Industrial and Corporate Change, Volume 12, Number 3, pp. 519–543

Bringing individuals back in: the effects of career experience on new firm founding

Scott Shane and Rakesh Khurana

Because of methodological and theoretical obstacles, research on organizational foundings has largely focused on societal and population-level explanations. This paper takes the view that understanding firm foundings also requires linking to individual-level processes. We suggest that careers are an important mechanism linking individual-level processes to firm foundings. The firm-founding experience of potential founders impacts organizational foundings by influencing expectations of the liability of newness. We test our explanation on the set of inventions patented by the Massachusetts Institute of Technology over the period 1980–1996 by examining the effect of inventors' career experiences on the likelihood that an invention will be commercialized through the founding of a new organization.

1. Introduction

Organization scholars have long been interested in examining the factors that influence firm foundings. Considered from the societal level, general factors such as literacy, specialized schooling, urbanization and a money based economy are argued to affect a society's capacity to develop and support new organizations (Stinchcombe, 1965). More recent work specifies the role of ecological factors, such as the nature of technological change (Nelson and Winter, 1982) and the dynamics of organizational populations (Hannan and Freeman, 1984), in influencing firm foundings.

While considerable insights have been generated from examining the relationship between these macro-level factors and firm foundings, inquiry on this topic has been limited in its ability to incorporate lower levels of analysis in explanations for this phenomenon. One reason for the lack of research on these lower-level factors is that the absence of an organization prior to founding makes it impossible to use organizational attributes to explain foundings. Moreover, sample selection issues plague efforts to provide individual-level explanations. Researchers do not generally observe non-entrepreneurs in the same decision-making setting as entrepreneurs.[1] The difficulty of finding non-entrepreneurs who are comparable with entrepreneurs imposes a selection bias that interferes with efforts to test individual-level explanations for firm foundings.

The methodological obstacles notwithstanding, linking individual-level factors to organizational foundings is important for organization theory. Even Stinchcombe

[1]We will use the term entrepreneur and firm founder interchangeably throughout the paper.

(1965) began his seminal essay on social structure and organizations by stressing the role of individuals' social experiences in the decision to found an organization. As Freeman (1982) notes, firms do not arise spontaneously from opportunities in the absence of human action, but rather are founded through the organizing efforts of individuals. Consequently, an explanation for firm foundings that specifies how individual experience influences the probability that people will found firms would be more comprehensive (Aldrich and Zimmer, 1986).

This article seeks to relate an individual-level explanation for firm foundings—career experience—with macro-level theories. To do so, we examine the effect of career experience on a critical mechanism discussed in macro-level theories of entrepreneurship: the liability of newness (Stinchcombe, 1965). We argue that an individual's prior firm-founding experience influences his or her expectations of the liability of newness that a new firm would face. Similarly, these experiences influence external expectations about a particular individual's ability to overcome a new organization's liability of newness. Specifically, differences in career experiences lead to differences in evaluations by potential entrepreneurs themselves and by others of the entrepreneur's ability to: (i) access resources that help them start organizations; (ii) adapt to the role of entrepreneur and; (ii) influence the reallocation of resources from old to new uses. Therefore, an individual's willingness to create a new organization in response to an organizing opportunity will be enhanced by prior firm-financing experience, prior firm-founding experience, and social status.

To support our argument, we use a unique data set of inventions patented by the Massachusetts Institute of Technology over the period 1980–1996 to examine the effect of inventors' career experience on the probability that an invention will be commercialized through the founding of a new organization. Our findings suggest that the inventors' career experiences influence the likelihood that a new firm will be founded to exploit an Massachusetts Institute of Technology (MIT) invention.

Before discussing the specifics of the theory and the data, we distinguish our research from previous empirical work on the topic. While there is a small literature on factors affecting self-employment (Carroll and Mosakowski, 1987; Evans, 1989), we believe that our research linking career experiences to the founding of technology firms is distinct from this earlier work for two reasons. First, the companies that are formed to exploit new technologies have significantly greater aggregate effect on society than do individual decisions to engage in self-employment. These companies are usually larger in absolute size and have a greater impact on overall economic productivity. Therefore, examination of the founding of high-technology firms has the potential to explicate a phenomenon that has significant impact on social and economic change.

Second, self-employment does not necessarily require the founding of firms. Much of the data on self-employment include the examination of people who adopt independent contractor status. As much of the literature on organizational ecology examines the foundings of firms, rather than the causes of self-employment, the examination of the effect of career experience on the founding of technology

companies provides a useful link to other strands of organizational theory in ways not possible with research on the self-employment decision.

In the following sections, we develop a perspective for linking the career experiences of individuals to the founding of firms. We then describe the nature of the data set and the measurements. Next, we present evidence supporting our claims that career experience significantly influences the likelihood of firm foundings. We conclude with a discussion of the implications of this research.

2. Firm foundings and organizational theory: missing connections

The ecological approach developed by Hannan and Freeman (1989) and their colleagues directs attention to the importance for social theory of understanding organizational foundings. Their empirical finding that organizational foundings vary with the number of existing organizations in the population, and with environmental conditions, is one of the most robust in organizational research (see Carroll and Hannan, 2000, for a review). Yet despite the established research demonstrating the importance of these population-level factors on firm foundings, researchers in this arena seek a more complete understanding of the founding process. Indeed, even Hannan (1988), one of the key intellects behind the development of the ecological perspective, argues that existing theory often treats organizational dynamics as exogenous to micro-level factors. Citing Olson (1986: 178), Hannan (1988) summarizes the problem:

> Some organization theory is a little bit like a murder mystery in which the victim is killed for no reason at all. That is to say, one doesn't get any sense of the reasons or individual motives that account for the existence of a particular organization and the characteristics it has.

The present analysis responds to the recommendation that organization scholars consider individual-level factors in the founding process by examining the effect of individual career experiences. We argue that people's career experiences influence firm foundings (Haveman and Cohen, 1994). As Hannan (1988: 171) noted: 'an obvious but easily overlooked fact is that new firms and new organizational forms are created by individuals trying to fashion careers.' Specifically, we will suggest that the career experiences of individuals affect their expectations of overcoming the liability of newness that new ventures face.

3. Firm foundings and the liability of newness

Career experience should influence firm foundings by mitigating people's perceptions of the liability of newness that new firms face (Stinchcombe, 1965). New firms lack the social ties to key stakeholders, as well as the structures and roles of established organizations. The absence of these characteristics creates a liability that disadvantages

new firms. We argue that these liabilities are particularly severe for inexperienced entrepreneurs. Inexperienced founders do not have a set of stable ties to resource holders, who are often relied upon to provide the resources necessary to found an organization. Inexperienced founders also need to learn new roles and acquire new skills in the course of structuring new organizations. The processes of learning these roles and acquiring organizing skills are resource- and time-intensive, and therefore can add to the inefficiency of a new organization. Finally, all founders are faced with the challenging task of convincing others to reallocate resources in non-traditional ways. Those actors who possess greater legitimacy can more easily obtain necessary resources than can actors who do not exhibit certain legitimating characteristics (Hannan and Freeman, 1989; Zuckerman, 1999).

