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Technology-Based Entrepreneurship

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This chapter addresses the field of technology-based entrepreneurship (TBE). My goal is to provoke discussion and hopefully spur research in a few directions rather than attempt an exhaustive treatment of the subject. Technology entrepreneurship is a field that draws from two research areas: the study of technical innovation on the one hand, and the study of entrepreneurship on the other. Like these research areas, rather than being oriented around any particular academic discipline, the field tends to be organized around a phenomenon. In my discussion throughout this chapter, I will therefore be drawing on multiple academic disciplines that contribute to our understanding of TBE, though my bias is on management issues associated with the phenomenon.[1] In addition, although I use a framing of new ventures developed to commercialize innovation, most of the discussion will also be of relevance to entrepreneurial efforts within the setting of established firms.

The study of TBE appears to have emerged in the early 1960s (Roberts, 2004), perhaps with the rise of research-based new ventures emerging from Silicon Valley and the Boston area companies. Although academic interest in TBE appears to have grown alongside the economic importance of the phenomenon, scholars at least since Joseph Schumpeter have understood entrepreneurs as efficiency-inducing change agents in the economy. One might argue that efficiency in the capitalist system is importantly driven by entrepreneurial actors who seize on previously unexploited economic opportunities. From a societal standpoint, it might be necessary to have a lot of experimentation in business ventures to discover the 'right' ones, and although there might be organizational failure in such a system, overall social efficiency may be enhanced by entrepreneurial experimentation. For the entrepreneurs of new firms that survive and flourish,

[1]There is also obvious overlap with some of the other chapters contained in this volume. When this is likely to be the case, I will concentrate my discussion on a few points and refer the interested reader to more in-depth discussion in the other chapters.

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there may be tremendous associated wealth creation – and it is these rewards that can help induce entrepreneurial entry. TBE is distinguished from other forms of entrepreneurial entry by being innovation-based, which may be construed as a barrier to entry. The job creation and potential economic development effects have led some national governments, such as Singapore, to promote TBE as an industrial policy (known as 'technopreneurship' in Singapore).

Although such macroeconomic effects may be quite important, I will concentrate my remarks and discussions to studies of individual- or firm-level behavior. Also, though there are many public policy implications for some of the topics that are discussed, the main purpose of this chapter is to explore business policy. As such, the decision maker will most often be an entrepreneur or potential entrepreneur, and research questions are framed from this perspective.

This chapter is organized to dovetail a stylized process of new venture development: new venture origins, human and financial resource assembly, strategizing, and growth and harvesting. Each of these areas is broad, and so my approach is to identify certain aspects and key questions that technology-based entrepreneurs face at each of these phases of venture development. I then discuss the approaches used in the literature to tackle these questions, and end each section with some thoughts on potential directions for future research in each domain.

New Venture Origins

The recent literature has underscored the proposition that entrepreneurial opportunities are ephemeral and transitory (e.g., Shane and Venkataraman, 2000), and so such windows of opportunity can open and shut over time. This structure, coupled with the high rate of entrant failures (e.g., Dunne, Roberts, and Samuelson, 1988), has led some researchers to ask whether entrepreneurial entry is economically rational, or in the alternative, entrepreneurs exhibit over-optimism and/or misperceived risk (e.g., Camerer and Lovallo, 1999; Moskowitz and Vissing-Jorgenson, 2002). In an early study, Cooper *et al.* (1988) found that 68 % of their surveyed entrepreneurs thought that the odds of their business succeeding was better than other businesses similar to theirs (only 5 % thought their odds were worse). Camerer and Lovallo (1999) find that their experimental subjects accurately forecast negative industry profits and enter anyway, and Moskowitz and Vissing-Jorgenson (2002) find that private equity returns do not seem to offer a premium to public equity. Although these three studies offer evidence from three methods (survey-based, experimental, and empirical) that appear consistent with the proposition that overconfidence is at the root of entrepreneurial entry, it may still be worthwhile to rule out explicitly more rational economic explanations. Two such explanations come to mind: first, entrepreneurs might be aware of the positively-skewed distribution of risk and reward associated with striking out on their own, but prefer buying a 'lottery ticket' in the off-chance that they end up in the right tail of the distribution. Second, individuals may have sufficiently high utility for nonpecuniary benefits associated with entrepreneurial activities that some expected monetary effects are overwhelmed.[2]

[2]It would be interesting to study if and how individual overconfidence interacts with technology quality.

After the entry decision is made, at least two types of knowledge are important as inputs into the entrepreneurial process for technology-based ventures: commercial and technical knowledge. It might be argued that the relative importance of technical as compared to commercial knowledge diminishes with stage of new venture development (and vice versa). For the moment, let us hold technical knowledge constant and discuss the role of commercial knowledge in the new venture formation process (in the next section, I discuss the effects of variation in technical knowledge).

Commercial knowledge

An important recent theme in the literature is that there may be substantial differences among entrants, particularly in the 'pre-history' of new venture development. These studies collectively consider the characteristics of the parent organization from which entrepreneurs were 'spawned', as well as the prior experience of the entrepreneurial individual or team. Although some studies emphasize one dimension or the other, I discuss them together because they shed insight into reasons for observed entrant heterogeneity.

In addressing the area of entrepreneurial origins of high-technology firms, it is hard to ignore the importance of new ventures that spin-off from more established firms. Bhide (1994, p. 151), in a survey of the Inc. ' 500′ fastest growing private companies, for example, found that 71 % had 'replicated or modified an idea encountered through previous employment'. Examples from the electronics industries (e.g., semiconductors, lasers, and hard disk drives) come readily to mind. Spin-offs of Fairchild Semiconductor (e.g., Intel, Advanced Micro Devices, and National Semiconductor) and Xerox Corporation (e.g., 3Com and Adobe) are often cited as examples of this phenomenon.[3] One set of studies has examined the characteristics of the spawning parent, asking the question: What types of parent organizations are more likely to spin-off progeny? In a cross-industry study of spawned venture capital-backed firms, Gompers, Lerner, and Scharfstein (2005) contrast two alternate views of the spawning process. In the first, would-be entrepreneurs prepare themselves (including through a process of social contagion), and become entrepreneurs by being exposed to the entrepreneurial process and developing network links with suppliers and customers while working at an established organization. A second view of the spin-off process is that bureaucratic organizations are reluctant to commercialize innovations, and so frustrated individuals leave the parent firm to strike out on their own. Although both accounts are likely to be true to a certain extent, Gompers, Lerner, and Scharfstein (2005) find more support for the employee learning rather than the organizational failure view in explaining venture capital-backed spin-offs. A second study, Agarwal *et al.* (2004), examined spin-offs in the hard disk drive industry and found that incumbents with both strong market pioneering and technical knowledge generated fewer spin-offs

[3]Anton and Yao (1994) found that there are conditions under which inventor-employees will start their own spin-off even though joint profits would have been larger had the parent organization exploited the invention (due to incentive conflicts arising from inventions that require little start-up capital and have weak or no property rights).

than did firms with competence in only one of these areas. These results seem consistent with the view that individuals compare their opportunity costs of staying with an incumbent organization with their beliefs about the potential size of an entrepreneurial opportunity when considering a spin-off venture.

