

## **Knowledge Transfer Through Congenital Learning: Spin-out Generation, Growth and Survival**

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## **ABSTRACT**

This paper examines the parent-progeny knowledge transfer relationship, and the impact of this congenital knowledge on the evolution and performance of a spin-out. We define a spin-out as an entrepreneurial venture founded by an employee of an incumbent firm. Using data from the disk drive industry spanning the years 1977-1997, we show that incumbent knowledge capabilities, related to technology and market pioneering, predict spin-out formation. Further, we predict and find that co-existence of these two capabilities *reduce* the probability of employees venturing out. We find that as a group, spin-outs are technologically superior to other forms of entrants, and that their knowledge capabilities are directly related to their congenital learning from parent's capabilities at the time of their founding. Finally, we show that due to a knowledge-based advantage, spin-outs have higher probabilities of survival.

*“No amount of legal protection can make a thoroughly appropriable commodity of something as intangible as information” (Kenneth Arrow, 1962)*

An emergent theme in the strategy literature relates privately held, tacit knowledge to competitive advantage, and makes a case that the resource-based view of a firm necessarily entails a knowledge-based perspective (Connor and Prahalad 1996). Assuming a dynamic process, sustained performance is linked to the ability of a firm to accumulate, and manipulate knowledge flows (Eisenhardt and Martin 2000; Dierickx and Cool 1989; Teece, Pisano and Schuen 1997; Grant 1996). Implied, thus, is the importance of learning in the sustained ability of a firm to integrate, build, and reconfigure technological and market related competencies to address rapidly changing environments (Teece, Pisano, and Schuen 1997). The empirical learning literature has typically focused on the performance implications of experiential and vicarious learning. However, Huber (1991) notes that organizations do not start with clean slates with respect to knowledge, and that they possess congenital knowledge as a result of founders employing various means to learn on behalf of the embryonic organization, and bringing in critical knowledge at the time of founding.

This initial stock of knowledge assumes criticality in the context of future learning. Starting with a ‘good model’ (Ingram and Baum 1997) can result in sustained inter-firm variance in performance (Cyert, Kumar and Williams 1993), given that “what an organization knows at its birth will determine what it searches for, what it experiences, and how it interprets what it encounters” (Huber 1991, p. 91). The argument that organizations often times emerge from other organizations, and that they are set on a course at founding (Stinchcombe 1965) implies that an organization’s learning trajectory, process of capability accumulation and mobilization over time, and therefore its long run performance and survival, are all inextricably linked to its

learning at the time of founding, or congenital knowledge. However, as Huber (1991) notes, there is a lack of empirical research on this issue.

The issue of congenital knowledge bears a close parallel to a stream in the organizational ecology literature that studies the transfer of rules, routines, and resources from parents to progeny organizations (Brittain and Freeman 1980; Hannan and Freeman 1986; Romanelli 1989), and posits that some degree of organizational blueprint is transferred through the career experiences of the progeny's founders very much like the reproduction and transmission of biological genes (Winter 1991). Further, the unique insights and decision rules firms use to transform resources into action (Prahalad and Bettis 1986), along with cognitive dimensions of competency (Fiol 1991) may also be transferred from parent to progeny by founders. Accordingly, founders may carry with them not only specific knowledge and information accrued in their previous position (Boeker 1997), but also decision-making and operational routines and related management memes that constitute a firm's competitive rationality (Dickson 1992).

In this paper, we focus on how congenital knowledge impacts the evolutionary process of a spin-out, which we define as an entrepreneurial venture founded by an employee of an incumbent firm. Innovation is usually the impetus behind their formation. Spin-outs are typically founded by knowledge-rich research engineers with support of venture capitalists, implying that they represent a particularly important agent of market evolution (Garvin 1983). Further, the reluctance of incumbents to introduce new products and services in order to protect the status quo and maintain their leadership and avoid cannibalizing their sales has been noted. Spin-outs often result when frustrated employees leave an incumbent organization that is unwilling to introduce an innovation, or take advantage of emerging market and technological opportunities

(Christensen 1993, 1997). Therefore, being agents that can successfully imitate incumbent knowledge and bring it into the market place, spin-outs have social welfare implications (Franco and Filson 2000).

In spite of their being agents of change that restructure a market's population and competitive characteristics, our understanding of spin-outs are limited. Although various factors such as human capital, stage of the industry cycle (Garvin 1983), an employee's job prospects in their current position, and firm know-how have been related to spin-out formation (Brittain and Freeman (1986), there is a void in our understanding of how 'basically new forms of organizations' are created (Singh and Lumsden 1991). Despite the prominence of spin-outs in industries such as semiconductors (Braun and Macdonald 1978; Malone 1985), disk drives (Chesbrough 1999; Christensen 1993), and more recently in information technology related new economy firms (Propson 2000), we know little about the types of firms that spawn them (Klepper and Sleeper 2000).

Secondly, as noted by Phillips (2000), there has been little systematic investigation of the consequences of congenital knowledge transfer from parent firms to their off-springs. Important questions arise regarding the sustainability of knowledge advantages over the life cycle of a spin-out. Given that much of the technological and marketing know-how may be tacit implies that they are difficult to transfer or imitate (Connor and Prahalad 1996). Also, even though an entrant may begin with a certain level of knowledge appropriated from its parents, it may find it difficult to sustain the rapid accumulation of such capabilities due to resource and learning constraints. Therefore, it is intriguing to investigate whether knowledge advantages at the time of founding, made possible through congenital learning, are sustainable over time and have implications on a firm's long-run survival.

