industry. Model II shows that the interaction between the two types of know-how has a negative impact on the probability of generating a spin-out, thereby supporting H_2. Thus, our results strongly support each of the first two hypotheses.

Table 4 presents test results for H_3, which relate the spin-out's know-how levels over its life-time to the know-how levels of the parent firm in the year prior to the spin-out's formation. Using firm-year observations pertaining to spin-out firms, models I (technological know-how) and II (market pioneering know-how) report results related to the impact of parents' know-how on the know-how of their spin-outs. Results show that the parent's technological and market pioneering know-how measured in the year preceding spin-out entry is strongly significant in predicting a spin-out's technological and market pioneering know-how, respectively, thereby

[13] Since only one foreign firm generated a spin-out, the foreign-firm dummy was not included in this analysis.

supporting H_3. Among the control variables, age of the spin-out controls for the effect of time. Both the linear and quadratic terms of age are significant in each equation, though they have opposite signs.[14] Spin-out firm sales is positively related to its market pioneering know-how, but not its technological know-how. Among the industry control variables, only industry sales matters in model II, indicating that higher contemporaneous industry sales are associated with lower levels of market pioneering know-how of spin-outs.

[Insert Table 4 here]

Table 5 reports the results for hypothesis H_4 using all firm-year observations for the post-1977 entrants in the industry. Models I and II report the effects of the three types of entrants, spin-outs, incumbent-backed entrants, and diversifying entrants, on the technological and market pioneering know-how, respectively. Non-spin-out *de novo* entrants are the control group. Model I shows that spin-outs, along with incumbent-backed entrants, have a higher level of technological know-how than the control group. The coefficient of diversifying entrants is negative and significant, indicating that the technological know-how of diversifying entrants is lower than the control group. Model II reveals that spin-outs possess higher levels of market pioneering know-how than the control group. The coefficient of incumbent-backed entrants is not significant, but the coefficient of diversifying entrants is once again negative and significant. Together, these results indicate that spin-out firms have higher know-how levels than both diversifying entrants and the non-spin-out *de novo* entrants, thereby supporting H_4.[15] Among the control variables, 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 has significant non linear effects on market pioneering know-how.[16] Also, industry sales have a negative relationship with the market pioneering know-how of entrants.

[14] To ascertain that the effect of parental know-how on spin-outs persisted over time, particularly given the non-linear main effects of age, we estimated age interactions with parent know-how. The results, available on request, indicate that the effects of parent know-how on the spin-out's is sustained over the life-span of the spin-outs.
[15] The results are robust to tests that include the six firms founded by former employees more than one year after they left an incumbent organization in the spin-out category, or exclude them from the sample altogether.
[16] Results from including spin-out and age interactions confirm that spin-outs maintain a higher level of know-how over time vis-à-vis other entrants, and are available on request.

[Insert Table 5 here]

Table 6 reports the results from the hazard rate analysis and shows that spin-outs have a higher probability of survival relative to all other types of entrants, thereby supporting H_5.[17] Higher technological know-how also increases the probability of survival, but market pioneering know-how does not appear to affect the probability of survival. As would be expected, firm sales is positively related to 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

Research suggests that the origin of new firms may explain heterogeneity in their capabilities and performance. Explanations of where new entrants come from, and how they acquire their initial stock of knowledge are thus issues that are central to organization scholars. In this context, although it has been noted that the pre-entry experience and employment affiliation of founders fashions a new de novo venture's resources and capabilities, our theoretical and empirical understanding of such firms is limited. The gap is especially pronounced for spin-outs, or entrepreneurial ventures founded by former employees of incumbent firms. A particularly innovative and powerful form of new entrant, spin-outs have been eulogized as 'paragons of innovation' as well as criticized for being 'rapacious plunderers' of their parent's innovations (Klepper, 2001). However, other than some early research that has noted the proclivity of some organizations to be breeding grounds for start-ups, and various theoretical pronouncements about the transfer of knowledge from parent to progeny firms, there is little scientific evidence surrounding spin-out formation, knowledge inheritance, and

[17] As before, the results are robust across sensitivity tests regarding the firms founded by former employees more than one year after they left the incumbent organization.

performance. Adopting a knowledge perspective, we focused on two kinds of knowledge, technological and market pioneering know-how, to analyze how knowledge levels of incumbent firms affect the likelihood of generating spin-outs (hypotheses 1 and 2), how parents' knowledge levels at time of spin-out inception affect the spin-outs' knowledge levels (hypothesis 3), and, as a result, whether spin-outs differ from other entrants in their the knowledge levels (hypothesis 4) and their survival chances (hypothesis 5).