We argue that career experience influences firm founding by affecting the potential entrepreneur's expectations of the liability of newness and by affecting the expectations of external stakeholders. These expectations can work either in favor of or against the founding of a new firm, and are deeply intertwined with the potential founder's career experiences. For example, how easily resources can be mobilized should affect the potential entrepreneur's judgements about whether an opportunity is worth pursuing. Similarly, potential entrepreneurs with greater firm-founding experience should be more familiar with the roles and skills necessary to establish a new organization, and should not expect to incur as high a cost of adapting to their new role and acquiring new skills as novice entrepreneurs. Finally, potential founders who have achieved high status in their careers should possess the necessary legitimacy to convince more easily others to reallocate resources to the new venture.

The potential entrepreneur's career experience should also influence external constituents' evaluations of her ability to overcome the liabilities of newness. Past experience in raising money suggests an existing set of ties to resource holders. In addition, prior founding experience should provide external constituents with evidence that the entrepreneur has completed the difficult process of adapting to the role of organizational founder and has developed the skills necessary to found an organization. Finally, having achieved high status in one's career should generate the necessary legitimacy to motivate potential investors, employees and other stakeholders to reallocate resources to the new activity. Below, we elaborate on those elements of career experience that are particularly relevant to firm foundings.

3.1 Access to resources

Founding an organization usually requires the acquisition of resources from other actors. An individual's ability to obtain such resources often depends on the nature of his relationships with these resource providers. To create organizations, potential entrepreneurs must establish trustworthy relationships with resource suppliers, but these relations of trust tend to be much more fragile and scarce for inexperienced individuals than for experienced individuals. Prior experience in gathering resources should enhance the strength of these relationships. Aldrich and Zimmer (1986) explain

that prior dealings can form the basis for a trustworthy relationship that makes it easier to obtain resources from the same party a second time around. In addition to capital and labor, these resources include ties to customers who will buy products and suppliers who will provide needed raw materials. Larson (1992) provides a fine-grained process analysis that demonstrates how repeated interaction between entrepreneurs and resource providers leads to the creation of a trustworthy relationship that facilitates the ability to obtain future resources. The literature on immigrant entrepreneurship also has shown the importance of prior kinship and co-ethnic ties on resource acquisition in the firm formation process (Waldinger *et al.*, 1990). Similarly, Shane and Cable (2002) provide evidence that the ability to obtain these resources in high-technology settings also increases with experience. They showed that social relationships are an important source of funding for new enterprises, and that prior experience in starting a company is an important predictor of the ability to obtain funds for a new venture. Thus, prior firm financing experience provides resource ties useful for the formation of new firms. This argument leads to hypothesis 1: The likelihood that a new firm will be founded to exploit an invention increases with the number of the inventors' prior inventions that were licensed by externally financed new firms.

3.2 New roles and skills

As Stinchcombe (1965: 263) writes: 'new organizations, especially new types of organizations, generally involve new roles, which have to be learned.' The role challenges for the organizational entrepreneur exist at two levels: the role of the entrepreneur and the role of others in the organization.

For the entrepreneur, previous experience in founding organizations should provide role familiarity and skills that cannot easily be acquired through other career processes. For instance, in his study of Boston's Route 128, Nohria (1992) points out the advantages that experienced entrepreneurs have over novice entrepreneurs. He discusses how experienced entrepreneurs are more comfortable in their roles, conveying a sense of confidence to others, and more easily attract them to their new ventures.

An individual's experience or inexperience in founding affects not only the mastery of her own roles, but also her ability to structure effectively the roles of others. When firms are first founded, entrepreneurs do not know how to structure relationships among organization members in a way that is as productive as the organization of established firms. Over time, the liability of newness dissipates as people learn these role relationships (Hannan and Freeman, 1984). If liabilities of newness dissipate over time, then it seems plausible to assume that entrepreneurs who have prior experience in the firm creation process build up organizing skills that minimize these future liabilities of newness. As Carroll and Mosakowski (1987: 574) explain, 'those who engage in self-employment build up a unique kind of human capital that may be valuable in later self-employment.' Therefore, prior firm founding experience should make firm formation more likely. This argument leads to hypothesis 2: The likelihood that a new

firm will be founded to exploit an invention increases with the number of the inventors' prior inventions that were licensed by new firms.

3.3 Legitimacy

To create new organizations, entrepreneurs must often shift resources away from other uses. However, the creation of new enterprises is an inherently uncertain process, with a high probability of failure. Thus, the process of resource reallocation exposes entrepreneurs' plans to the scrutiny of others, who compare their novel ideas against existing wisdom (Hannan *et al.*, 1996).

The ability to convince others that a new approach should be adopted in place of established ways of doing things requires the proposer to have legitimacy with external stakeholders. Because the quality of a new venture is always a matter some debate, the decision of external resource providers to invest their resources in a new organization is one that must be made under considerable uncertainty regarding the organization's future prospects (Stuart *et al.*, 1999).

When unambiguous measures of quality are not easily observed, resource providers often look at other attributes. Evaluators often rely on the status of the inventor in making decisions about a technological opportunity (Merton, 1973b; Latour, 1987). We argue that in the case of firm founding to exploit university inventions, inventor rank serves as a measure of status, providing legitimacy, which makes it easier for a potential entrepreneur to motivate others to reallocate resources in ways counter to established norms. Many people perceive higher-ranked professors more positively than lower-ranked ones. When financing new ventures, external stakeholders might be more confident in the ideas that higher-ranked professors are proposing and, therefore, be more likely to attribute high value to them. Consequently, higher-ranked inventors should be more likely than lower-ranked ones to found firms in response to the discovery of an entrepreneurial opportunity.

Second, rank provides job security, facilitating the willingness and ability of the entrepreneur to bear the uncertainty demanded to acquire resources for an entrepreneurial venture. Because lower-ranked academics face much greater risk to their academic careers if their efforts to found firms to exploit technology fail, they should be less likely to found firms to exploit their inventions. This career risk should be greatly reduced if the inventor waits to found firms until he or she has been promoted to full professor. These arguments lead to the hypothesis 3: The likelihood that a new firm will be founded to exploit an invention increases with academic rank of the inventors.

4. Research setting: the founding of technology organizations

Inventors face a choice in commercializing their inventions. They can choose to do nothing, license the technology to existing firms, or they can create new firms. While licensing involves less risk, it usually generates less value to the entrepreneur. We argue that the choice between these outcomes is influenced by the characteristics of the

inventors. Different people should respond differently to the same technological opportunities because they have a different set of experiences from which to evaluate that opportunity and because external stakeholders should respond differently to them. If the inventors of a new technology have more founding experience, more prior experience with resource providers, and greater status, we argue that their invention will be more likely to be exploited by the founding of a new firm than if these conditions were not present.