In undertaking this inquiry, we argue that it is a combination of inside-out and outside-in knowledge-based capabilities that lead to competitive advantage (Day 1994; Moorman and Slotegraaf 1999). While inside-out capabilities relate to technological know-how, outside-in capabilities relate to an organization's ability to undertake advantage of market making opportunities. We relate these two capabilities to the main themes in this paper, namely an inquiry into the phenomena surrounding the birth of spin-outs, the process of their growth, and survival. The rest of this paper is laid out as follows. First, we develop the theoretical framework and develop our hypotheses. Next, we discuss the industry setting in which we test our model. Then we operationalize relevant variables, and discuss our empirical testing approach. Subsequently, we test our models, and report our results. Finally, we discuss the implications of our findings.

## **THEORETICAL FRAMEWORK**

We organize our genealogical framework along two themes. In theme 1, we link parent traits to the incidence of spin-out formation. Theme 2 explores the issue of spin-out evolution and performance. We distinguish between spin-out and non spin-out entrants vis-à-vis their technological know-how and evolution, and examine one of the most common outcomes of interest within organizational ecology, industrial economics and technology management – namely organizational mortality. As mentioned earlier, although we account for alternate explanations in our model testing, our focus is primarily driven by a strategic, resource-based view that focuses on knowledge-based capabilities, namely technological and market pioneering know-how.

## **THEME 1: Spin-Out Formation**

### **Technological Know-How**

Organizational environments that are munificent in scientific know-how are likely to be fertile breeding grounds for entrepreneurial ventures. Garvin (1983) notes that spin-out formation is more likely to occur from environments where exploitable knowledge is embodied in human capital, as against physical capital. Franco and Filson (2000) develop a theoretical model that shows employees are more likely to leave organizations that possess high levels of technical know-how to start up their own firms.

Scientific knowledge generated in a firm is typically tacit, developed over time, and carried within the knowledge structures of specialist personnel. Thus, the scientific know-how of a firm's researchers is likely to be higher if the firm itself is operating close to the technological frontier. Further, advancements in scientific capabilities imply market opportunities. So, chances that employees create new knowledge that is not adopted by the incumbent organization are higher when the technological ferment in the firm increases. Hence, frustrated engineers willing to embark on their own is more likely to occur from organizations that generate more technological knowledge (Christensen 1997). Accordingly, the likelihood of spin-out creation is greater from technologically superior organizations.

While the tacit nature of this knowledge poses formidable structural barriers to entry by outside firms, it also implies that would-be founders face lower entry barriers since they possess or have access to relevant knowledge. From a potential founder's perspective, the perception of risk involved in giving up a secure job and launching into entrepreneurship is likely to be mitigated by the belief that one possesses valuable, yet difficult to acquire know-how (Shaver and Scott 1991). In addition, the external institutional structure is also more likely to extend

support to a would-be entrepreneur when the founder is from a technologically cutting-edge parent. Venture capitalists are likely to see higher potential in such start-ups under the assumption that the founders carry with them more valuable scientific know-how derived from the parent (Fried and Hisrich 1994), since this knowledge is likely to act as an isolating mechanism and provide a higher stream of returns (Rumelt 1984). Therefore, all else equal, external support is more likely to go to an employee from an organization that has a reputation for being closer to the technological frontier. Thus,

*H<sub>1</sub>: The likelihood of spin-out generation will be increasing in an incumbent's technological know-how.*

### **Market-Pioneering Know-How**

In addition to scientific knowledge, we argue that an incumbent's market pioneering know-how is likely to be an important determinant of spin-out formation. The market orientation literature suggests that both cultural and process based capabilities are involved in creating markets. This capability encompasses a range of strategy-making organizational activities, such as planning and decision making, as well as aspects of an organization's culture, shared value system, and corporate vision that serves to unify organizational marketing capability into a cohesive whole (Day 1994). Conceptualized as a cross-functional, shared "set of shared assumptions and understandings about organization functioning" (Deshpande and Webster 1989, p. 4), market-pioneering capabilities represent superior skills in understanding and satisfying customers (Jaworski and Kohli 1993). It is viewed as a form of innovative behavior that is reflected in a firm's ability and will to be market driven (Slater 1997; Narver and Slater 1990).

The organizational memory literature suggests that market-pioneering know-how is likely to exist ubiquitously in an organization's memory in the form of shared beliefs, values, assumptions, norms, and behaviors (Argyris and Schon 1978; Levitt and March 1988). Further,

would-be founders are likely to internalize the results of prior experiences in market-pioneering by sharing the organization's belief structure, imbibing its behavioral routines and embodying both procedural and declarative knowledge on new product development and marketing (Moorman and Miner 1997).

Accordingly, we believe that past market pioneering behavior of an incumbent is likely to influence a would-be founder's propensity to leave and form an entrepreneurial venture. First, we can expect a transference effect from the organization's past market pioneering efforts to an individual, thus increasing the propensity to venture out. Second, 'war stories and 'hall talk' of past market pioneering successes are likely to motivate a potential founder to embark on one's own and reap the rewards of such entrepreneurial rents. As a result, we posit that:

*H<sub>2</sub>: The likelihood of spin-out generation will be increasing in an incumbent's market pioneering know-how.*

### **Interaction of Technological Know-How and Market Pioneering Know-How**

In addition to the independent effects of these two kinds of incumbent knowledge-based resources, we suggest that there may also be an interaction effect that may reduce the chances of spin-out formation. When an incumbent possesses high levels of either technological know-how or market pioneering know-how, employees are likely to be empowered and oriented to venture out on their own, carrying with them either cutting-edge product development knowledge or marketing pioneering savvy. However, when an incumbent possesses high levels of both capabilities, the incidence of spin-out formation is likely to be lowered. We present our rationale below.