A related domain of research has tried to better understand what exactly is transferred from the parent to the spin-off organization. The studies in this arena have found that the parent organization's capabilities at the time of spin-off are significantly related to the progeny's subsequent performance. Agarwal *et al.* (2004) found this result in the hard drive industry using probability of spin-off survival as the performance metric. This effect may not be confined to technology-intensive industries. Phillips (2002) found that spin-offs of Silicon Valley law firms received resources and routines from the parent organization, which increased survival likelihoods of the spin-off while decreasing them for the parent. As in the legal market, commercializing technical products requires specialized human capital, so there are some linkages between the two settings. Burton, Sorensen, and Beckman (2002) suggest that status effects are transferred from the parent organization to the offspring. In their study of Silicon Valley high-tech firms, they find that the status of the entrepreneurs' previous employers is positively related to the likelihood that the start-up secures financing at the founding of the new venture. The status effect is consistent with the view that resource providers regard the reputation of entrepreneurial affiliates as a signal of entrepreneurs' underlying quality.

Another set of studies in the spin-off literature has tried to understand the effects of experience associated with prior employment. The emergence and early history of the automobile industry has been the subject of a few studies in this regard. Klepper (2002) found that 'while diversifying firms on average outperformed *de novo* entrants, *de novo* entrants founded by individuals that worked for the leading automobile firms outperformed all firms and dominated the industry' (p. 645). Similarly, Carroll *et al.* (1996) found that entrants with pre-production experience and prototypes in the auto industry had lower mortality rates relative to those without such experience. Both studies suggest important heterogeneity among new entrants in this industry, and the results are consistent with the hypothesis that knowledge of quality production processes and/or business relationships with key actors such as suppliers or customers are associated with organizations' ability to innovate and effectively commercialize innovations, which may ultimately correlate with firm performance. Consistent with these auto studies, research in other industries also suggests that experienced entrants, especially those that have a background in a related industry, are advantaged relative to *de novo* entrants when new industries are born. Klepper and Simons (2000) find, for example, that 'no non-radio producer ever captured a significant share of the television market' (p. 998).

Finally, in a study that is not situated in the spin-off literature, Shane (2000) studies the effects of prior experience on how individuals recognize and interpret an entrepreneurial opportunity. For a given technology developed at MIT (three-dimensional printing), which was available for licensing, different individuals perceived different commercial opportunities depending on their prior knowledge and experience. This study nicely illustrates a fundamental point about the nature of entrepreneurial opportunities: the information set about potential ways to exploit

a given entrepreneurial opportunity is not uniform across individuals – but rather is heterogeneous across the population of potential entrepreneurs. Furthermore, individuals are likely to differ in their opportunity costs to engaging in entrepreneurship, as well as in their beliefs about the likely size of a given entrepreneurial opportunity.

It appears that recognition of technology-based entrepreneurial opportunities is a complex function of active search, problem solving ability, prior knowledge, and serendipity. If the four elements identified here are indeed elements of the entrepreneurial production function, new venture creation would appear to involve opportunity recognition and entrepreneurial opportunity creation based on entrepreneurial conjectures (Shane and Venkataraman, 2000). Moreover, several of the inputs depend on individual investments rather than stable individual or personality differences.

Overall, the research discussed in this section has highlighted two important issues: first, there are significant differences among entrepreneurial founding teams (especially in their pre-venture history), and second, that some organizational 'genetic' material is passed on from incumbent to spin-off organization. Looking to the future, it would be interesting to further investigate three issues. First, a deeper understanding of what exactly is typically 'inherited' from incumbent organizations (and why?) would be worthwhile. Second, although the within-industry studies in this literature that track the origins of the entrants from the beginning of the industry allow detailed analyses that shed a great deal of insight on entry in emergent industries, it would be interesting from a prescriptive standpoint to better understand what might be important in more generic situations. Restated, because most individuals can treat innovations that become the basis of new industries as exogenous events for which timing is highly uncertain, what general entrepreneurial skills and experience importantly separate would-be entrepreneurs in non-new industry settings?[4]

Finally, the results of these studies also suggest that potential selection effects in the entry process are important (and should be considered when doing studies of this kind). Klepper and Simons (2000) find that more experienced radio firms were more likely to enter television manufacturing (and succeed when they did so). In a broader assessment of this literature, Helfat and Lieberman (2002) conclude that there seems to be growing evidence that entry is more likely to succeed if founders feel that their resources and capabilities are well suited to entry, again suggesting an important potential selection effect leading to observed entrants.

Technical knowledge

So far the technical component of technology-based venture origins has been left untouched. In this section, therefore, I discuss three dimensions of technical knowledge as it relates to entrepreneurial origins: local technological search, knowledge spillovers, and intellectual property.

[4]Not only can entrants differ with respect to prior industry work experience (in a related or unrelated industry), but they may also differ in their founding experience. Such 'serial entrepreneurs' might be advantaged in the timing and valuation of received external financial resources (Hsu, 2007), as well as in resource attainment more generally.

Individuals are likely to vary in their degree of technical knowledge that may be germane to new venture formation. In this section, it will be useful to consider a setting in which commercial knowledge is fixed, and examine the effects of changes in technical knowledge. Individuals or teams of individuals have different stocks of technical knowledge and training, and so may have differential abilities to recognize and understand the commercial consequences of technical knowledge. Although founders can assemble entrepreneurial team members with diverse knowledge sets (Eisenhardt and Schoonhoven, 1990) with varied implication organizational behavior (Beckman, 2006), the corresponding authority transfer given to additional founding team members can have business policy and 'imprinting' effects on the venture's subsequent development (more on this below).

With a given collection of founders, the technological search process of the new venture is often characterized as locally circumscribed. The underpinnings for this behavior have been explored at multiple levels of analysis, ranging from individual-level explanations of bounded rationality (March and Simon, 1958) to firm-level capabilities, routines, and learning myopia (Nelson and Winter, 1982). New venture 'imprinting' by their founders (Stinchcombe, 1965) and firms' initial conditions (Cockburn, Henderson, and Stern, 2000) also suggest alternative mechanisms by which firms' search behavior is perpetuated. To the extent that the founders' entrepreneurial conjectures are correct, and entry is profitable, local search processes may not be as problematic, though the transitory nature of entrepreneurial opportunities might make such entry timing difficult.

In environments in which innovation is important as the basis for competition, firms and their managers may be particularly concerned about the long-term competitive effects of local search (March, 1991). Not surprisingly, then, there has been considerable interest in mechanisms associated with overcoming local search, particularly in the context of firms in research and development-based industries. For example, Mowery, Oxley, and Silverman (1996) examine strategic alliances as a mechanism for overcoming local search. Engineers are mobile, and their movement is another means by which firms can overcome local search (Rosenkopf and Almeida, 2003). Even with a given technological starting point, entrepreneurs will draw on knowledge from other technological domains in varying intensities, representing another possible means to overcome local search behavior (Hsu and Lim, 2007). This study also finds that firms' degree of technological search is responsive to changes in the business and commercialization environment, a finding consistent with Cockburn, Henderson, and Stern (2000), who find that initial founding effects are indeed important, but are not all-encompassing in determining organizational practices on innovation.