With respect to the hypotheses on spin-out generation, the results of this research suggest that organizations that have abundant, underexploited knowledge are fertile grounds for spin-out formation. An imbalance in an organization's focus on value creation and value appropriation increases its likelihood of generating spin-outs. Anecdotal evidence from Christensen (1997) showed that Conner Peripherals was founded by disaffected employees who left Seagate and Miniscribe, the two largest 5.25 inch manufacturers, when the incumbent firms developed the 3.5-inch drive but chose not to market it. Similarly, the founder of the 8-inch drive, Micropolis, came from Pertec, a 14-inch drive manufacturer. Incumbent firms, however, appear to have retained their employees by proactively investing in both technological and market pioneering know-how. For example, Quantum and Control Data created subsidiaries that targeted emerging segments to prevent spin-out formation. Another case in point is Micropolis, itself a spin-out and an early mover, which successfully made the transition to a disruptive platform by managing the change from within the existing organization, and succeeding in retaining its employees. This supports the idea that while an abundance of underutilized knowledge can cause spin-outs, their formation is dissuaded when a firm puts its knowledge to good use. Our findings also indicate that while larger firms are more likely to generate spin-outs, presence in a large number of market segments lower chances of spin-out formation. Thus, a larger product scope may guard against spin-out formation. The non-significant effects of age indicate that spin-out generation is not related to organizational age.

In support of the notion that knowledge may be inherited, we found that parental knowledge levels at the time of spin-out formation positively affect spin-outs' knowledge levels.

For instance, all but one of the new diameters were introduced by a spin-out, even though the technology had been developed by the parent. Also, progenies of smarter parents appear to have higher knowledge levels. Only four of the 40 spin-outs had lower technical know-how measure than their parents, contrasted with 16 high technology spin-outs spawned from parents with high technical know-how. Thirty-three percent of spin-outs whose parents were market pioneers were market pioneers themselves; while non-market pioneering parents resulted in only 6.8 percent of spin-outs that were market pioneers. Further, our results support the notion that direct links to industry knowledge through founders facilitates the integration of this knowledge, as compared to grafting knowledge through hiring employees with industry experience. Given that incumbent-backed ventures have similar direct access to knowledge, we had not formally hypothesized any advantage in knowledge capabilities of spin-outs with respect to this group. The results are mixed on the two dimensions of knowledge capabilities. While incumbent-backed ventures, like spin-outs, have higher levels of technological know-how, they do not have similar higher levels of market pioneering know-how. In terms of a key performance dimension, we found 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 incumbent-backed ventures to either gain market pioneering know-how, or more importantly, have higher probabilities of survival. These findings seem to indicate that incumbent-backed ventures may potentially be subject to certain disadvantages due to initial or continued parental involvement. This further highlights the importance of entrepreneurial flexibility. Finally, while not a hypothesized relationship, the insignificance of market pioneering in explaining survival suggests that by itself, pioneering may not lead to sustained advantages.

Limitations and Future Research

Our study's limitations also provide exciting areas for future research. First, we should be careful about over-generalizing the findings from a single industry, and future research could investigate the extent to which our framework holds in other industries. Second, our measure of

firm size relies on disk drive sales rather than number of employees.[18] While literature suggests that these alternative measures of firm size are highly correlated and thereby yield similar results (Chandy and Tellis, 2000), a fact also true in our sub-sample of all publicly traded disk drive firms, the use of sales rather than employees is a limitation of our study given its focus on human capital and entrepreneurial motives. Third, while we establish a relationship between parental and progeny knowledge, we are unable to unravel endowment and learning effects, and whether spin-outs learn faster and better than other entrants, or whether non-spin-out entrants can ever play "catch-up." This is important given that over time, a firm may lose its position relative to the technological frontier, even though it may have entered with cutting edge knowledge (Bahk & Gort, 1993; Jovanovic & Nyarko, 1996). Moreover, 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.