5. Data, measurement and methods

5.1 Sample

We have collected all of the US patents assigned to the MIT for 17 years, from 1980 to 1996. The population consists of all inventions made by all members of the MIT community that made material use of MIT property during their development.

We examine the period 1980–1996 because in 1980 the federal law on government-funded research granted universities the property rights to federally funded inventions. Given the preponderance of university inventions that result from federal funding (roughly 70%), this change drastically altered the environment for university technology commercialization (Henderson *et al.*, 1998).

MIT provides a valuable setting in which to explore firm foundings. MIT is the largest single university source of patents in the United States and accounts for 8% of all university patents (Henderson *et al.*, 1998). As an institution, MIT has adopted an explicit set of policies that encourage new-firm formation based on its patents. These policies have made MIT the leading generator of university based startups in the United States (AUTM, 1996). Three policies are of particular note. First, MIT will accept equity in place of the payment of patent costs. This policy encourages entrepreneurship by reducing the upfront cost of firm formation. Second, MIT allows inventors to retain their proportional share of royalties even if they found a firm. This policy makes startup activity more lucrative to inventors. Third, inventors are often encouraged to exploit their own inventions. Taken as a whole, these conditions create a context in which inventors routinely make decisions to consider founding new firms to exploit their inventions.

While restricting our analysis to MIT has some limitations with respect to generalizability, it also has some advantages. First, by looking at patents, we can examine the founding of firms in a setting in which we have information about a defined set of opportunities equally conducive to firm founding. MIT inventors and inventions form a distinct set and are comparable with one another along a variety of important dimensions that influence the likelihood of firm founding. Consequently, by focusing on this setting we can control for a variety of unobserved characteristics that may affect firm foundings.[2] Second, the population of patented MIT inventions and their

[2]Because the data examine only firms founded to exploit university assigned inventions, we do not

licensing is carefully recorded, mitigating selection biases that plague much of the survey or case study work on firm foundings. Third, patents have been studied in many contexts other than firm creation, providing comparability of the findings about firm creation to findings about other aspects of technological change.

5.2 Analysis

We model patent-transition rates using a Weibull hazard-rate model. Each spell begins when a patent is issued and ends when a firm is founded. Evaluating the transformations of non-parametric estimates of survivor functions with the prediction from parametric models led to the choice of the Weibull model as the best-fitting model for the time dependence (Blossfeld and Rohwer, 1995: chapter 8).

The destination state of interest is whether a firm is founded or not founded. Patents that did not result in a firm founding are treated as censored observations. Once a patent is issued, firm foundings can occur at any point in time and our theoretical discussion suggests that there are both time-constant and time-varying factors influencing the founding event.

5.3 Dependent variable: firm founding

To measure firm founding, we model the likelihood that an invention assigned to MIT was licensed to a company that was founded to exploit the invention. Defining a new firm as the founding of a new legal entity has a long tradition in the entrepreneurship literature (Aldrich, 1999; Carroll and Hannan, 2000). Although some researchers challenge this definition and would define a new organization as having been founded when it initiates production, hires employees or obtains financing, we believe defining a firm founding as the creation of a new legal entity captures the decision of an entrepreneur to found a firm without confounding that decision with success at the entrepreneurial process. Because the initiation of production, the acquisition of capital or the hiring of employees is an outcome that only the most successful new ventures achieve (Aldrich, 1999), defining a new company as an entity that has initiated production, hired employees, or acquired external capital would confound the effect of experience on the decision to found a firm with the effect of experience on performance at the entrepreneurial process.

We coded firm founding as 1 if the invention led to the founding of a new company, and as 0 otherwise. The university maintains records of its inventions and the outcome of those inventions. In particular, MIT records whether or not the invention was licensed and, if it was licensed, the identity of the licensee. MIT's files contain detailed

observe firms founded to exploit inventions by MIT entrepreneurs that bypassed the university technology licensing office. While we do not observe such foundings, our discussions with inventors, the heads of the major laboratories, and the licensing office lead us to believe that the number of such firms is relatively few, since any inventions that have made material use of university resources need to be filed with the licensing office.

information about the legal status of the licensee, including the date of firm incorporation. If the MIT records revealed that the licensee did not exist as a legal entity prior to receiving the license, the patent was defined as a new-company patent. Of the 1397 inventions in our sample, 363 (26%) were licensed to organizations founded to exploit the inventions.

The event of firm founding is not the same as the event of producing a commercializable patent or even licensing a piece of technology. Less than one-third of the MIT patents licensed (to either new firms or already established firms) ever get commercialized (introduced to the market in the form of a product or service). Moreover, most licensed MIT patents do not result in firm foundings, but, instead, are licensed to established firms. In fact, we will provide regression analysis that predicts licensing by established firms to show that the prior firm-founding experience, prior new firm-financing experience, and status do not predict licensing by established firms but only new-firm founding.

We also note that we measure the event of firm founding for all patented MIT inventions during our period of observation regardless of the number of prior inventions belonging to each inventor and regardless of the outcome of efforts to exploit the inventors' prior inventions. Our approach is equally likely to include inventions belonging to inventors who had past successes as those who had past failures. Thus, professors with a large amount of prior firm-founding and firm-financing experience would be included in the data set regardless of whether they had been successful with their past ventures or not.

5.4 Predictor variables

Firm-founding experience. Prior research (Jensen and Thursby, 2001) and conversations with MIT's technology licensing officers, inventors and investors indicate that university inventors are almost always involved in the subsequent efforts to exploit their inventions. Moreover, when the licensee is a new firm, nearly everyone who is an inventor of the technology is involved in one way or another with the development of the new firm. However, the inventors often take on a variety of different roles in these new ventures, including positions as chief executive officer, chief scientist, chief technology officer, scientific advisory board member, director of business development, contract researcher, and consultant. Consequently, we needed to measure prior firm-founding experience in a way that best captures the full set of ways that inventors can gain firm-founding experience from involvement with the efforts of startup firms to commercialize their inventions. Conversations with practitioners indicated that a count of inventors whose invention was commercialized by startups is the best measure of the number of people who gain experience from the creation of new technology firms to exploit university inventions. For this reason, we measure firm-founding experience as the average number of prior MIT inventions that led to the founding of a new organization across all of the inventors who filed for the

patent.[3] Because this variable is log-normally distributed, we transform it by taking its square root before including it in our regression analysis.