First, incumbents with high levels of both technological and market pioneering know-how are likely to reduce the incentives for employees to embark on entrepreneurial ventures. This is likely to occur in two ways. One, such organizations are likely to reduce scientists' and

engineers' sense of aggravation in not seeing their inventions find expression as market place realities. A common theme, as we mentioned earlier, is employee frustration that occurs when employers are not willing to pursue cutting-edge innovative technological breakthroughs and ideas that they are instrumental in developing (Garvin 1983; Christensen 1993, 1997). Thus, higher levels of job satisfaction and future prospects that result when engineers perceive that the organization is committed to 'taking to market' emergent technological developments may reduce the chances of employee mobility (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' (Chandy and Tellis 1998). These incumbents are willing to reduce the actual or potential value of the investments with which they serve existing markets and proactively destroy an existing business in the pursuit of promising, yet risky future ones. Firms that have both the ability to develop new innovations and develop markets for them are likely to sustain leadership in dynamic markets (Chandy and Tellis 1998). Third, these organizations are likely to take advantage of emerging niche opportunities with technologically advanced products. By filling these niches, they reduce the incentives or opportunities for employees to consider venturing out themselves (Garvin 1983; Brittain and Freeman 1986; Klepper and Sleeper 2000).

Accordingly, we argue that the presence of these two co-specialized assets (Teece 1988), namely product development and market pioneering capabilities, are likely to interact such that they reduce the chances of spin-out formation. The complementary nature of these two capabilities create a synergy (Moorman and Slotegraaf 1999; Day 1994), and increases barriers to imitation when present simultaneously (Dierickx and Cool 1989). Thus, from an incumbent

organization's perspective, the probability of it generating spin-outs, or potential competitors, is less likely when it possesses both these capabilities. Correspondingly,

*H<sub>3</sub>: 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 and Performance**

In the preceding section, we examined the pressing question related to the formation of spin-outs. We argued that they are more likely to be spawned from incumbent firms that possess high levels of technological know-how, or market pioneering know-how, and that their incidence is reduced from incumbents that possess high levels of both. We now turn to post-entry performance of spin-outs, and examine whether there are systematic differences between them and other entrants regarding the evolution of capabilities, and the key outcome of organization mortality.

The earlier discussion highlights the antecedent and triggering role of parent capabilities on the formation of spin-outs. However, parental know-how is the basis on which an employee turned founder derives a relevant knowledge base for the entrepreneurial venture. In other words, the base of parental know-how forms the potential pool from which a particular spin-out is likely to inherit its congenital knowledge. Simplistically, the question is whether a 'smart parent' is more likely to create a "smart" offspring.

There has been little systematic inquiry of the consequences of congenital knowledge transfer from parent firms to their offspring. We approach this issue by examining the accumulation of technological know-how of a spin-out or its dynamic learning capability to create technological know-how. We link this to its congenital knowledge base, namely the parent's technological know-how at the time of its founding.

We draw on the absorptive capacity literature to suggest that a firm's ability to learn depends on its initial stock of knowledge. Extending insights from an individual level to an organizational level, Cohen and Levinthal (1990) suggest that an organization's absorptive capacity, defined as a firm's ability to value, assimilate, and commercialize new, external technology, develops cumulatively, is path dependent, and builds on prior investments. Further, they argue that a firm's prior scientific and technological knowledge facilitates the understanding and generation of new knowledge, especially when the prior knowledge is of a basic and diverse nature. In our context, this means that congenital learning has a long-term effect on the trajectory of a firm's capability accumulation as path dependence implies that the stock of knowledge at founding leaves a long-lasting imprint on a firm's future competitiveness.

Thus, it would appear that the congenital knowledge affects future learning and an entrant's ongoing capability to innovate at the cutting edge of technology. Starting off on a certain plane of knowledge inherited from parent implies that it is easier for a spin-out to sustain its technological leadership compared to other entrants through R&D spending and innovation. Due to higher levels of absorptive capacity at each period, they can learn and take advantage of technological knowledge that is internally developed, as well as those that can be tapped into vicariously. Two issues emerge: that a spin-out's capability accumulation is likely to be higher depending on the parental know-how that it inherits, and that compared to non-spin-out entrants, they are likely to be advantaged in the learning race that typifies most high technology industries. Accordingly, the following two hypotheses flow out from the preceding discussion:

*H<sub>4</sub>: Spin-out technological know-how will be increasing in its parent's technological know-how.*

*H<sub>5</sub>: The level of technological know-how will be greater in spin-out than in non-spin-out entrants.*

In addition to technological and market pioneering related congenital knowledge and its lasting impact, spin-outs are advantaged in several ways over other forms of entrants. The transfer of know-how, rules and routines from technologically advanced parents implies that a spin-out is able to start at a higher point on the learning curve compared to other entrants. Having imbibed the experiential learning of their parents with regard to reliable routines, spin-outs have the advantage of ‘inside’ knowledge and are less likely to face the costs of a pure trial and error process compared to other entrants. Further, institutional theory suggests that spin-outs also inherit intangible social capital such as reputation and connections into the parent’s network (Higgins and Gulati 1999). Higher degrees of legitimization with external stakeholders thus result. Previously established connections and valuable internal routines possibly reduce spin-outs’ liabilities of newness (Stinchcombe 1965) and adolescence (Levinthal and Fichman 1988) compared to other entrants. Accordingly, we argue that:

*H<sub>6</sub>: The likelihood of survival for spin-outs will be greater than for non-spin-out entrants.*