Fourth, our data precluded finer grained analysis on founders. There are exciting questions related to founder characteristics, and their specific experiences as employees, that may 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 that there were no formal ties between parents and progenies, we were however unable to ascertain the absence or presence of informal ties. Fifth, data limitations necessitated pooling several different forms of incumbent-backed entrants together. Therefore, care must be taken in the interpretation of the results related to incumbent-

[18]Employee data are not available for the smaller or private firms, so including the number of employees in the analysis would restrict the sample to the larger and public firms, causing problems of selection bias

backed ventures. It would be particularly important for future research to identify those instances of incumbent-backed ventures that were created to encourage "intrapreneurship" and deter spin-out formation and gauge their performance consequences. Finally, although survival studies assume equivalency between survival and economic performance, there is evidence that due to varying performance thresholds, some under-performing firms persist whereas some proactive exit occurs without pressures of economic dissolution (Gimeno et al., 1997). Our study therefore suffers from a limitation that is endemic to most survival studies.

Theoretical Contributions

In providing an explicit theoretical model and empirical evidence relating knowledge capabilities and their inheritance to the spin-out phenomenon, our paper is related to and builds on a number of theoretical streams of research. First, distinct from the economic and sociological literature on knowledge diffusion and inter-organizational mobility of managers, we develop a strategic management view of knowledge spillovers on new venture formation and performance. While the economic literature focuses on R&D under-investment that occurs due to knowledge spillovers from employee mobility (e.g., Moen, 2001; Zucker, Darby and Brewer, 1998), the sociological approach investigates knowledge diffusion and the interorganizational social structure created by executive migration (e.g., Aldrich and Pfeffer, 1976; Boeker, 1997). With the exception of some recent research (Burton, et al., 2002; Gunz & Jalland, 1996; Higgins & Gulati, 2003; Shane & Khurana, 1999), the focus of extant research has predominantly been on large, incumbent organizations, and consequently, new ventures have been ignored. We address this theoretical shortcoming.

Second, while early work indicates that spin-outs may be triggered by organizational crisis, change in leadership, and lack of upward mobility for employees (Garvin 1983; Brittain and Freeman 1986), there is little systematic evidence for why some incumbents tend to be "entrepreneurial hotbeds" (Burton, et al., 2002). For example, Braun and MacDonald (1978) noted that Fairchild spawned ten new ventures in its first eight years, while others produced relatively few, if any. Some have speculated, based on anecdotal evidence, that not only are

knowledge-intensive industries more conducive to spin-out formation, but knowledge conditions internal to the firm may also have a bearing on employee's entrepreneurship (Brittain & Freeman, 1986; Garvin, 1983). Our study provides a formal theory to shed light on the phenomenon, and systematically links human capital and knowledge capabilities to new venture formation.

Third, we contribute to the ongoing debate surrounding the identity of the fields of entrepreneurship and strategic management.[19] Recent controversy over what makes the field of entrepreneurship distinct from strategic management relates to their relative focus on value creation versus value appropriation (Shane & Venkataraman, 2000; Zahra & Dess, 2001). Arguing for an integration of entrepreneurship and strategic management on the basis of wealth creation being at the heart of both, Hitt at el. (2001) advanced the notion of "strategic entrepreneurship." Our work highlights this aspect, since we found evidence that firms need to strategically accomplish a syncretic balance between value creation and appropriation (Moran & Ghoshal, 1999). Failing to do so would result in pockets of underexploited knowledge, which may be deleterious to a firm by enhancing 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. In showing empirical support for the ideas noted above, we advocate the view that the organization of capabilities may be as important a source of performance heterogeneity as the capabilities themselves (Leiponen, 2003). Thus, a managerial implication of our study is that rather than resigning themselves to the notion that knowledge is a double-edged sword that results in competition from within, managers can orient strategies toward both value creation and appropriation and thus limit potential competition.