A second area of research related to technical knowledge observes that because appropriability of technical knowledge is imperfect (authors of such knowledge are rarely able to capture the full financial return associated with their invention), agents in the economy have the possibility of capturing knowledge spillovers. The ability to recognize and integrate extramural knowledge – an actor's absorptive capacity (Cohen and Levinthal, 1990) – represents an alternative path (outside of own knowledge generation) to exploiting technical knowledge. The circumstances surrounding the commercialization of biotechnology illustrate the phenomenon of

new organizations choosing geographic locations to attempt specialized scientific knowledge capture. At the beginning of commercial applications of biotechnology (recombinant DNA technology), the relevant technical knowledge was highly specialized and primarily resident in institutions of higher education (Kenney, 1986). Commercial operations disproportionately located their operations near such knowledge centers (and their associated 'star' scientists) in hopes of being able to capture potential knowledge spillovers (Zucker, Darby, and Brewer, 1998). More generally, the locality of knowledge flows as evidenced through patent citations (Jaffe, Trajtenberg, and Henderson, 1993) suggests that knowledge exchange tends to be local, perhaps as a result of knowledge tacitness that can become 'unstuck' (Von Hippel, 1994) through social interactions. Recent evidence suggests, however, that the Jaffe, Trajtenberg, and Henderson (1993) results may need revisiting, as a different method of constructing control patents attenuates the locality of patent citations effect (Thompson and Fox-Kean, 2005).

Geographic location may also be important to new venture creation for a reason other than knowledge spillovers. Certain geographic areas may be associated with different cultures of risk taking and career norms, which may differ even within technology intensive regions (e.g., Silicon Valley versus Boston's Route 128 area (Saxenian, 1994)). In regions in which entrepreneurial failure is stigmatized, individuals tend to be more hesitant to experiment with new ventures, which can lead to higher costs of start-up capital (Landier, 2006).

A final area of technical knowledge is intellectual property existence and strength as applied to knowledge transfer relevant to venture creation. Intellectual property licensing in this regard has recently received attention because of the potential for value enhancement both to the technology owner (e.g., corporations and universities (Arora, Fosfuri, and Gambardella, 2001; Gans, Hsu, and Stern, 2002)) as well as to start-up licensees of intellectual property (e.g., Shane, 2001a; 2001b). University technology licensing is a fortuitous setting to study technology transfer as the basis for ventures both because of data availability (through, for example, the Association of University Technology Managers, AUTM) and because the possibility of strategic effects of potential self-commercialization is remote (these conditions may not be true in the corporate setting). The empirical context of university technology licensing is an interesting setting in its own right as a source of technological input to new ventures. 214 US academic institutions accounted for a total of 450 new start-ups through technology licensing in the fiscal year 2002, and since 1980, 4320 new companies have formed based on university technology licenses, with 2741 still operating as of fiscal year 2002 (http://www.autm.net/about/dsp.licensing_surveys.cfm). Using data from technology licensed from MIT, Shane (2001a; 2001b) found support for enhanced likelihoods of new venture formation as a function of patent radicalness, importance, scope, and effectiveness. Again in the MIT context, Agrawal and Henderson (2002) found that knowledge diffusion via patenting among electrical engineering and computer science faculty represented only a minority of overall knowledge flows (scientific paper publishing and graduate student training were perhaps more important). In situations in which relevant knowledge is complex, tacit, and/or embryonic, which is typically true in university technologies, there may be few substitutes for inventor involvement and/or scientific exchange to aid

commercial development of the invention, though inventors may have to be given appropriate incentives to do so (Jensen and Thursby, 2001).

In summary, recent contributions have added to our understanding of the technical knowledge inputs to the origins of technology-based ventures. I conclude this section by mentioning one potential research area spurred by this discussion: What explains organization-level heterogeneity in the ability to absorb extramural knowledge in settings in which the sources of relevant technical knowledge are more diffuse and/or uncertain? This is a difficult problem to address, and may require a different initial research strategy than constructing a large dataset, because the mechanism of capturing knowledge spillovers may be better understood in ways that may be difficult to address immediately if a larger dataset comes at the likely expense of more granular detail. Although much of the research in technology-based entrepreneurship (and innovation) has made progress by studying the medical science areas (where we know a great deal about the institutional features of the phenomenon, and for which we know have readily-available data sources), much interesting economic activity takes place in other institutional settings – and the field would benefit from studies drawn from a broader domain of industrial fields.

Resource Assembly

After developing and evaluating the venture idea, the next step in the process of venture development is to secure human and financial resources. Although this conceptualization of linear development is very much stylized (i.e., in the process of trying to obtain resources, the venture idea and business model may be amended), I use this scheme for expositional ease. The main challenges that technical entrepreneurs face during the resource assembly stage are recruiting talented technical workers and managers and convincing financial resource holders to fund the new venture. These challenges are exacerbated for early stage ventures with mostly intangible, intellectual-based assets. I concentrate on relatively early stage ventures in this discussion because ventures that receive early buy-in from resource holders are likely to be the ones that benefit from a virtuous upward cycle of business development, and so entrepreneurial challenges may be most demanding in the early stages of development. I discuss the literature addressing human resource and then financial resource assembly, and conclude by posing some possible future directions in this literature.

A preliminary observation is worth noting before jumping into the discussion: it is important to establish some baseline expectations of why entrepreneurs differ in resource assembly. It would seem that the market for resources is relatively efficient in the sense that ventures of a given quality are matched with resources of commensurate quality. Quality in this setting might include at least the following dimensions:

- *ex ante* levels of human and social capital; and
- *ex ante* technological quality.

It might be useful to conceptualize these quality dimensions as 'controls' in an analysis, because these dimensions are well-established in the literature.

In this discussion of recruiting human resources, I first briefly consider recruiting managers and executives in start-ups. I then devote more attention to examining the technical labor market in the context of new ventures. Personnel at start-ups are typically compensated in a scheme that has a fixed component (wage) and a variable one (equity). Although the fixed component is likely to be smaller than for employment at more established firms, the entrepreneurial contract is meant to allow employee sharing of potential upside gains. Liquidity on the variable component of compensation is usually deferred (sometimes forever!), possibly making recruitment challenging as potential employees examine their opportunity costs. Although my focus here is not on optimal compensation schemes, it may be useful to consider the relative weighting of rewarded dimensions of merit in allocating equity to personnel. Because compensation schemes are meant to induce managerial and employee behavior, a clearer understanding of *what behavior* should be rewarded in the context of high-technology ventures is in order. Some candidate dimensions of personnel merit include: venture idea origination and evaluation, business plan preparation, commitment to the venture, skills and relevant business experience, and level of responsibility, and so on. Relevant compensation policy decisions, for example, might include the relative equity weighting assigned to historical contributions (e.g., venture idea origination) versus forward-looking contributions (e.g., effort toward shipping a product).