## **METHOD**

### **Data and Measurement**

#### **The Rigid Disk Drive Industry**

We test our hypotheses using data collected from the rigid disk drive industry, one that has been marked by rapid growth, market dynamism, and technology-driven creative destruction. Disk drives are magnetic information storage devices used with computers. We refer interested readers to Christensen (1993, 1997) and Lerner (1997) for detailed histories of the rigid disk drive. This industry is characterized by a great deal of innovative activity, with numerous

architectural, modular and incremental innovations<sup>1</sup> (Henderson and Clark 1990) being observed in the 20 year period that we consider. Architectural innovations resulted in five new diameters that catered to newer markets being introduced after the initial introduction of the 14” drive. Also, several modular and incremental innovations resulted in dramatic increases in the areal densities<sup>2</sup> of the disk drives. In response to profit opportunities from such rapid technological dynamism and market growth, net entry occurred. Among the entering firms, approximately 25% of firms were spin-outs and they represented an important source of knowledge diffusion and technology transfer in this industry. Thus, the richness of the events and the availability of spin-outs data make the disk-drive industry an appropriate industry for our analysis.

### **Description of Dataset**

One of the main problems with testing hypotheses related to spin-out generation and firm survival is the lack of available historical data on spin-outs. For accuracy, particularly on the early histories of firms in the disk drive industry, we collected data from sources that document facts *at the time of occurrence*, rather than rely on recollections of events. Creating such a database entailed using a reliable data source that would track information on important historical events in the industry and for *all* firms and that entered and exited these specific new markets. We use information compiled from the *Disk/Trend Report*, a market research publication that has covered the disk drive industry since 1975. It is a reliable and complete data source that has been used in past studies (Christensen 1993, 1997; Christensen and Bower 1996; Lerner 1997; Christensen, Suarez, and Utterback 1998). We constructed the genealogy of the firms and determined parent-spin-out relationships based on background information of founders

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<sup>1</sup> Optical drives are considered radical innovations, but are not included in the dataset since their introduction date occurred late in the time period under study and there are not enough longitudinal data on the firms producing optical drives.

<sup>2</sup> Areal density, which measures how much information can be stored on each square inch of disk, is an important measure of product performance.

of new firms from the *Disk/Trend Report*, supplemented by additional company press reports and news releases, and other data sources including 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 information search and data collection tasks were time and effort intensive. To minimize possible data-entry errors, the database was developed independently by three research assistants. The databases were then compared to reconcile discrepancies, rectify mistakes, and ensure that the records were accurate. The entire exercise was 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 that entered or existed in the industry after 1976, resulting in 1190 firm/year observations and 11,644 model/year observations. In addition, the data include detailed information on introduction dates of the sequential innovations in the industry (e.g. new diameters), product characteristics, and annual sales of disk drives<sup>3</sup> for the majority of the firms. The inventory of firms is complete and since our database includes every productive firm, regardless of size, surviving or dead, as long as they entered the relevant product market. Thus, our sample does not suffer from survival bias.

### **Operationalization of Constructs**

Table 1 provides the rationale and empirical operationalization of all the variables used in the study. Below, we describe our operationalization of the two key variables namely, market pioneering and technological know-how below.

[Insert Table 1 here]

***Market Pioneering Know-how:*** All the major architectural innovations in this industry catered to and satisfied new markets. Five such innovations, namely the 8”, 5.25”, 3.75”, 2.5”, and 1.8”

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<sup>3</sup> Sales information is available by firm at an aggregate disk-drive level, and not at the individual diameter level.

drives, were introduced between 1977-1997. The market pioneering know-how variable captures the know-how associated with bringing an innovation to market. 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. 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.

**Technological Know-how:** The outcomes of all modular and incremental innovations are manifested in 'areal density,' or the megabytes per square inch of a particular drive. Figure 1 shows the rapid technological progress over the years within and across the diameters<sup>4</sup>. 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 leveling off and 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.

[Insert Figure 1 here]

The areal density measure thus enables across diameter comparisons. We conceptualize a firm's technological capabilities as being reflected in its proximity to the technological frontier in each diameter at a point of time. Thus, our focus is on technological capabilities of a firm relative to the 'best' drive in the market. We calculate a firm's relative areal density in a particular diameter as follows. We first divide the areal density of the best drive produced by a firm in a certain diameter in a particular year, by the highest areal density in that diameter

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<sup>4</sup> Figure 1 is consistent with the information provided by Christensen (1993) in Figure 5, where he reports on the increase in the total hard disk capacity of each diameter. Using the hard disk capacity per square inch allows us to capture the technological frontier in any given year across all diameters.

available in the market that year. We then average this measure across all diameters produced by the firm to obtain a measure of the firm's technological know-how in a particular year<sup>5</sup>.

## Model Testing and Results

### Theme 1: Spin-out Generation

The hypotheses generated in Theme 1 pertain to the knowledge capabilities of firms and the likelihood of spin-out generation. The maximum number of spin-outs generated by a firm in any one year is 2, and accordingly, we test these hypotheses using an ordered probit model<sup>6</sup>. The results of the tests of hypotheses 1-3 are shown in Table 2. Recall that H<sub>3</sub> proposes a contingent relationship. Since the evaluation of main effects change in the presence of an interaction term (Aiken and West, 1991), we estimate the model in two stages. In the first stage, the main effects and the control variables are entered. In the second stage, we enter and estimate the interaction term. Column 1 reports the main effects of technological know-how and market pioneering know-how and Column 2 reports the results of the two-way interaction between technological know-how and market pioneering know-how.