Readers should note that prior founding experience in our analysis includes both 'successful' and 'unsuccessful' efforts. Prior firm-founding patents that resulted in a bankrupt company, an acquisition, an initial public offering, or a going private concern would all be included in our prior experience measure. Therefore, this measure is not necessarily equal to the number of prior successful firm foundings or the number of prior failed firm foundings. For example, a score of two on this measure could mean the team of inventors has two prior firm-founding patents that resulted in new companies that went bankrupt or it could mean the team of inventors has two prior firm-founding patents that resulted in new companies that experienced initial public offerings.

Firm-financing experience. To measure firm-financing experience, we calculated the average number of prior MIT inventions that led to the external (non-founder) financing of a new organization across the set of inventors who filed for the patent.[4] Readers should note that firm-financing experience and firm-founding experience are significantly positively correlated, but are not the same construct. Entrepreneurs can found firms without obtaining external financing, thus never gaining firm-financing experience.

Readers should also note that prior financing experience could be positive or negative. The experienced founders could have raised money for a bankrupt company or a company that experienced an initial public offering. Therefore, this measure is not necessarily equal to the number of prior successful firms financed.

Academic rank. To measure academic rank, we calculated the maximum university rank across the set of inventors who filed for the patent.[5] We coded rank as 0 for

[3]Although some inventors appear as part of different teams of inventors, and some teams of inventors file patents at different points in time across the 17-year period we observe, we find that no two patents filed in the same year have the same team of inventors. For this reason, we believe that the patents are independent with respect to inventors. We believe that each team of inventors making the decision what to do with a patent at given point in time is unique.

[4]There is a strong correlation between financing experience and founding experience. To avoid biased standard errors that can arise from multicollinearity, we use the residuals of founding experience for our analysis. This involves formalizing the relationship to model the overlap between the two measures and using the residuals as the predictor. This measure separates out the financing effects from the founding effects. This is a standard technique when correcting for potential multicollinearity (Kennedy, 1992). The assumption here is that multicollinearity arises from an actual approximate linear relationship among some of the regressors, which in the case of financing and founding may be true. Consequently, this relationship is formalized and the estimation then proceeds in the context of a simultaneous equation-estimation problem.

[5]We used rank as the measure of social status based on the extensive literature in the sociology of science demonstrating that advancement in the organizational hierarchy is a critical indicator of an

students; 1 for post-doctoral fellows and research staff; 2 for assistant professors; 3 for associate professors without tenure; 4 for associate professors with tenure; and 5 for full professors.

5.5 Control variables

As many factors other than career experience may influence firm foundings, we control for other factors that previous research suggests should explain high-technology firm foundings.

Entrepreneurial type. There are two explanations for the empirical finding that an individual who experienced an event in the past is more likely to experience a similar event in the future. The first is that prior experience alters the individual's decision model. The second explanation is that individuals who found firms are different from individuals who do not found firms because they are different types of people (Heckman, 1978). Figure 1 provides a conceptual illustration of our approach to controlling for entrepreneurial type while measuring the effect of experience. In our analysis, we include a dummy variable of 1 for entrepreneurial type if any of the set of inventors who filed for the patent had previous patents that were commercialized through the founding of a firm.[6] Consequently, the effect of the type of the person on having founded a firm in the past is captured in the intercept. If additional founding experience does not matter, the propensity to found a firm should not vary with additional founding experience, as represented by the slope B. However, if additional founding experience increases the propensity to found a new firm, we would expect an increase in the hazard rate of founding, represented by slope A.

Prior patents. Because inventors with more patents should be likely to have more patents that led to new companies than inventors with fewer patents, we control for the

individual's position in the professional hierarchy. As Merton (1973a,b) has discussed, status in science is commonly measured by organizational rewards, such as departmental affiliation and rank in the department. He emphasized that rank in the department indicates the regard the organization has for the individual and influences the treatment of him or her in such areas as resource allocation and deference to particular ideas. Neyman (1977) has found that university rank is highly correlated with other types of status indicators such as scientific productivity, membership in scientific associations, membership in the editorial bodies of scientific journals, and the external acclaim commanded by the scientist as an expert.

[6]The problem of distinguishing between true and spurious experience dependence is of considerable research interest. Research on unemployment, in particular, has focused on this issue. To explore this issue further we also utilized the maximum-likelihood probit estimation with selection techniques suggested by Heckman (1978, 1979) in his research on female labor-force participation. The probit procedure involved fitting the data to various multivariate probit models to investigate the importance of controlling for heterogeneity in the panel analysis. Likelihood-ratio test statistics (twice the difference of the log-likelihood value) robustly indicated the acceptance of experience as an important determinant of firm founding even when controlling for individual heterogeneity of a very general type.

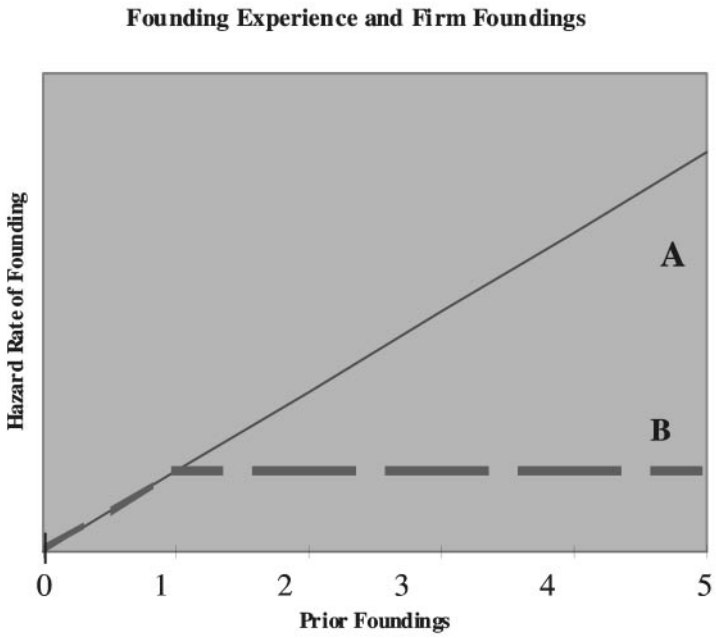

Figure 1 Conceptual model of founding experience and firm founding using prior founding as a proxy for entrepreneurial type.

average number of prior patents possessed by the inventors making the exploitation decision. Because this variable is log-normally distributed, we transform it by taking its square root before including it in the regression models.

Radicalness. There is likely heterogeneity in patents with respect to the degree to which they represent an opportunity to found a firm. Some patents, for example, represent radically new products or processes, while others are simply refinements of existing products or processes. The former group of radical inventions is argued to be more likely to lead to firm foundings than the latter group. More radical inventions are competence destroying (Tushman and Anderson, 1986) and existing firms have less incentive than new firms to develop radical technologies (Henderson, 1993). Further, existing firms may be more reluctant to invest in technologies that sharply deviate from their established niches and thus draw question to their claims on specific technical domains.