Most of my discussion in this section, however, is on other dimensions of human resource assembly. Stern (2004) finds that in the Ph.D. biologist labor market (which spans academia and private industry), scientists are willing to tradeoff monetary returns for utility-generating job dimensions (such as the ability to pursue, at least in part, their own scientific agenda). Henderson and Cockburn (1994) find that in the setting of pharmaceutical drug discovery efforts, human resource policies that promote scientists based on public science norms (publishing in top peer-reviewed academic journals) are associated with drug discovery productivity. This finding is consistent with the proposition that scientists working in pharmaceutical drug discovery value avoiding private industry-specific career investments (retaining the option of potentially crossing boundaries between academia and industry), and so higher ability scientists may be attracted to business environments featuring 'open science' policies.

Evidence on human resource practices and recruiting from a broader set of high-tech industries featuring entrepreneurial companies comes from the Stanford Project on Emerging Companies (SPEC). Baron, Burton, and Hannan (1996) describe this longitudinal dataset of Silicon Valley firms spanning technology-intensive industrial segments, and categorize firms into one of five archetypes according to the founders' organization of human resource practices (there is variation of human resource models within industries in their sample). These archetypes take into account employee attachment, coordination and control, and new venture selection of employees. Hannan, Burton, and Baron (1996) find that some human resource archetypes are less stable than others from the viewpoint of transition rates to nonfounder CEOs, but are also the same employment models that experienced higher rates of initial public offerings.

Both the Henderson and Cockburn (1994) and the SPEC studies link business policies to organizational performance outcomes. Armed with these results, it would seem that founders and mangers of technology-oriented entrepreneurial ventures would rapidly converge on the performance-enhancing practices identified by these studies. As Henderson (1994) reports, a simple change in promotion policy without accompanying changes to accommodate the exchange of knowledge across external and internal boundaries of the firm should not be considered an organizational competence. To the extent that adoption of an optimal human resource archetype is contingent on post-founding factors, we may believe that changing human resource policies might be worthwhile. Baron, Hannan, and Burton (2001), however, find that such organizational changes can be disruptive, leading to higher employee turnover rates. In any case, a deeper understanding of what accounts for the slow diffusion of organizational practices that have been associated with firm performance (or the persistent *non*-diffusion of such practices) would seem worthwhile.

I also discuss two additional areas for possible future research in the area of human resource assembly for entrepreneurial ventures. First, much of what we know about corporate open science policies comes from the health science industries (and primarily from drug discovery efforts in pharmaceutical or biotechnology firms). It would be interesting to investigate the policy's generality and boundary conditions (under what circumstances do costs of such policies exceed benefits?). Lewis and Yao (2003) have made some progress in this area by modeling how such open R&D policies can vary as a function of the business environment (including labor market, product development, and intellectual property conditions).

Since human resource assets are typically disproportionately important to the long run competitiveness of innovation-intensive firms, losing valuable scientists or engineers with specialized knowledge stocks could devastate firms. A second potential area of research would therefore examine productivity consequences of knowledge worker turnover, both for the knowledge worker, as well as for the firms involved. Groysberg, Nanda, and Nohria (2004) suggest that mobility of star investment bank professionals is associated with productivity losses both individually and for the firm the knowledge worker joins. Do the same results hold for scientists and engineers?

A second major input to new venture development is financial resources. Evans and Leighton (1989) find that men with greater assets are more likely to switch into self-employment, inferring that entrepreneurs face liquidity constraints. A focal point in this literature has been on venture capital (VC), which is not surprising given the fact that this institutional form has taken steps to design specialized mechanisms to permit funding new ventures (e.g., Gompers and Lerner, 1999; Hsu and Kenney, 2005).[5] Because the financing of innovation is covered elsewhere in this volume, my discussion here is brief, and I do not propose specific research directions in this area.

[5]For early stage firms, more informal means of financing (through 'angel' investors and friends and family) are also likely to be important. Systematic studies of angel investors have been elusive, however, due to the typically informal and private nature of this market. Corporate venture capital (CVC) represents another source of entrepreneurial funding. Dushnitsky (2004) studies the conditions under which an entrepreneur chooses to approach a CVC versus an independent venture capitalist.

The recent empirical literature on VC has highlighted not only the financial intermediation role of VCs, but also their extra-financial role in start-up business development. This literature has highlighted the role of VCs in business development, including start-up product development, human resource management professionalization, and strategic alliance formation (Hellmann and Puri, 2000, 2002; Hsu, 2006).

Two main mechanisms have been proposed to enable entrepreneurial funding. The first is a contractual approach in which financial resource holders offer funding under rather stringent conditions, which serves the function of screening entrepreneurial type (e.g., Kaplan and Strömberg, 2003). A second research stream has suggested that when the quality of a start-up cannot be directly observed, external actors rely on the quality of the start-up's affiliates as a signal of the start-up's own quality. (e.g., Megginson and Weiss, 1991, and Stuart, Hoang, and Hybels, 1999). This certification-based approach may help legitimate startups and entrepreneurs without a prior track record.

The first research stream emphasizes the VC's problem (designing the appropriate mechanisms) and the second highlights the entrepreneur's potential actions more directly (whether to affiliate with highly reputable partners, and at what cost?). Notice that these streams are most relevant in settings in which little or no external information is available about the qualities of the entrepreneurs (i.e., career experience is missing or not relevant to the entrepreneurial undertaking). Although several studies have documented performance benefits associated with 'leasing' a reputation via certification, my own research in this domain suggests that start-ups wishing to affiliate with a high reputation VC pay a monetary price (Hsu, 2004). The finding is consistent with the view that entrepreneurs who are tied into more connected networks at reputable VC firms expect to come across more opportunities for start-up growth, but must pay a premium for such access.

Strategizing

One of the main issues confronting start-ups is the question of how to earn returns from their innovative efforts when industry incumbents typically have much greater resources and could ostensibly compete successfully against entering start-ups. In this section, I review four prescriptive themes in the literature that might guide start-up entry strategy:

- entering into a niche;
- exploiting relative organizational flexibility;
- differentiating product or service offerings;
- cooperating with industry incumbents.

The first start-up strategy is the conventional wisdom to enter in a discreet market niche, making sure to stay below the radar screen of industry incumbents (e.g., Yoffie and Kwak, 2001). The idea is that inconspicuous entry allows entrants to improve their offerings without established incumbents perceiving an immediate threat to their business, allowing entrants to improve their capabilities and learn

over time while avoiding direct head-to-head competition in the near term. This phenomenon is consistent with Romanelli's (1989) finding in the minicomputer industry that a 'specialist', or niche-targeted strategy, is associated with new venture survival. Consider the experience of Southwest Airlines: founded in 1972, the airline got its start serving cities in Texas on short-haul flights, which were meant to compete against other modes of transportation (not necessarily other airlines). In the 1980s, the airline expanded to California and certain cities in the US Midwest, and by the 1990s, Southwest moved into the highly competitive US eastern seaboard, as well as into the American southeast and northwest. The question, of course, is whether a controlled growth strategy is available in contexts in which technical change, rather than operational efficiency (for example), tends to drive competitive outcomes. Incumbents, particularly multi-divisional ones, have the potential of realizing economies of scale and/or scope in their operations (see Henderson and Cockburn, 1996, for evidence in pharmaceutical drug discovery). Early stage entrants rarely can achieve these economies, especially if they follow a niche entry and controlled growth strategy. Therefore, for technology intensive new ventures, the scale of entry decision is probably a more complex decision that will weigh marginal technological and feature improvements as compared to extant offerings (taking into account cost considerations), intellectual property characteristics, potential network effects, as well as the usual firm-level strategic considerations such as industry structure.