[Insert Table 2 here]

Results from the main effects only model reveal that the probability of generating a spin-out in the following period increases with increases in both technological know-how ( $b = 1.13$ ;  $p < 0.05$ ) and market pioneering know-how ( $b = 0.30$ ;  $p < 0.10$ ) of the firm thereby supporting both H<sub>1</sub> and H<sub>2</sub>. Computing the marginal effects, we find that, holding other things constant at

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<sup>5</sup> Note that we focus on the *average* 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 out the diameters that are leveling off and producing in markets that are advancing their technological frontier more quickly.

<sup>6</sup> Using the logit model for testing hypotheses 1-3 and hypotheses 6 gave largely the same results, and are available upon request.

their mean levels, changes in technological know-how increases the probability of generating one spin-out by 5.7 percent, while changes in market pioneering know-how increase the probability of generating one spin-out by 1.5 percent. The control variables that are significant relate to competitive density. All other variables, including economic and firm-specific ones do not matter<sup>7</sup>. Examining the contingency model (Column 2) shows that the interaction between technological know-how and market pioneering know-how ( $b = -1.31$ ;  $p < 0.05$ ) negatively impacts the probability of generating a spin-out, thereby supporting H<sub>3</sub>. The marginal effects computed at the mean level shows that firms that are high on both technological and market pioneering know-how dimensions are 6.4 percent less likely to generate spin-outs than other firms. Thus, our empirical results show strong support for each of the three hypotheses developed in Theme 1.

## **Theme 2: Knowledge Transfer and Performance**

To test the hypotheses of knowledge capabilities of spin-outs, we use a regression framework. In Table 3, the sample is restricted to observations pertaining only to spin-out firms. Results show that parent technological know-how measured in the year preceding spin-out entry ( $b = 0.17$ ,  $p < 0.01$ ) is strongly significant in predicting spin-out's technological knowledge over time, thereby supporting H<sub>4</sub>. Among the controls, firm specific, industry and ecology variables are all significant. While age of the firm is negative and significant, both industry and firm size as measured by sales are positive and significant. Competitive density is negative, while competitive density squared is positive and significant<sup>8</sup>.

[Insert Table 3 about here]

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<sup>7</sup> The foreign firm dummy is not included in the model since only one foreign firm created a spin-out.

<sup>8</sup> The results are unchanged when firms are grouped in either a "high" or a "low" technological know-how category based on the median technological know-how in any one year.

Table 4 shows that a spin-out firm's technological knowledge over time is significantly higher than that of a non-spin-out firm ( $b = 0.12, p < 0.01$ ), thereby supporting H<sub>5</sub>. There is no difference in the technological know-how of a U.S. or a foreign firm. Larger the size of the firm, greater is the technological know-how, since the coefficient of firm sales is positive and significant. The technological environment, as measured by the highest areal density for the year in the entire industry, is positively correlated with the technological know-how of the firm, as this coefficient is positive and significant. Age of the firm and other industry and population ecology variables are not significant when all firms rather than the subset of only spin-outs are considered.

In order to test the hypotheses relating to the probabilities of survival of spin-out vis-à-vis non spin-out startups, we use a probit framework. Table 5 reports the probit results<sup>9</sup>. Results from Model 5a reveal that even after controlling for technological and market pioneering know-how, spin-outs indeed have a higher probability of survival in a given year than non-spin-outs ( $b = 0.56, p < 0.01$ ), thereby providing support for H<sub>6</sub>. Marginal effects indicate that a spin-out has a 2.4 percent higher probability of survival in any one year relative to a non spin-out firm. Higher technological know-how also increases the *probability* of survival ( $b = 0.77, p < 0.05$ ) by 2.8 percent, but market pioneering know-how decreases the probability of survival ( $b = 0.38, p < 0.05$ ) by 1.3 percent. A foreign firm has a higher probability of survival<sup>10</sup>. Firm size increases the probability of survival, whereas industry sales affect survival adversely. Competitive density and industry technological knowledge do not matter.

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<sup>9</sup> Firm sales growth is not included in the models since there is an endogeneity issue with survival as growth in sales is itself a result of "success" and continued survival. This endogeneity is not seen in the case of industry sales growth.

<sup>10</sup> This result is not surprising because typically more successful and bigger foreign firms entered the market. Also many of the foreign firms are captive or pre-existing firms that are only expanding into the disk drive market, whereas most of the new US firms are start-ups.

Several of the smaller start-ups with lower technological know-how were in the competitive fringe of the industry and have missing data on sales for their entire lifecycle, and almost all of the spin-outs have missing data on sales in their first few years. Including firm sales in model 5a results in observations on these entrants being ignored. Model 5b reports some additional analysis to ensure that the results are not an artifact of a statistical sample that may be biased in favor of or against a particular type of firm. When the model is estimated without firm sales to include these firms, the results on spin-out and technological know-how are essentially the same, but the coefficient of market pioneering know-how is not significant. Thus, market pioneering know-how impact on survival is sensitive to the smaller entrants being dropped from the analysis. Not surprisingly, the intercept term and some of the industry control variables become significant in model 5b, given that a significant variable is dropped from the model.

## **DISCUSSION**

To better understand the parent-progeny relationship in organizational founding, we theorized and modeled spin-out formation, and their growth and survival as a product of organizational learning. Following organizational learning scholars, we represented spin-outs as organizations that possess critical congenital knowledge at the time of birth, as a result of founders bringing with them codified and tacit knowledge from their previous place of employment. We focused on two domains of knowledge-based capabilities of parent firms that are emphasized in strategy research, namely technology and market pioneering.