Following Rosenkopf and Nerkar (2001) and Shane (2001), we measure the radicalness of patents as the count of the number of different three-digit patent classes to which the patent is not assigned but from which the invention cites prior art. There are approximately 600 'three-digit' classes, which represent distinct technological domains (Jaffe *et al.*, 1997). By assigning a patent to a particular patent class, the US Patent and Trademark Office (USPTO) indicates that a patent belongs in a particular

technical domain (Shane, 2001). We argue that when a patent cites prior art in other technology classes, this represents an effort to draw upon other technological paradigms in developing the invention. Following previous research (Jaffe and Trajtenberg, 1998; Rosenkopf and Nerkar, 2001; Shane, 2001), we argue that the more patent classes (other than those to which it is assigned) that a patent cites, the more radical is the invention because such a citation pattern indicates that the invention is drawing upon more technical paradigms other than its own.

Number of firms. The number of firms in an industry should influence the probability that a new firm will be founded to exploit an invention as it is an indication of the carrying capacity of a particular niche (Hannan and Freeman, 1989). Prior research has shown that probability of firm founding follows a non-monotonic pattern with the existing number of firms in the industry. When the number of firms is few, the probability of firm founding increases. When the number of firms is many, the probability of firm founding decreases. We measured number of firms as the count of firms in the 3-digit SIC code, provided by the Census of Manufactures and Annual Survey of Manufactures.

Technical fields. Using dummy variables for drugs, mechanical inventions, electrical inventions and chemical inventions, we control for the general technical field of the invention. For purposes of analysis, the base case is 'other' inventions. We control for the technical field because the mode of invention commercialization tends to vary by technical field.

Period. Using dummy variables for the year in which the patent was issued (except for 1996), we controlled for period effects because changes over time in federal law and MIT policy may have increased the incentives for inventors to start companies to exploit MIT inventions (Henderson *et al.*, 1998; Shane, 2001). In 1984 Congress revised the Bayh–Dole Act to give universities expanded rights to federally funded inventions. In 1987 MIT agreed to take equity in lieu of patent costs. In 1990 MIT allowed founders taking equity in a company to retain their share of MIT's cash royalties.

6. Results

Table 1 indicates that the number of issued patents that become startup patents varies according to the technical field in which they were issued: Of the patents issued in the drugs and chemical fields, 38% and 42%, respectively, are the technological basis for newly founded firms. This is greater than the remaining classes of electrical (32%), mechanical (4%) and others (22%), suggesting the value of controlling for technical field in the statistical analyses. Table 2 summarizes the main variables used in our analysis.

Table 3 presents the estimates the effects of the independent variables on firm foundings. Model 1 predicts the likelihood of firm foundings on the basis of the control variables alone. This model shows that the type of patent issued influences the

Table 1 Distribution of MIT patents issued and startup patents, 1980–1996

	Number of patents issued	Number of startup patents	Percent of patents becoming startup patents
Drugs	264	100	38
Chemical	256	108	42
Mechanical	351	13	4
Electrical	275	89	32
Other	251	54	22
Total	1397	364	26

Table 2 Descriptive statistics for variables used in the analysis: MIT patents, 1980–1996

Variable	Mean	SD	Min.	Max.
Control variables				
Number of firms	17671.34	14609.89	4762	50911
Radicalness	3.56	3.84	0	41
Drug invention	0.14	0.35	0	1
Chemical invention	0.35	0.48	0	1
Electrical invention	0.36	0.48	0	1
Mechanical invention	0.05	0.22	0	1
1980	0.08	0.27	0	1
1981	0.10	0.30	0	1
1982	0.07	0.26	0	1
1983	0.06	0.24	0	1
1984	0.06	0.24	0	1
1985	0.04	0.19	0	1
1986	0.04	0.21	0	1
1987	0.06	0.24	0	1
1988	0.05	0.22	0	1
1989	0.07	0.25	0	1
1990	0.07	0.25	0	1
1991	0.05	0.23	0	1
1992	0.06	0.23	0	1
1993	0.04	0.19	0	1
1994	0.03	0.17	0	1
1995	0.02	0.14	0	1
Predictor variables				
Entrepreneurial type	0.21	0.41	0	1
Previous patents	5.70	6.86	0	39
Founding experience	0.52	1.71	0	21
Financing experience	0.43	1.58	0	21
Status	2.41	2.31	0	5

Table 3 Weibull regressions [coefficient (SE)] to predict firm founding MIT patents, 1980–1996

	All patent data: predicting firm founding			For year > 1990: predicting firm founding	All patent data: predicting licensing by established firm
Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Predictor variables					
Sq. rt. founding experience	–	0.553*** (0.094)	0.548*** (0.094)	0.892*** (0.142)	0.195 (0.152)
Financing experience	–	0.041 (0.052)	0.042 (0.052)	0.086* (0.063)	–0.170 (0.133)
Status	–	0.048** (0.028)	–	0.064** (0.038)	–0.030 (0.016)
Staff	–	–	–0.054 (0.195)	–	–
Assistant professor	–	–	0.328 (0.597)	–	–
Untenured associate prof.	–	–	–0.778 (0.718)	–	–
Tenured associate prof.	–	–	–0.133 (0.273)	–	–
Full professor	–	–	0.251** (0.145)	–	–
Control Variables					
Number of firms	–2.15-E05 (3.56E–05)	–1.69-E05 (3.49E–05)	–1.73-E05 (3.51E–05)	–1.04-E05 (5.35E–05)	–4.33-E05 (3.13E–05)
Number of firms squared	6.10-E10 (5.84E–10)	4.78-E10 (5.72E–10)	4.95-E10 (5.76E–10)	1.82-E9** (8.59E–10)	5.95-E10 (5.29E–10)
Sq rt. previous patents	0.091** (0.051)	–0.147** (0.066)	–0.158*** (0.066)	–0.358*** (0.115)	–0.083*** (0.068)
Entrepreneurial type	1.607*** (0.165)	1.477*** (0.180)	1.489*** (0.181)	1.054*** (0.251)	–0.415** (0.251)
Radicalness	0.019** (0.011)	0.048*** (0.010)	0.048*** (0.011)	0.015 (0.013)	–0.029** (0.016)
Electrical invention	–0.293* (0.188)	–0.570*** (0.190)	–0.552*** (0.192)	–0.842*** (0.263)	0.302* (0.212)
Mechanical invention	–0.351 (0.332)	–0.336 (0.333)	–0.334 (0.334)	0.084 (0.392)	0.237 (0.388)
Drug invention	0.562*** (0.187)	0.290* (0.191)	0.301* (0.192)	–0.090 (0.264)	0.213 (0.234)
Chemical invention	–0.003 (0.176)	–0.235* (0.176)	–0.238* (0.176)	–0.324* (0.241)	0.138 (0.211)
1980	–1.190*** (0.428)	–0.923** (0.439)	–0.870** (0.440)	–	0.680* (0.448)
1981	–0.772*** (0.328)	–0.673** (0.335)	–0.632** (0.337)	–	0.756** (0.415)
1982	–1.087*** (0.345)	–1.072*** (0.354)	–1.068*** (0.357)	–	1.205*** (0.428)
1983	–0.881*** (0.324)	–1.020*** (0.333)	–0.999*** (0.333)	–	1.438*** (0.421)
1984	–0.708** (0.316)	–1.066*** (0.325)	–1.054*** (0.324)	–	1.455*** (0.420)
1985	–0.451 (0.380)	–0.935*** (0.382)	–0.916*** (0.383)	–	1.969*** (0.431)
1986	–0.812*** (0.342)	–1.287*** (0.348)	–1.276*** (0.348)	–	2.267*** (0.410)
1987	–0.461* (0.363)	–0.722** (0.334)	–0.694** (0.334)	–	2.509** (0.399)
1988	–0.426* (0.311)	–0.613** (0.314)	–0.563** (0.315)	–	2.333** (0.402)
1989	–0.118 (0.255)	–0.117 (0.264)	–0.053 (0.267)	–	2.648*** (0.390)
1990	–0.302 (0.254)	–0.619*** (0.265)	–0.590** (0.266)	–	3.312*** (0.395)
1991	–0.212 (0.259)	–0.290 (0.266)	–0.261 (0.268)	–1.285*** (0.305)	–14.083 (516.305)
1992	–0.113 (0.234)	–0.200 (0.240)	–0.164 (0.241)	–1.105*** (0.279)	–14.056 (508.691)
1993	–0.342* (0.241)	–0.056 (0.241)	–0.041 (0.242)	–0.924*** (0.265)	–14.066 (630.803)
1994	0.557** (0.251)	0.134 (0.252)	0.183 (0.256)	–0.631*** (0.267)	–14.021 (751.416)
1995	0.461** (0.265)	0.317 (0.273)	0.394* (0.279)	–0.389* (0.286)	–14.023 (931.978)
Constant	–4.959*** (0.419)	–3.560*** (0.393)	–3.543*** (0.394)	–1.441*** (0.602)	–3.708*** (0.478)
–2 Log likelihood	1811.89	2025.557	2021.274	887.681	1511.142
Cases	1397	1397	1397	673	1397
Spells	9002	9002	9002	1931	7779
Events	364	364	364	184	363