A second possible entry strategy is to exploit the start-up's organizational flexibility relative to industry incumbents. For example, when Dell entered the personal computer market in 1984, Compaq used an extensive network of distributors and resellers to sell its computers. Compaq's sales model meant forecasting demand, and given the rate of price depreciation on computers and inventory expenses, inaccurate forecasts were costly. Dell's direct distribution model economized on inventory because products were not assembled until after they were sold. Compaq's strategy of emulating the direct sales model while retaining its prior distribution channels was largely unsuccessful, as governance costs for the dual sales channels were high. This anecdote illustrates the conventional wisdom that entrants, by starting from a clean slate, are necessarily more flexible. Although new ventures at their inception are probably less constrained relative to ongoing operations with respect to organizational design decisions, business environment shifts, as are common in technologically dynamic settings, would suggest that organizational flexibility *after* founding is also quite important. Several studies, however, suggest important 'imprinting' effects and other constraints imposed from founding conditions. Starting with Stinchcombe's (1965) proposition that founding conditions have long-lived effects, researchers have found support for the proposition in the context of corporate strategy (Boeker, 1989; Romanelli, 1989), top management teams (Eisenhardt and Schoonhoven, 1990), human resource management (Hannan, Burton, and Baron, 1996), and interfirm network structures (Marquis, 2003).[6] It would be

[6]Levinthal (1997), through simulation studies, finds that imprinting effects do not depend on lack of organizational change; rather, the combination of firms' local search in a rugged fitness landscape (in which the value of a particular organizational feature depends on a variety of other organizational features) results in founding organizational form persistence.

interesting in future research to delve more into the origins and evolution of organizational flexibility and explicitly address the causal mechanisms of organizational response, which is particularly important in technology-intensive settings. Why might such responses differ by organizational size or age, for example?[7]

A third start-up entry strategy is to differentiate the new product or service offering, preferably reinforced with intellectual property protection. Differentiation can result from technical innovation, and theoretical evidence (Reinganum, 1983) suggests that when innovations are sufficiently radical and the inventive process is stochastic, incumbent firms have weaker incentives to invest in research and development relative to entrants. Using direct measures of innovation, Acs and Audretsch (1988) find that although innovation size is not statistically different between small and large firms, industries composed of large firms tend to have more innovations, but higher innovative activity in such industries is associated with smaller rather than larger firms.[8] These findings are consistent with the proposition that entrants try to differentiate their offerings through innovation. Another means by which new ventures can differentiate themselves is to adopt a novel business and revenue model, which can have performance consequences for entrepreneurial firms (Zott and Amit, 2007). Research in this domain is emergent, and it would be interesting to address the appropriability of business and revenue model innovations in future research. In fast-paced business environments, competitive leads (regardless of source) are likely to be temporary, even if appropriability conditions are perfect, and so development strategy would ideally extend beyond initial entry strategy.

A different strategy from those noted above involves entrepreneurial start-ups deciding to develop products or services jointly with industry incumbents to diffuse potential competition and/or to tap into complementary assets that might be expensive or difficult for the start-up innovators to acquire. Various forms of cooperative product development between innovators and established firms, ranging from technology licensing to strategic alliances and even to outright acquisition, have increasingly been subjects of study (e.g., Gulati, 1998; Gans, Hsu, and Stern, 2002; Mathews, 2006). This academic interest in cooperative behavior appears to mirror the tremendous growth in actual inter-organizational cooperative behavior in the real world.

A better understanding of the determinants of when start-up innovators decide to develop their products jointly with established firms (such as frequently observed in the biotechnology industry (e.g., Lerner and Merges, 1998)) as opposed to competing with them (such as is often true in the hard disk drive industry (e.g., Christensen, 1997)), impacts both the nature of competition in high-tech industries and potentially social efficiency as well. In particular, social gains might result from dividing innovative labor according to comparative advantage (start-ups innovate while

[7]Henderson and Clark (1990) provide a framework for understanding the disruptive impact of architectural knowledge on established firms' competitiveness and illustrate the phenomenon in the semiconductor photolithographic alignment industry. Future research efforts might investigate whether the disruptive impact of architectural innovation is an inevitable outcome of organizational bureaucratization and growth.

[8]In a broader review of empirical studies of innovation and market structure, however, Cohen and Levin (1989) state: 'The most notable feature of this considerable body of empirical research on the relationship between firm size and innovation is its inconclusiveness.' (p. 1069).

established firms commercialize) and avoiding duplication of development efforts (leaving aside the possible effect of duplicative R&D effort spurring technical progress). Gans, Hsu, and Stern (2002) examine three effects that may determine start-up commercialization strategy:

- the role of formal intellectual property (patents) in negotiating with established firms;
- the role of venture capitalists as information brokers, lowering transaction costs of cooperation;
- the relative costs of entry and associated complementary assets necessary for entry (Teece, 1986; Tripsas, 1997).

Gans, Hsu, and Stern (2002) develop a novel dataset to test these factors, and find that each of the three factors has a quantitatively significant effect on the probability of start-up cooperation. For example, firms with patents associated with their projects are 23 % more likely to pursue a cooperative strategy than firms without patents associated with their projects. The results are consistent with the notion that patents allow start-up innovators to enter negotiations in the first place with prospective collaboration partners. The results also suggest that although patents affect the absolute return to innovation (regardless of start-up commercialization strategy), they also enhance start-up bargaining power due to the ability for start-ups to credibly threaten product market entry in the absence of a cooperative agreement (which increases the relative return to a cooperative strategy).

A follow-on paper, Gans, Hsu, and Stern (2008), provides evidence for the causal role of formal patent rights in enabling technology transfer. Although efficiency might favor cooperation as soon as the inventor is able to transfer the key knowledge to the licensee, uncertainty about the scope of patent protection might delay the achievement of such an agreement. The authors contend that the timing of cooperation is thus a key strategic choice. The hypothesis is that patent allowances (the administrative notification prior to formal patent grant) mitigate intellectual property scope uncertainty, and will therefore boost the hazard rate of engaging in the ideas market, though the effect of such allowances depends on the commercialization environment in which the new venture operates.