Fourth, in terms of the literature on organizational learning, we provide evidence of genealogical links between parent and progeny organizations. Our study is among the first to substantiate empirically the theoretical claim that knowledge is inherited from a parent by

[19] We appreciate the insights provided by an anonymous reviewer in articulating this thought.

progeny. We thus add to the growing literature in entrepreneurship relating to initial endowments. In addition to social capital, employee entrepreneurs also benefit from the knowledge they acquire while working with an incumbent firm. Further, we found that the directness of knowledge transfer through founders results in a higher level of integration of knowledge for effective use relative to knowledge that might be transferred by hiring industry incumbent employees. Taken together, the implication for aspiring entrepreneurs is that apprenticing with leading incumbent firms may be an important route to accumulate human capital that is specific to the industry within which they wish to establish new ventures.

Finally, 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 studies have typically compared diversifying and *de novo* entrants and argued 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 alio* entrants (Carroll et. al., 1996; Klepper & Simons, 2000). Very little has been said about the advantages that enable *de novo* entrants to compete successfully, other than their flexibility (Tushman & Anderson, 1986). By distinguishing between four types of entrants and comparing spin-outs with other *de-novo* entrants, diversifying entrants, and incumbent-backed entrants (Helfat & Lieberman, 2002), we investigated how some *de novo* firms benefit from both the advantage of entrepreneurial origin and an additional undiscovered source, inherited knowledge. Our findings indicate that ex-employees who engage in entrepreneurship to exploit knowledge learned while working with an incumbent firm have a sustainable source of competitive advantage.