*P 0.10; **P 0.05; ***P 0.01 in one–tailed tests.

likelihood of exploitation through firm formation: More radical patents are more likely to be exploited through firm founding. This result is consistent with findings in the technology management literature, which has shown a relationship between the nature of technological change and firm founding (Utterback, 1994).

Model 1 also shows that, compared with the omitted category of other inventions, drug patents are more likely to be exploited by newly founded firms and electrical inventions are less likely to be exploited by newly founded firms. One interpretation of this result is that the efficacy of drug patents is more easily evaluated than that of electrical, mechanical, or chemical technologies, thereby increasing the likelihood of firm foundings in these areas. Another interpretation is that relative to other technical fields, the biotechnology industry is new, and new fields tend to generate a higher number of startups (Utterback, 1994). This result is also consistent with Zucker *et al.*'s (1998) argument that university inventors start firms to exploit their intellectual capital. As the locus of intellectual capital in drugs lies in universities, but the locus of intellectual capital in other fields lies in more traditional commercial settings, university drug patents should be more likely to lead to firm foundings.

The year dummy variables in Model 1 indicate significant period effects for founding rates. Negative coefficients characterize the early periods of the study and decline steadily over subsequent periods. One interpretation of this finding is that MIT's research activity has become increasingly commercial over time. A second interpretation points to research that shows an increasing amount of entrepreneurial activity in the economy (Gartner and Shane, 1995).

Model 2 includes our three predictor variables along with the control variables. The inclusion of the predictor variables improves the overall fit of the model. This result is consistent with our argument that individual career experiences affect firm foundings.

Specifically, our results show that founding experience has a positive effect on the likelihood of firm founding. This measure is significant even after the inclusion of the control for entrepreneurial type. If the likelihood of firm founding were a function only of an individual's entrepreneurial propensity, then the measure for founding experience would have been insignificant when the dummy variable for entrepreneurial type was included. However, our finding that both the type and experience variables are significant supports the argument that an individual's career experience plays a part in his or her evaluation of organizing opportunities, and thus in the subsequent decision on whether to exploit these opportunities through the founding of a new firm.[7]

[7]Chamberlain (1978) supports this interpretation. Chamberlain recognized that a key difference between true dependence and serial correlation arising from spurious experience dependence is whether or not there is a dynamic response to an intervention. He argued that effects that are changing as experience accumulates are evidence of true experience effects, whereas effects that are constant suggest unobserved heterogeneity, and thus spurious experience effects. An intervention that affects the probability of y in period t will continue to affect the probability of y in period $t+1$ even though the intervention was present only in period t. An interpretation of serial correlation arising from unobserved variables is that these effects will remain constant over time.

Consistent with our expectations, we also found a significant positive effect of inventors' highest academic rank on the likelihood of firm foundings. This result is consistent with Podolny and Stuart's (1995) finding that when the quality of an innovation cannot be easily evaluated, perceptions of that innovation are contingent on the status of the actor associated with it. It is also consistent with the argument that higher-ranked inventors are likely to face less risk in founding firms as they have already progressed through the academic hierarchy.

The results for Model 2 do not show that prior financing experience increases the likelihood of firm founding. Firm-financing experience has no additional effect over the effect of firm-founding experience on the likelihood of firm founding.

While we have found support for our argument linking career experience to firm foundings, one concern with our findings is that the effect of status is not linear. Although anecdotal evidence indicates that external stakeholders view university rank as hierarchical and linear, it is possible that the differences between staff and assistant professor are not equal in size to the differences between assistant and associate professors or between associate and full professors. Therefore, in Model 3, we also examine rank as a series of dichotomous variables. In this model, we include dummy variables for staff, assistant professors, associate professors without tenure, associate professors with tenure, and full professors (students are the omitted category). As the results for Model 3 show, we achieve similar results for rank with a series of dichotomous variables as we do for a continuous variable. Compared with the omitted category of inventions belonging to students and compared with inventions belonging to other ranks of faculty, inventions of full professors more likely to be exploited by newly founded firms.

A second possible objection to our results is that the time-varying effects that we observed are an artifact of left truncation. Because we do not have data for our time-varying independent variables prior to 1980, we face the possibility of sample-selection bias for data in the earliest periods. To address this problem, we reanalyzed the data excluding first half of the sample. Because our sample consists of 1397 inventions, half of our sample is approximately 699 inventions. Therefore, we dropped all observations prior to 1991 and re-estimated the models on the 673 inventions from 1991 to 1996. Model 4 shows the results of this analysis. The coefficient estimates are similar in magnitude, direction and significance as those reported for Model 2, suggesting that the problems of left truncation do not affect our main findings.