To test these ideas, Gans, Hsu, and Stern (2008) assembled a dataset that combines information on the timing of patent allowances with data on the timing of cooperative licensing by start-up entrepreneurs, exploiting the significant empirical variation in the timing of patent allowance to identify the role of patent grants on the timing of technology licenses.[9] Empirical findings suggest that the hazard rate for achieving a cooperative licensing agreement increases 70 % with the allowance of formal intellectual property rights, and the boost is most pronounced in the time period immediately following patent allowance. In addition, the overall rate of licensing and the importance of patent allowance on the licensing hazard rate depend on the strategic and institutional environment in which firms operate. Patent allowance plays a particularly important role for technologies with longer

[9]Much of the prior literature explicitly or implicitly assumes that patent rights are conferred coincidentally with invention, and the literature is increasingly recognizing the importance of treating patent rights as probabilistic rather than determined across various stages of the patenting cycle.

technology life cycles or that lack alternative mechanisms for appropriation such as copyright or reputation. The authors conclude that delays in the patent grant system impacts the market for ideas transfer (Gans, Hsu, and Stern, 2008).

Growth and Liquidity

Growth of the new enterprise is typically not linear, because there are likely to be continuous challenges for the entrepreneurial team. It is almost a truism to characterize the process of new venture business development in the following ways: 'The only certainty is uncertainty' and 'double the expected time and effort put into the venture, and cut the business plan projections in half, and you will have reality'. From a research standpoint, the gray boundaries of the growth stage of venture development compound the research difficulties. In particular, it is not clear when a fledgling start-up graduates from early stage status and into the growth phase. Should the decision rule be based on employee size, age, or product development, for example? And can we use the selected criteria to meaningfully compare firms across industries? Also, several of the issues associated with maturing firms are covered by other literatures. For example, growth issues start to converge with the strategy literature and some harvesting issues converge with the finance literature.

It is worthwhile to list some of the major entrepreneurial management challenges during the growth phase before discussing some of the associated research issues:

- meeting projections and milestones;
- raising additional financing to fund further development (perhaps preparing for a liquidity event);
- motivating, retaining, and further recruiting managers and scientific employees;
- refining business and revenue models;
- positioning or repositioning product portfolios, including strategic entry or exit of product or service lines;
- managing product development including expansion and possible entry into new products and/or markets; managing multiple lines of business;
- sustaining innovation and keeping ahead of actual or potential competitors;
- professionalizing organizational practices (including corporate governance);
- developing the formal and informal sides of the organization, including scaling a corporate culture alongside the necessary level of organizational bureaucratization;
- managing the scope of the firm (including integration or outsourcing decisions for downstream commercialization assets such as manufacturing or distribution channels);
- preparing for a liquidity event (e.g., an initial public offering, a merger/acquisition, or a management buyout).

Unlike in the other sections, I do not have a strong view on the few key research questions that face ventures in the growth phase of development. The challenges during this phase are sufficiently diffuse that a deeper understanding of many of the foregoing issues would be interesting. In addition, as ventures develop, their needs and challenges of growth are more diffuse relative to earlier stages of new

venture development. For this reason, perhaps, there is no natural focal point in these studies. My strategy here is to discuss a few topics that may have applicability across areas.

One important theme is the development of corporate leadership and governance among technology-based entrepreneurial firms. Since venture capitalists tend to fund such enterprises, and because VCs typically acquire equity stakes in exchange for their cash infusions (which may have corporate control implications), several studies in this area have not surprisingly examined their role in start-ups' corporate governance. Baker and Gompers (2003) find that VC-backed firms are more likely to build 'professional' boards of directors in the sense of having more independent directors, which is linked to corporate value, at least at larger firms (Gompers, Ishii, and Metrick, 2003).

An intriguing question is why (and under what circumstances would) founder-entrepreneurs voluntarily give up control rights (such as the right to be replaced as CEO) to venture capitalists? The results of Hellmann's (1998) model suggest that such rights are necessary to give VCs the incentive to find professional managers to increase the value of the venture. This finding is consistent with the view that VCs act as more than traditional financial intermediaries (simply taking capital from savers and channeling financial resources to users). Further evidence in this regard comes from Lerner (1995) who found enhanced VC representation on biotechnology firm's boards of directors around the time of CEO turnover (there was no such increase among other directors).

The rate of founder-CEO turnover among technology-based start-ups appears substantial. Hannan, Burton, and Baron (1996) find that in the SPEC study of Silicon Valley area start-ups, the likelihood that a nonfounder is appointed CEO reaches about 40 % 40 months after the venture is founded, and 80 % after 80 months (departures for voluntary and involuntary reasons are not distinguished in their data). More recently, Boeker and Karichalil (2002) found empirical evidence that the likelihood of founder departure increases with firm size, decreases with founder ownership, and has a U-shape relationship with firm growth. Wasserman (2003) reports two events that are related to founder-CEO departure: VC funding rounds and product development completion. Looking to the future in this literature, it would be interesting to construct a baseline for the rate of founder-CEO departures to be expected (after all, different management challenges are likely to be associated with various stages of venture development, and market efficiency requires replacing ineffective top managers) and then compare actual rates of departure to that benchmark. More fundamentally, it would be interesting to examine potential differences in business policy decision making between founder-CEOs and outside CEOs in the setting of entrepreneurial firms. Are there biases by founder-CEOs? If so, what accounts for the biases?

Despite the importance of entrepreneurial harvesting events – exit timing and mode issues are important to growth-oriented start-ups because of their effects on entrepreneurs' incentives to engage in new venture activity in the first place – there has been limited work done by management scholars on the liquidity phase of venture development. In an interesting study, Sorenson and Stuart (2003) examine the regional consequences (new venture founding rates) of prior biotechnology IPOs

and acquisitions. They find that liquidity events accelerate founding rates in the same and adjacent regions, though the results are moderated by state-level heterogeneity in enforceability of post-employment 'non-compete' covenants. Graebner and Eisenhardt (2004) examine entrepreneurial motivations for merging their venture. Further research on the causes and consequences of liquidity (or the absence of liquidity) events would be welcome.

Below I highlight a few other potential research questions in the domain of venture growth that might be interesting to investigate in future research:

- Black and Gilson (1998) argue that stock market-centered capital markets foster venture capital markets (affecting the supply of entrepreneurial ventures) more so than bank-centered ones, because legal environments affecting entrepreneurial exit affect the entrepreneurs' incentives to enter in the first place. It would be interesting to better understand what accounts for differential rates of VC and entrepreneurial activity *within* stock market- or bank-centered capital markets.
- How much conflict (and exercise of control rights) is there between entrepreneurs and VCs in timing and mode of exit?
- How much *entrepreneurial* skill dispersion is there in the timing of exits? (Lerner, 1994, finds that seasoned VCs appear to be able to take biotechnology firms public near market peaks.)
- Do entrepreneurs prepare their ventures for certain exit events? How? When? How would we know?
- What factors are involved in entrepreneurs' decision to abandon a venture?