We argued that the odds of an incumbent firm generating a spin-out depends on their technological and market-pioneering capabilities. Further, we had argued that the initial stock of congenital knowledge derived from parents not only lowered spin-out vulnerability to the typical

liabilities of newness that entrants encounter, but also enhanced their ability to maintain a ‘flow’ of knowledge-base capability over subsequent periods. This allows them to maintain a technology trajectory superior to other forms of entrants, and as a result, perform better. Our hypotheses thus revolved around a common theme: is there a parent and spin-out knowledge transfer relationship that impacts evolutionary processes and spin-out performance? With a dataset that includes both product and genealogical information about firms in the disk drive industry from 1977-1997, we test our hypotheses, and find resounding support for our central thesis. Broadly, our results indicate that a transfer of both codifiable and tacit knowledge, and theories of action from parents to progenies does occur, and also that these initial founding conditions have sustained performance implications.

We found that technologically advanced firms were more prone to spin-out formation, and thus creating their own future competition. This finding from the disk drive industry is also reinforced by evidence from the semi-conductor industry that shows that almost half the entering firms had at least one founder who had worked at Fairchild, which was considered to be the industry’s technological leader (Braun & Macdonald 1982). Further, parents that had been market pioneers themselves in preceding years were more likely to spawn spin-outs. For example, IBM and Shugart, both early-movers generated numerous spin-outs, of which two, namely Seagate and Rotating Memory Systems, became early movers themselves (Franco and Filson 2000).

Knowledge is thus a double-edged sword from an incumbent’s perspective. Interestingly, our results also indicate that firms that possessed both capabilities simultaneously were more likely to be successful in lowering the incidence of spin-out formation. Typically, technological and marketing capabilities are viewed as complementary assets, in that together they create

synergy, and enable a firm to undertake product development more effectively under certain situations (Moorman and Slotegraaf 1999). Our results indicate another important reason why firms may be better-off investing in building up dual capabilities, rather than concentrating in either technology or marketing as a single core area of competency. The leakage of important trade secrets, and R&D spillovers to competitors through employee mobility may be significantly deterred if a firm possesses these co-specialized assets. Due to a combination of enhancing research scientists' satisfaction at seeing their technological breakthroughs become market place realities, and covering niches that might entice employees to venture on their own if left unfulfilled, firms that are high on both technological and marketing capabilities are thus less vulnerable to the threats poised by spin-out formation.

Anecdotal evidence in Christensen (1997) shows that disaffected employees left Seagate and Miniscribe, the two largest 5.25 inch manufacturers who also developed the 3.5 inch drive, but shelved it due to lack of interest from current consumers. They founded the leading 3.5 inch drive maker, Conner Peripherals. Similarly, the founder of 8 inch drive Micropolis came from Pertec, a 14 inch drive manufacturer, and the founders of Shugart and Quantum defected from Memorex for similar reasons. In contrast, some companies, such as Quantum and Control Data created subsidiaries to target 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 mainstream company and thus retaining its employees.

None of the other firm-level variables appear to have any impact on spin-out formation. Therefore, speculations that larger, older, and more diversified organizations may be more prone to spin-outs are not supported. Organizational ecology variables, interestingly, appear to have

some impact. As the entrepreneurial fervor in the market increases, as reflected in the number of firms, the likelihood for spin-out formation increases. However, at one stage, competitive density reaches a stage where it is a deterrent to would-be founders to leave their jobs and venture out. In summary, we believe that we shed light on a vexing issue that is not well understood – a knowledge based explanation of spin-out formation, a relatively less understood form of organization.

Our second theme addressed spin-outs resource positions over time and their performance. Our findings strongly support spin-outs having higher likelihood of survival than other entrants. The results indicate that this is the outcome of spin-outs being able to accumulate superior technological knowledge and thereby occupy superior resource positions compared to other entrants. Further, the technological capabilities of spinouts appear related to those of their parents. Thus, there seems to be support for the view that congenital knowledge harnessed at the time of founding has a long-term impact on the ability of the entrants to sustain their technological leadership over time. In our analysis of knowledge accumulation, spin-outs were significantly higher in their technological capabilities than non-spin-outs, even after controlling for various firm, industry and chronology related factors. Spin-outs therefore do gain from their parent's technical expertise, and this helps them perform better than other types of entrants over time.

As further analysis of this issue, we grouped firms into either a “high” or a “low” technical know-how category based on a median split in any one year. Only four of the 40 spin-outs had lower technical know-how measure than their parents, as contrasted with 16 of the high technology spin-outs who were spawned from parents with high technical know-how. Also, there is anecdotal evidence that spin-outs imitated their parent's technology. Dastek, an IBM spin-out,

produced hard drives using thin film head technology, which IBM had developed just before Dastek's entry in the industry. All but one of the new diameters in the disk drive industry were introduced by a spin-out, even though the technology had been developed in the incumbent parent firm.

Regarding market pioneering know-how, 33 percent of spin-outs whose parents were market pioneers were pioneers themselves, whereas only 6.8% of spin-outs from a non-market pioneering parent were market pioneers. This difference is significant at a 1% level (Franco & Filson 2000). All in all, we find resounding support for the idea that technological and market pioneering knowledge transfers from parent to spin-out, and that this is instrumental in enabling spin-outs to sustain their technological leadership over other entrants.