A third possible objection to our results is that we have not unambiguously demonstrated that the career-experience model we identified for firm foundings is any different from the model affecting licensing to established firms. To address this possibility, we re-estimated the model using licensing to established firms as a destination state for a patent in Model 5. We find that the main career-experience variables do not predict licensing a patent to an established entity. The coefficients decline sharply and the standard errors increase markedly, indicating an alternative process for licensing to existing firms. Moreover, as expected by research that considers

technological discontinuity, the control variable, radicalness, is opposite in direction from the one observed for firm foundings. That is, the more radical a patent, the less likely it will be licensed to an established firm. This finding is consistent with recent ideas developed in the disruptive technology literature, which suggests that established firms are often locked into established technological trajectories and are not likely to adopt radically new technologies (Henderson, 1993; Christensen, 1997; Sorensen and Stuart, 2000).

The results for our model predicting licensing to established firms is useful in supporting our argument that the status variable does not proxy labor-market experience. A labor-market-experience effect would suggest that more experienced inventors should be more likely to license their own inventions because they have more data (from their own inventions as well as from the inventions of their colleagues) to evaluate the commercialization potential of inventions. However, the negative effect of the number of previous patents on the hazard of licensing to established firms is not consistent with this alternative explanation.

A fourth possible objection to our results is that the effect of rank varies across technical fields. In some technical fields (e.g. computer science) being a higher-ranked inventor may be less important in founding a firm than in other technical fields (e.g. biotechnology). For this reason, in unreported regressions, we examine interactions between rank and the four technology type variables. We find one significant interaction (that between chemicals and rank). Although the main effect of rank on the hazard remains positive and significant, the interaction between chemicals and status is negative and significant. None of the other interaction effects are significant. These results suggest that the relationship between rank and the hazard of firm founding appears to be as we predicted for electrical, drug, mechanical and other inventions, but not for chemical inventions. Although future research is necessary to explain why chemical inventions follow a different pattern from other inventions, we speculate that this effect may have to do with either the importance of postdoctoral researchers or the relevance of research groups in chemical technology.

A fifth possible objection to our results is that founding experience matters more when capital is more readily available in a field than when it is less available. For this reason, in unreported regressions we interact the availability of venture capital with the prior firm-founding experience and prior firm-financing experience. We measure the annual amount of venture capital available in the industry in which the patent was assigned by the US Patent and Trademark Office using data from the Securities Data Corporation's venture-capital database. The results show no significant interaction between capital availability in an industry and firm-founding experience or firm-financing experience on the hazard of firm founding.

A sixth possible objection to our results is that firm-founding experience has a non-linear relationship with the likelihood of firm founding because there are diminishing returns to prior experience. In unreported regressions, we measured this non-linear effect by creating a series of dummy variables for those cases with an average

of 2, 3, 4 and more than 4 prior firm-founding experiences across the inventors on the patent. We do not find evidence of a non-linear effect of firm-founding experience on the hazard of firm founding.

7. Conclusions

Using a unique data set that observed corresponding non-founders in the same decision-making setting as founders, our study provides evidence of a relationship between career histories and firm foundings. The results are consistent with our argument that prior career experiences affect a potential entrepreneur's own and other constituents' expectations of liabilities of newness in founding a new firm.

Although our study offers insights into the role of career experiences in the founding of new organizations, our findings have some limitations:

1. For example, our attempt to control for unobserved differences by restricting our analysis to one setting may have created biases with respect to the unique character of the setting. Recent studies of regional economies points to considering such factors in understanding organizational dynamics (e.g. Piore and Sabel on regional economies in Europe; Saxenian on Route 128 vs. Silicon Valley; Powell and Smith-Doerr on biotechnology). Future research that compared the relationship between university patenting and firm formation across research universities would help to illuminate any potential biases engendered by geography.
2. We do not have data on firm survival. The logic of our argument would suggest that the factors that we find to make firm founding more likely should also make firm survival more likely. While we have not collected data on firm survival, a series of recent papers (Boeker, 1997; Sorensen, 1999; Burton *et al.*, 1999) finds that the divergent experiences of managers are an important determinant of firm prospects and industry dynamics.
3. We focused exclusively on patented inventions. While inventors are potential entrepreneurs, they may not be representative of the total population of potential entrepreneurs. Thus, caution must be exercised in generalizing about firm foundings from this sample. Nevertheless, we believe that our results are generalizable to other settings as ours is a study of the manner in which career experiences affect firm founding.
4. Our study does not deal with team-specific heterogeneity. Our results could be biased if particular teams of inventors tend to work together to found multiple firms, allowing unobserved team-level characteristics to explain the tendency of inventors to found firms. However, this problem is relatively unlikely in the context we study because most of the inventions we examine do not include the same teams of inventors.
5. This study assumes that the observations are independent. As a result, if inventors appear on more than one patent, they make the decisions about firm formation independently for each of their inventions. Our discussions with inventors suggests

that this assumption is correct, because inventors are rarely teamed with exactly the same inventors on more than one patent and even when they are, most inventions are made at different points in time. However, we cannot know for sure that all of the observations in our sample are independent. If they are not and a small number of inventors are very likely to found firms due to some unobserved factor, our results could be biased.

Despite its limitations, our study suggests that future empirical research on organizational foundings should incorporate lower-level factors if researchers are to develop a more complete understanding of the founding process (Aldrich and Zimmer, 1986). The absence of individual actors from much of the empirical research on organizational foundings is inconsistent with the prominent role that individuals play in the theoretical discussions of firm foundings. For example, Stinchcombe (1965) stressed the role of individuals' social experiences in the decision to found an organization. Indeed, even Hannan (1988) and Freeman (1982), two of the key intellects behind the development of the ecological perspective, argue that research should incorporate micro-level factors (Hannan, 1988) because firm founding depends on the organizing efforts of individuals (Freeman, 1982).

We believe that a good place to start this effort would be to incorporate career experience of founders into empirical tests of firm founding. The central idea that career experience leads people to have differential probabilities of founding new firms in response to the discovery of a technological opportunity has implications for several strands of organizational research. First, by accounting for the role of the individual in firm founding, researchers can advance their understanding of this process (Thornton, 1999). As Freeman (1982) and Hannan (1988) explain, a theoretical mechanism that links individuals to firm foundings is useful to our understanding of firm foundings as firms do not arise spontaneously from opportunities in the absence of human action.