Concluding Thoughts

In this chapter, I have discussed a wide range of management issues related to technology-based entrepreneurial business development. The discussion was organized around research issues faced at different stages of venture development: venture origins, resource assembly, strategizing, and growth and harvesting issues. I will not attempt to summarize the discussion or the areas I have highlighted for potential future research here. Instead, I conclude with a few methodological points that apply to future empirical research in the field. Data are hard to come by to study emerging ventures. Researchers will have to employ creative and entrepreneurial means to obtain interesting data for future research. In addition, multiple or even non-standard methods may have to be employed to make progress. Finally, I would encourage researchers to consider ambitious data collection efforts, preferably longitudinal, to address research questions in this field.[10] There appears to be increasing interest in technology-based entrepreneurship among management researchers. My hope is that this chapter has usefully discussed some of the recent research in the field and that future research will be stimulated by some of the discussion contained here.

[10]Some recent examples include the panel data assembled by the Stanford Project on Emerging Companies by Baron, Burton, and Hannan and the MIT licensing data by Shane.

References

Acs, Z., and Audretsch, D. (1988). Innovation in small and large firms: an empirical analysis. *American Economic Review*, 78, 678–90.

Agarwal, R., Echambadi, R., Franco, A.M., and Sarkar, M.B. (2004). Knowledge transfer through inheritance: spin-out generation, development, and survival. *Academy of Management Journal*, 47, 501–22.

Agrawal, A., and Henderson, R. (2002). Putting patents in context: exploring knowledge transfer from MIT. *Management Science*, 48, 44–60.

Anton, J.J., and Yao, D. (1994). Expropriation and inventions: appropriable rents in the absence of property rights. *American Economic Review*, 84, 190–209.

Arora, A., Fosfuri, A., and Gambardella, A. (2001). *Markets for technology: economics of innovation and corporate strategy*. MIT Press.

Association of University Technology Managers (AUTM). http://www.autm.net/about/dsp.licensing_surveys.cfm.

Baker, M., and Gompers, P. (2003). The determinants of board structure at the initial public offering. *Journal of Law and Economics*, 46, 569–98.

Baron, J.N., Burton, M.D., and Hannan, M.T. (1996). The road taken: origins and evolution of employment systems in emerging companies. *Industrial and Corporate Change*, 5, 239–75.

Baron, J.N., Hannan, M.T., and Burton, M.D. (2001). Labor pains: change in organizational models and employee turnover in young, high-tech firms. *American Journal of Sociology*, 106, 960–1012.

Beckman, C.M. (2006). The influence of founding team company affiliations on firm behavior. *Academy of Management Journal*, 49, 741–58.

Bhide, A. (1994). How entrepreneurs craft strategies that work. *Harvard Business Review*, 72, 150–61.

Black, B.S., and Gilson, R.J. (1998). Venture capital and the structure of capital markets: banks vs. stock markets. *Journal of Financial Economics*, 47, 243–77.

Boeker, W. (1989). Strategic change: the effects of founding and history. *Academy Management Journal*, 32, 489–515.

Boeker, W., and Karichalil, R. (2002). Entrepreneurial succession: factors influencing the departure of founding managers. *Academy of Management Journal*, 45, 818–26.

Burton, M.D., Sorensen, J., and Beckman, C. (2002). Coming from good stock: career histories and new venture formation. *Research in the Sociology of Organizations*, 19, 229–62.

Camerer, C., and Lovallo, D. (1999). Overconfidence and excess entry: an experimental approach. *American Economic Review*, 89, 306–18.

Carroll, G.R., Bigelow, L.S., Seidel, M.L., and Tsai, L.B. (1996). The fates of *de novo* and *de alio* producers in the American automobile industry 1885–1981. *Strategic Management Journal*, 17, 117–37.

Christensen, C.M. (1997). *The innovator's dilemma: when new technologies cause great firms to fail*. Harvard Business School Press.

Cockburn, I., Henderson, R., and Stern, S. (2000). Untangling the origins of competitive advantage. *Strategic Management Journal*, 21, 1123–45.

Cohen, W., and Levin, R. (1989). Empirical studies of innovation and market structure. In R. Schmalensee and R. Willig (eds), *Handbook of Industrial Organization, Vol. 2*, North Holland, 1059–107.

Cohen, W.C., and Levinthal, D.A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 35, 128–52.

Cooper, A.C., Woo, C.Y., and Dunkelberg, W.C. (1988). Entrepreneurs' perceived chances for success. *Journal of Business Venturing*, 3, 97–108.

Dunne, T., Roberts, M.J., and Samuelson, L. (1988). Patterns of firm entry and exit in U.S. manufacturing industries. *RAND Journal of Economics*, 19, 495–515.

Dushnitsky, G. (2004). Limitations to inter-organizational knowledge acquisition: the paradox of corporate venture capital. Best Paper Proceedings of the 2004 Academy of Management Conference.

Eisenhardt K., and Schoonhoven, K. (1990). Organizational growth: linking founding team, strategy, environment, and growth among U.S. semiconductor ventures, 1978–1988. *Administrative Science Quarterly*, 40, 84–110.

Evans, D.S., and Leighton, L.S. (1989). Some empirical aspects of entrepreneurship. *American Economics Review*, 79, 519–35.

Gans, J.S., Hsu, D.H., and Stern, S. (2002). When does start-up innovation spur the gale of creative destruction? *RAND Journal of Economics*, 33, 571–86.

Gans, J.S., Hsu, D.H., and Stern, S. (2008). The impact of uncertain intellectual property rights on the market for ideas: evidence from patent grant delays. *Management Science*, 54, 982–97.

Gompers, P.A., Ishii, J.L., and Metrick, A. (2003). Corporate governance and equity prices. *Quarterly Journal of Economics*, 118, 107–55.

Gompers, P., and Lerner, J., (1999). *The venture capital cycle*. MIT Press.

Gompers, P., Lerner, J., and Scharfstein, D. (2005). Entrepreneurial spawning: public corporations and the formation of new ventures, 1986–1999. *Journal of Finance*, 60, 577–614.

Graebner, M.E., and Eisenhardt, K.M. (2004). The seller's side of the story: acquisition as courtship and governance as syndicate in entrepreneurial firms. *Administrative Science Quarterly*, 49, 366–403.

Groysberg, B., Nanda, A., and Nohria, N. (2004). The risky business of hiring stars. *Harvard Business Review*, 82, 92–100.

Gulati, R. (1998). Alliances and networks. *Strategic Management Journal*, 19, 293–317.

Hannan, M.T., Burton, M.D., and Baron, J.N. (1996). Inertia and change in the early years: employment relations in young, high technology firms. *Industrial and Corporate Change*, 5, 503–36.

Hargadon, A., and Sutton, R. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly*, 42, 716–49.

Helfat, C., and Lieberman, M. (2002). The birth of capabilities: market entry and the importance of pre-history. *Industrial and Corporate Change*, 11, 725–60.

Hellmann, T. (1998). The allocation of control rights in venture capital contracts. *RAND Journal of Economics*. 29, 57–76.

Hellmann, T., and Puri, M. (2000). The interaction between product market and financing strategy: the role of venture capital. *Review of Financial Studies*, 13, 959–84.