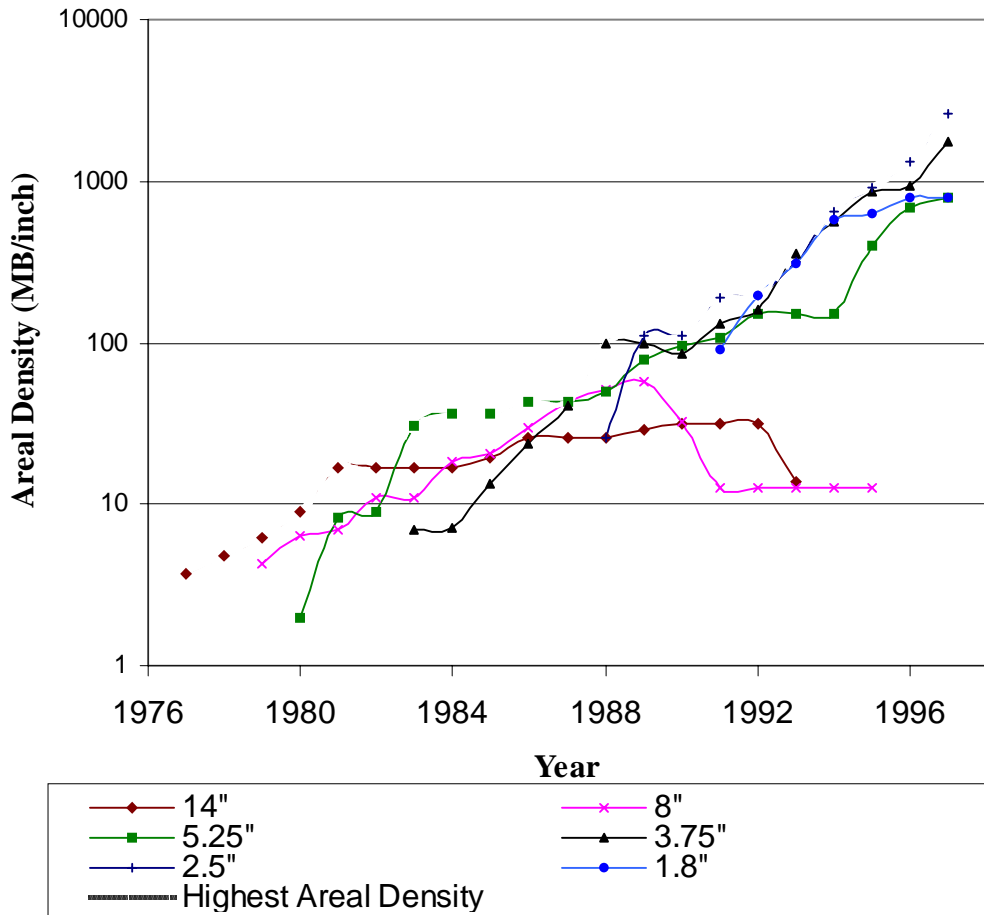
An interesting finding that deserves discussion relates to the relationship of technological and market pioneering know-how to survival. Although the former is in the expected direction, the results of market pioneering on survival is mixed. While this result seems counter-intuitive, there is a rich stream of literature on order of entry effects that argue for follower and late-mover advantages (see Shankar, Carpenter, and Krishnamurti 1998). This issue certainly is worthy of investigation in future research.

We find that spin-out entrants have a higher probability of survival than all other forms of start-ups, even after controlling for technological and market pioneering know-how. The non spin-out start-ups include subsidiaries and diversification efforts of existing firms that have access to parental "deep pockets," and have the option of hiring employees away from incumbents. Therefore, the significance of the spin-out dummy is clearly demonstrative of the crucial role of entrepreneurial ventures by employees possessing tacit and non-codifiable knowledge.

Our findings have implications for strategy, population ecology, and learning research. Sustainability of an advantageous resource position in knowledge, which according to the resource based view, explains superior performance over time, is path-dependent, and related to founding conditions. The effect of congenital learning has a long-term effect on the trajectory of a firm's capability accumulation. The path dependence in acquiring, accumulating, and deploying complex capability implies that the stock of knowledge at founding leaves a long-lasting imprint on a firm's future competitiveness. From a resource based perspective, our research provides further validation of the value of this approach.

Technology transfer from parents to progenies is widespread in several high tech industries, including the semi-conductor, computer hardware and software industries (Braun and Macdonald 1982; Christensen 1997). We hope that our research spurs thoughts on related issues. One avenue for future research would be to extend the study to cover other industries, and see if there are any industry specific moderating factors that affect the results. In addition, the study highlights the fact that technology lock-in by incumbent firms causes them not to pursue emerging markets. Employees then exploit the in-house developed technology by leaving the parent firm and become formidable competitors. This technology lock-in effect needs to be quantified, and one potential way of doing so is to measure the differences in the profit streams of the incumbents in established vs. emerging markets. Thus, our research emphasizes the fact that knowledge creation can be a double-edged sword for an incumbent firm, and knowledge management issues are crucial strategic considerations when firms consider staving potential competition.

Figure 1: Areal Density of Drives by Diameter



**Table 1: Definition of Variables and Rationale**

<b>Variable Name</b>	<b>Variable Description</b>	<b>Rationale</b>
<b>Key Variables in Study</b>		
Spin-out	Dummy = 1 if one of the founders of a firm was an ex-employee of an incumbent firm	Entrepreneurial ventures by ex-employees are different from other types of entry and represent technological transfer
SpinD	Number of spin-outs a firm generated a in any given year (0 if no spin-outs were generated)	Dependent variable for H1-H3
SurviveD	Dummy = 1 if firm survived to the following period (acquisitions treated as censored observations)	Dependent variable for H6
Technological Know-how	Firm's technological know-how in any year relative to the frontier technological know-how. Areal density (information 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. This measure is then averaged across diameters to obtain a single measure for the firm in each year.	Resource-based view argues that knowledge-based technological capabilities are critical to performance
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	Measures the early-mover advantage of the firm
Parent Technological Know-how	Technological know-how (as described above) of the parent in the year preceding the spin-out's entry into the industry.	Measures the capabilities of a parent firm regarding technological knowledge
<b>Firm Specific Control Variables</b>		
FirmSales	Sales of the firm per year, in millions of dollars	Larger firms may generate more spin-outs
FirmGrowth	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
Ndrives	Number of drives produced by the firm in any given year	Product diversity may enhance generation of spin-outs
Foreign	Dummy = 1 if firm was a foreign firm	Foreign firms may be different from US due to institutional reasons.
Age	Chronological age of firm since founding	Spin-out generation may increase with age