Figure 1: Areal Density of Drives by Diameter

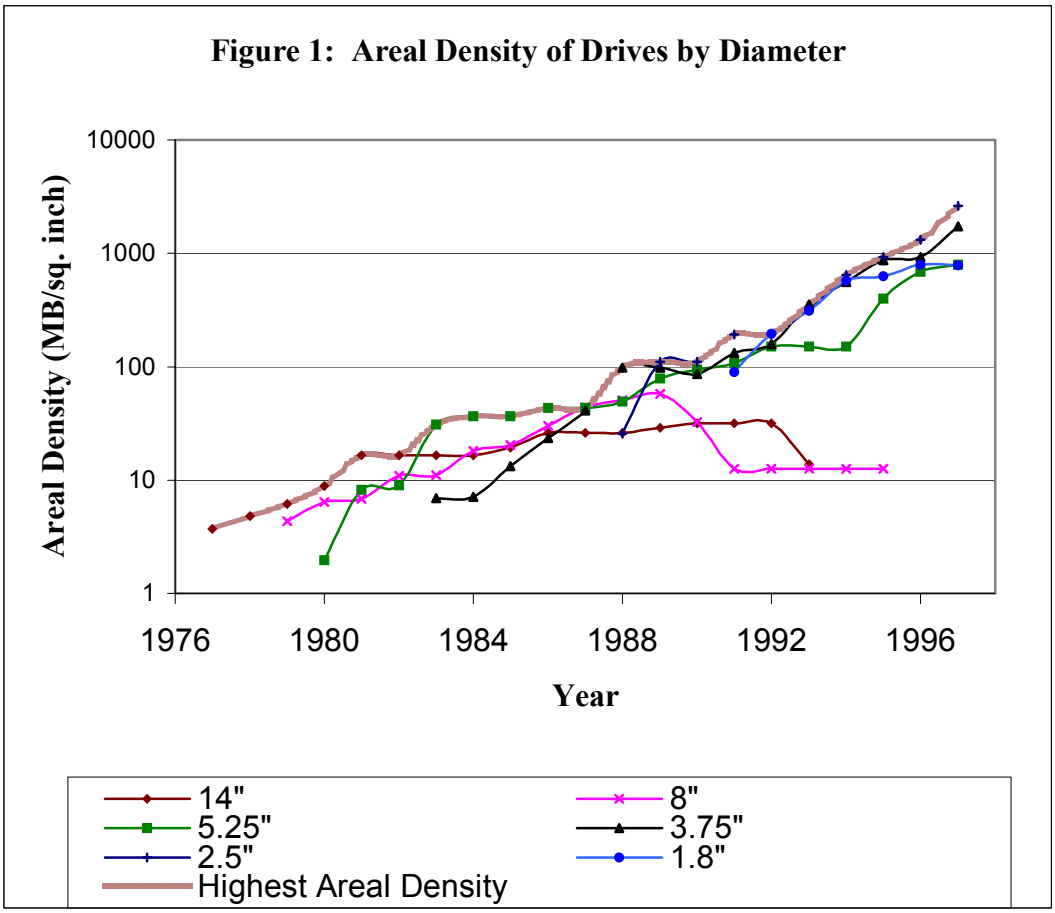

Table 1: Definition of Variables and Rationale

Variable Name	Variable Description	Rationale
Key Variables in Study		
Spin-out Creation	Dummy = 1 if a spin-out was 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 and H2.
Survival	Dummy = 1 if a firm survived to the following year (acquisitions treated as censored observations)	Dependent variable for H5.
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 H1, H2 and H5; dependent variable for H3 and H4.
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 new diameter introductions in industry since firm entry	Measures the early-mover advantage of the firm Explanatory variable for H1 and H2 and H5; dependent variable for H3 and H4.
Parent Tech. Know-how	Technological know-how (as measured above) of the parent in the year preceding the spin-out's entry into the industry.	Measures parent firm technological know-how. Explanatory variable for H3 and H4.
Parent Mkt. Pion. Know-how	Market pioneering know-how (as measured above) of the parent in the year preceding the spin-out's entry into the industry.	Measures parent firm market pioneering capabilities. Explanatory variable for H3 and H4.
Spin-out	Dummy = 1 if at least one of the founders of a firm was an ex-employee of an incumbent firm in the year prior to its formation.	Entrepreneurial ventures by ex-employees are different from other types of entry and represent technological transfer. Explanatory variable for H4 and H5.
Firm-specific Control Variables		
Incumbent-backed entrant	Dummy = 1 if the firm was affiliated with an incumbent firm in the disk-drive industry (e.g., subsidiary, parent backing, joint venture).	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 Sales	Logged value of all disk-drive sales of the firm per year, in millions of dollars.	Larger firms may generate more spin-outs, and firm sales is our proxy for number of employees
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 testing hypotheses H1-H3 which pertain to spin-out formation/inheritance from parents.	Foreign firms may be different from U.S. for institutional reasons.
Age, Age^2	Chronological age of firm since founding.	Spin-out generation/inheritance/survival affected non-linearly by firm age.
Parent Presence	A dummy variable if parent was present in the diameter market in which the spin-out first entered.	Measures the impact of the parent's presence on 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 (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.	Represents possible extent of churn in the industry.
Chronology Specific Control Variables		
Y78-Y97	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	21
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 Incumbent backed Entrant	0.03	0.18	-0.03	-0.06	0.03	-0.06	-0.08	-0.06	-0.12	1.00													
9 Diversifying Entrant	0.18	0.38	-0.04	0.04	0.03	-0.03	-0.20	0.03	-0.29	-0.01	1.00												
10 Foreign Entrant	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 Firm 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 Sales	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 Density in Industry	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	1.00

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

Variable	Model I	Model II
Intercept	-35.803	-41.464
	(24.046)	(24.873)
Technological Know-how	2.492**	3.715**
	(0.862)	(1.057)
Market Pioneering Know-how	1.592**	3.589**
	(0.536)	(1.095)
Technological Know-how * Market Pioneering Know-how	---	-3.835*
		(1.941)
Firm Age	-0.162	-0.175
	(0.175)	(0.176)
Firm Age ^{2}	0.002	0.003
	(0.006)	(0.006)
Firm Sales	0.510**	0.466**
	(0.161)	(0.162)
Industry Sales	0.566	0.672
	(1.472)	(1.504)
Firm Growth	0.146	0.201
	(0.394)	(0.385)
Industry Growth	-2.729	-2.515
	(2.821)	(2.782)
Highest Areal Density in Industry	-0.016	-0.016
	(0.015)	(0.015)
Product Diversity of Firm	-0.528*	-0.602*
	(0.289)	(0.283)
Incumbent 76 Dummy	-0.589	-0.489
	(0.729)	(0.747)
Number of Firms	0.844*	0.945**
	(0.363)	(0.375)
Number of Firms ^{2}	-0.006**	-0.007**
	(0.002)	(0.003)
Number of Entrants	-0.031	-0.018
	(0.078)	(0.079)
Number of Observations	1180	1180
Log Likelihood	-85.984	-83.974

Standard errors are in parentheses; **Significant at the 5% level; * Significant at the 10% level.