Hellmann, T., and Puri, M. (2002). Venture capital and the professionalization of start-up firms: empirical evidence. *Journal of Finance*, 62, 169–97.

Henderson, R. (1994). The evolution of integrative capability: innovation in cardiovascular drug discovery. *Industrial and Corporate Change*, 3, 607–30.

Henderson, R., and Clark, K. (1990). Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly*, 35, 9–30.

Henderson, R., and Cockburn, I. (1994). Measuring competence? Exploring firm effects in pharmaceutical research. *Strategic Management Journal*, 15, 63–84.

Henderson, R., and Cockburn, I. (1996). Scale, scope, and spillovers: the determinants of research productivity in drug discovery. *RAND Journal of Economics*, 27, 32–59.

Hsu, D.H. (2004). What do entrepreneurs pay for venture capital affiliation? *Journal of Finance*, 59, 1805–44.

Hsu, D.H., and Kenney, M. (2005). Organizing venture capital: the rise and demise of American research and capital corporation, 1946–1973. *Industrial and Corporate Change*, 14, 579–616.

Hsu, D.H. (2006). Venture capitalists and cooperative start-up commercialization strategy. *Management Science*, 52, 204–19.

Hsu, D.H. (2007). Experienced entrepreneurial founders, organizational capital, and venture capital funding. *Research Policy*, 36, 722–41.

Hsu, D.H., and Lim, K. (2007). The antecedents and innovation consequences of organizational knowledge brokering capability. mimeo. Wharton School, University of Pennsylvania.

Jaffe, A., Trajtenberg, M., and Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, 103, 577–98.

Jensen, R., and Thursby, M. (2001). Proofs and prototypes for sale: the licensing of university inventions. *American Economic Review*, 91, 240–59.

Kaplan, S., and Strömberg, P. (2003). Financial contracting theory meets the real world: an empirical analysis of venture capital contracts, *Review of Economic Studies* 70, 281–315.

Kenney, M. (1986). *Biotechnology: the university-industrial complex*. Yale University Press.

Klepper, S. (2002). The capabilities of new firms and the evolution of the US automobile industry. *Industrial and Corporate Change*, 11, 645–66.

Klepper, S., and Simons, K.L. (2000). Dominance by birthright: entry of prior radio producers and competitive ramifications in the U.S. television receiver industry. *Strategic Management Journal*, 21, 997–1016.

Landier, A. (2006). Entrepreneurship and the stigma of failure. mimeo. New York University.

Lerner, J. (1994). Venture capitalists and the decision to go public. *Journal of Financial Economics*, 35, 293–316.

Lerner, J. (1995). Venture capitalists and the oversight of private firms. *Journal of Finance*, 50, 301–18.

Lerner, J., and Merges, R. (1998). The control of strategic alliances: an empirical analysis of the biotechnology industry. *Journal of Industrial Economics*, 46, 125–56.

Levinthal, D. (1997). Adaptation on rugged landscapes. *Management Science*, 43, 934–50.

Lewis, T.R., and Yao, D.A. (2003). Innovation, knowledge flow, and worker mobility. mimeo. Duke University.

March, J.G., and Simon, H.A. (1958). *Organizations*. John Wiley & Sons, Inc.

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2, 71–87.

Marquis, C. (2003). The pressure of the past: network imprinting in intercorporate communities. *Administrative Science Quarterly*, 48, 655–89.

Mathews, R.D. (2006). Strategic alliances, equity stakes, and entry deterrence. *Journal of Financial Economics*, 80, 35–79.

Megginson, W., and Weiss, K. (1991). Venture capital certification in initial public offerings. *Journal of Finance*, 46, 879–903.

Moskowitz, T.J., and Vissing-Jorgenson, A. (2002). The returns to entrepreneurial investment: a private equity premium puzzle? *American Economic Review*, 92, 745–78.

Mowery, D.C., Oxley, J.E., and Silverman, B.S. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal*, 17 (Winter special issue), 77–91.

Nelson, R.R., and Winter, S.G. (1982). *An evolutionary theory of economic growth*. Harvard University Press.

Phillips, D.J. (2002). A genealogical approach to organizational life chances: the parent-progeny transfer among Silicon Valley law firms, 1946–1996. *Administrative Science Quarterly*, 47: 474–506.

Reinganum, J.F. (1983). Uncertain innovation and the persistence of monopoly. *American Economic Review*, 73, 741–48.

Roberts, E. (2004). A perspective on 50 years of the engineering management field. *IEEE Transactions on Engineering Management*, 51, 398–403.

Romanelli, E. (1989). Environments and strategies of organization start-up: effects on early survival. *Administrative Science Quarterly*, 34, 369–87.

Rosenkopf, L., and Almeida, P. (2003). Overcoming local search through alliances and mobility. *Management Science*, 49, 751–66.

Saxenian, A. (1994). *Regional advantage: culture and competition in Silicon Valley and Route 128*. Harvard University Press.

Shane, S. (2000). Prior knowledge and the discovery of entrepreneurial opportunities. *Organization Science*, 11, 448–69.

Shane, S. (2001a). Technological opportunities and new firm creation. *Management Science*, 47, 205–20.

Shane, S. (2001b). Technology regimes and new firm formation. *Management Science*, 47, 1173–190.

Shane S., and Venkataraman, S. (2000). The promise of entrepreneurship as a field of research. *Academy of Management Review*, 25, 217–26.

Sorenson, O., and Stuart, T.E. (2003). Liquidity events and the geographic distribution of entrepreneurial activity. *Administrative Science Quarterly*, 48, 175–201.

Stern, S. (2004). Do scientists pay to be scientists? *Management Science*, 50, 835–53.

Stinchcombe, A.L. (1965). Social structure and organizations. In J. March (ed.), *Handbook of Organizations*. Rand-McNally, 142–93.

Stuart, T.E., Hoang, H., and Hybels, R. (1999). Interorganizational endorsements and the performance of entrepreneurial ventures. *Administrative Science Quarterly*, 44, 315–49.

Teece, D. (1986). Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy*, 15, 285–305.

Thompson, P., and Fox-Kean, M. (2005). Patent citations and the geography of knowledge spillovers: evidence from inventor- and examiner-added citations. *American Economics Review*, 95, 450–60.

Tripsas, M. (1997). Unraveling the process of creative destruction: complementary assets and incumbent survival in the typesetter industry. *Strategic Management Journal*, 18, 119–42.

Von Hippel, E. (1994). 'Sticky information' and the locus of problem solving: implications for innovation. *Management Science*, 40: 429–39.

Wasserman, N. (2003). Founder-CEO succession and the paradox of entrepreneurial success. *Organization Science*, 14, 149–72.

Yoffie, D., and Kwak, M. (2001). *Judo strategy*. Harvard Business School Press.

Zott, C. and Amit, R. (2007). Business model design and the performance of entrepreneurial firms. *Organization Science*, 18, 181–99.

Zucker, L., Darby, M., and Brewer, M. (1998). Intellectual human capital, and the birth of U.S. biotechnology enterprises. *American Economic Review*, 88, 290–306.