<b>Variable Name</b>	<b>Variable Description</b>	<b>Rationale</b>
<b>Industry Specific Control Variables</b>		
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
Nfirms	Number of firms in the industry per year	Competitive density affects survival
Nfirms2	Square of Nfirms	Competitive density may affect survival non-linearly
Nentries	Number of firms entering the industry per year	Bandwagon effect may explain spin-out formation, and possibly extent of churn in the industry
<b>Chronology Specific Control Variables</b>		
Yre77-Yre97	Year Dummies for the entry year of the firm	Possible effect of founding year and traces entry cohorts

**Table 2: Spin Out Generation (Hypotheses 1-3)**

<b>Variable</b>	<b>Model 1a Coefficient (std. error)</b>	<b>Model 1b Coefficient (std. Error)</b>
	-7.75**	-8.37**
Constant	(3.60)	(3.67)
Lagged Technological Know- How	1.13** (0.32)	1.44** (0.36)
Lagged Market Pioneering Know-How	0.30* (0.16)	0.87** (0.31)
Age	-0.04 (0.03)	-0.04 (0.03)
Lagged Technological Know- How* Early-Mover Know-How	---	-1.31** (0.64)
Lagged Firm Sales	1.17 (0.81)	1.29 (0.82)
Lagged Firm Growth	0.06 (0.14)	0.06 (0.14)
Lagged Ndrives	-0.01 (0.01)	-0.01 (0.01)
Highest Areal	-0.0001 (0.002)	0.00002 (0.002)
Lagged Industry Sales	-2.1E-8 (3.2E-8)	-1.97352E-8 (3.2E-8)
Lagged Industry Growth	-1.26 (1.22)	-1.24 (1.23)
Lagged Nfirms	0.20* (0.11)	0.22* (0.11)
Lagged Nfirms2	-0.002** (0.0008)	-0.002** (0.0008)
Lagged Nentries	-0.02 (0.03)	-0.01 (0.03)
Number of observations	775	775
Likelihood Ratio Chi square	33.48	37.84

Standard Errors are in parentheses

\*\*Significant at the 5% level

\* Significant at the 10% level

**Table 3: Spin Out Technological Know-how and Parent's Technological Know-how  
(Hypothesis 4)**

<b>Variable</b>	<b>Coefficient (std. error)</b>
	1.36**
Constant	(0.45)
	0.17**
Parent Technological Know-how <sup>1</sup>	(0.05)
	5.8E-8**
Firm Sales	(1.9E-8)
	-0.04**
Age	(0.01)
	0.0002
Highest Areal	(0.0002)
	1.9E-8**
Industry Sales	(8.7E-9)
	-0.04
Industry Growth	(0.18)
	-0.02*
Nfirms	(0.01)
	0.0002*
Nfirms2	(0.0001)
	-0.002
Nentries	(0.004)
Number of observations	276
Adjusted R <sup>2</sup>	0.29

Standard Errors are in parentheses

\*\*Significant at the 5% level

\*Significant at the 10% level

<sup>1</sup>Parent technological know-how measured in the year preceding spin-out entry into the market.

Year of entry dummies included but not reported.

**Table 4: Technological Know-how of Spin-out and Non Spin-out Firms  
(Hypothesis 5)**

<b>Variable</b>	<b>Coefficient (std. error)</b>
	-0.20
Intercept	(0.47)
	0.12**
Spin-out	(0.02)
	-0.02
Foreign	(0.3)
	3.3E-8*
Firm Sales	(1.8E-8)
	0.006
Age	(0.02)
	0.00003
Highest Areal	(0.0001)
	-5.9E-10
Industry Sales	(9.6E-9)
	-0.10
Industry Growth	(0.17)
	0.02
Nfirms	(0.01)
	-0.0002
Nfirms2	(0.0001)
	0.0007
Nentries	(0.003)
Number of observations	478
Adjusted R <sup>2</sup>	0.17

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: Probability of Survival of Spin-out and Non Spin-out Firms  
(Hypothesis 6)**

<b>Variable</b>	<b>Model 5 Coefficient (std. error)</b>	<b>Model 5a Coefficient (std. error)</b>
Intercept	-1.72 (3.61)	-2.70* (1.61)
Spin-out	0.56** (0.22)	0.58** (0.16)
Technological Know-how	0.77** (0.34)	0.44** (0.23)
Market Pioneering Know-how	-0.38** (0.18)	-0.14 (0.15)
Foreign Firm	0.69** (0.26)	0.43** (0.15)
Age	-0.06* (0.04)	-0.01 (0.02)
Firm Sales	0.00001** (0.27E-7)	---
Highest Areal	0.001 (0.001)	0.001* (0.008)
Industry Sales	-0.85E-9** (0.27E-9)	-0.44E-9** (0.18E-9)
Industry Growth	1.22 (1.49)	1.97** (1.00)
Nfirms	0.12 (0.11)	0.14** (0.05)
Nfirms2	-0.001 (0.001)	-0.001** (0.0004)
Nentries	-0.004 (0.04)	0.005 (0.03)
Number of observations	479	750
Likelihood Ratio Chi square	89.01	55.05

\*\*Significant at 5 percent level

\*Significant at 10 percent level

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