Table 4: Seemingly Unrelated Regression Results for Inheritance of Knowledge

VARIABLE	Model I Spin-out Tech Know-how	Model II Spin-out Market Pion. Know-how
Intercept	-0.137	2.348**
	(0.675)	(1.124)
Parent Technological Know-how (in year prior to spin-out inception)	0.148**	---
	(0.045)	
Parent Market Pioneering Know-how (in year prior to spin-out inception)	---	0.106**
		(0.044)
Spin-out Age	-0.035**	0.044**
	(0.009)	(0.015)
Spin-out Age^2	0.002**	-0.002**
	(0.0005)	(0.0009)
Spin-out Firm Sales	-0.001	0.003*
	(0.001)	(0.001)
Industry Sales	0.059	-0.131**
	(0.038)	(0.063)
Industry Growth	0.090	0.042
	(0.148)	(0.131)
Highest Areal Density in Industry	-0.0002*	0.00006
	(0.0001)	(0.0002)
Number of Firms	-0.003	-0.009
	(0.009)	(0.016)
Number of Firms^2	0.0001	0.0001
	(0.0007)	(0.0001)
Number of Entrants	0.000001	-0.003
	(0.004)	(0.007)
Number of Observations	344	344
System R^2	0.28	0.28

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

Table 5: Seemingly Unrelated Regression Results for Technological and Market Pioneering Know-how of Entrants

Variables	**Model I Tech Know-how**	**Model II Market Pion. Know-how**
Intercept	0.704	2.636
	(0.462)	(0.674)
Spin-out	0.137**	0.165**
	(0.021)	(0.030)
Incumbent-backed Entrant	0.129**	0.048
	(0.045)	(0.066)
Diversifying Entrant	-0.127**	-0.108**
	(0.034)	(0.050)
Foreign	-0.033	0.143**
	(0.023)	(0.034)
Firm Age	-0.004	0.058**
	(0.006)	(0.009)
Firm Age^2	0.0004	-0.003**
	(0.0004)	(0.0006)
Firm Sales	-0.00005	0.0003
	(0.0006)	(0.001)
Industry Sales	-0.015	-0.157**
	(0.027)	(0.039)
Industry Growth	-0.059	0.040
	(0.109)	(0.159)
Highest Areal Density in Industry	-0.00001	0.000001
	(0.00004)	(0.0001)
Number of firms	-0.001	-0.008
	(0.007)	(0.010)
Number of firms^2	0.000004	0.0001
	(0.00005)	(0.00008)
Number of Entrants	0.0006	-0.0007
	(0.003)	(0.005)
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 but not reported.

Table 6: Probability of Survival of Entrants

Variable	Model
Intercept	28.627**
	(12.945)
Spin-out	0.70**
	(0.309)
Incumbent-backed Entrant	-0.671
	(0.523)
Diversifying Entrant	-0.103
	(0.428)
Technological Know-how	0.839**
	(0.420)
Market Pioneering Know-how	-0.198
	(0.350)
Foreign Firm	0.397
	(0.279)
Firm Age	-0.108
	(0.164)
Firm Age^2	0.013*
	(0.007)
Firm Sales	0.047**
	(0.008)
Parent Presence in Diameter of Entry	0.72
	(0.48)
Highest Areal Density in Industry	0.003**
	(0.001)
Industry Sales	-2.344**
	(0.894)
Industry Growth	-0.886
	(1.466)
Number of firms	0.321**
	(0.089)
Number of firms^2	-0.002**
	(0.0006)
Number of Entrants	-0.046
	(0.043)
Number of observations	767
Log likelihood	-261.43

Standard errors are in parentheses; **Significant at the 5% level; * Significant at the 10% level

Year of entry dummies included but not reported

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