Secondly, the role that career experience plays in overcoming liabilities of newness in firm foundings provides an important extension of this theoretical construct. The liability of newness is one of the most robust empirical findings in the literature on organizational mortality. A wide variety of studies have shown that new firms have a higher propensity to fail than older firms (Hannan and Carroll, 1992). Despite the power of this construct to explain firm mortality, to date this construct has had no analog in the explanation of firm founding. We suggested how career experience could provide a mechanism through which liabilities of newness influence firm foundings. Individuals' variance in career experience impacts their own and others' expectations of their ability to organize successfully a new firm in response to the discovery of an entrepreneurial opportunity.

Thirdly, the role of career experience on firm foundings has important implications for research on technical change. Much of the contemporary research on this topic has pointed to the importance of attributes of industry and technological opportunities in explaining firm founding (Hannan and Freeman, 1989; Acs and Audretsch, 1990). However, our empirical findings demonstrate that a focus on these factors alone

provides only a partial explanation that neglects the role of agency. Our results show that who obtains decision rights over a new technology can influence the probability that a new firm will be created to exploit that invention. This observation implies that human agency is central to the process of technological change and that theories of technological change need to incorporate heterogeneity among individuals.

Finally, our results have useful implications for research on careers. Organization scholars have developed a wide range of useful theories to explain the career paths of individuals within established organizations. However, today the rate of firm founding in the economy is higher than at any time since the mid-1800s (Gartner and Shane, 1995). Moreover, at any given time, approximately 4% of the work force is engaged in the process of firm founding, and over 20% of the population will engage in this activity at some time during their careers (Reynolds and White, 1998). Research on careers has not kept pace with this economic transformation. While a few studies have begun to test whether theories that are used to explain careers in large, established organizations are relevant for careers that involve small, new organizations (Baron *et al.* 1996 and Burton *et al.*, 1999, are important examples), we do not yet know what boundary conditions from these theories explain the role of careers that involve activity in a new entrepreneurial economy. Our basic observation that career experience with firm foundings influences the subsequent founding of new firms suggests that scholars have only begun to examine careers in these new settings.

In summary, by showing that career experiences affect firm foundings, even after attributes of industry and technological opportunities are controlled, our research shows that firm foundings are not determined solely by the characteristics of opportunities themselves but by the confluence of enterprising individuals and valuable opportunities. This result supports the argument that accounting for the role of individuals in the firm founding process is critical for advancing theory. As Baumol (1968: 66) eloquently remarked, the study of firm foundings without a role for the founders is like the study of Shakespeare in which 'the Prince of Denmark has been expunged from the discussion of *Hamlet*.' We hope to have made one step toward advancing this understanding.

Acknowledgements

Both authors contributed equally to the writing of this manuscript and are listed randomly. Thanks to Don Kaiser, Lita Nelson and Lori Pressman of the MIT Technology Licensing Office for access to the MIT patent data and answering numerous questions about them. We would also like to thank Howard Aldrich, Roberto Fernandez, John Freeman, Heather Haveman, Rebecca Henderson, Mikolaj Piskorski, Toby Stuart, Michael Tushman and seminar audiences at Stanford University and Northwestern University for comments and suggestions. All mistakes, of course, are our own.

Address for correspondence

Scott Shane, University of Maryland, Van Munching Hall 3321, College Park, MD 20742, USA. E-mail: sshane@rhsmith.umd.edu

References

Acs, Z. J. and D. B. Audretsch, D. B. (1990), *Innovation and Small Firms*. MIT Press: Cambridge, MA.

Aldrich, H. E. and C. Zimmer (1986), 'Entrepreneurship through social networks,' in D. Sexton and R. Smilor (eds), *The Art and Science of Entrepreneurship*. Ballinger: New York.

Aldrich, H. E. (1990), 'Using an ecological perspective to study organizational founding rates,' *Entrepreneurship Theory and Practice*, Spring, 7–24.

Aldrich, H. (1999), *Organizations Evolving*. Sage: London.

Aldrich, H. E. and R. Waldinger (1990), 'Ethnicity and entrepreneurship,' *Annual Review of Sociology*, **16**, 111–135.

AUTM (1996), *The AUTM Licensing Survey*. Norwalk, CT.

Barley, S. R. (1989), 'Careers, identities, and institutions,' in M. B. Arthur, D. T. Hall and B. S. Lawrence (eds), *Handbook of Career Theory*. Cambridge University Press: New York.

Barley, S. R. (1990), 'The alignment between technology and structure through roles and networks,' *Administrative Science Quarterly*, **35**, 61–103.

Baron, J. N., M. T. Hannan and M. Burton (1996), 'The road taken: origins and early evolution of employment systems in emerging companies,' *Industrial and Corporate Change*, **5**.

Baumol, W. J. (1968), 'Entrepreneurship in economic theory,' *American Economic Review Papers and Proceedings*, 64–71.

Becker, G. S. (1975), *Human Capital*, 2nd edn. University of Chicago Press: Chicago, IL.

Blau, P. M. and O. D. Duncan (1967), *The American Occupational Structure*. Wiley: New York.

Blossfeld, H.-P. and G. Rohwer (1995), *Techniques of Event-History Modeling: New Approach to Causal Analysis*. Erlbaum: Mahwah, NJ.

Boeker, W. (1997), 'Executive migration and strategic change: the effect of top manager movement on product-market entry,' *Administrative Science Quarterly*, **42**, 213–236.

Borjas, G. J. (1986), 'The self-employment of immigrants,' *Journal of Human Resources*, **21**, 485–506.

Brockhaus, R. and P. Horowitz (1986), 'The psychology of the entrepreneur,' In D. Sexton and R. Smilor (eds), *The Art and Science of Entrepreneurship*. Ballinger: Cambridge.

Burt, R. J. (1992), *Structural Holes*. Harvard University Press: Cambridge.

Burton, D. M., J. B. Sorensen and C. Beckman (1999), 'Coming from good stock: career histories and venture formation,' working paper, Harvard Business School.

Busenitz, L. A. and J. B. Barney (1997), 'Differences between entrepreneurs and managers in large organizations: biases and heuristics in strategic decision-making,' *Journal of Business Venturing*, **12**, 9–30.

Carroll, G. R. and M. T. Hannan (2000), *The Demography of Corporations and Industries*. Princeton University Press: Princeton, NJ.

Carroll, G. and E. Mosakowski (1987), 'The career dynamics of self-employment,' *Administrative Science Quarterly*, **32**, 570–589.

Caves, R. (1998), 'Industrial organization and new findings on the turnover and mobility of firms,' *Journal of Economic Literature*, **36**, 1947–1982.

Chamberlain, G. (1978), 'Omitted variable bias in panel data: estimating the returns to schooling,' *Annals de l'INSEE*, 30, 49–82.

Chen, C. C., P. G. Greene and A. Crick (1998), 'Does entrepreneurial self-efficacy distinguish entrepreneurs from managers?' *Journal of Business Venturing*, **13**, 295–316.

Christensen, C. (1997), *The Innovators Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business School Press: Boston, MA.

Cressey, P. G. (1932), *The Taxi-Dance Hall: A Sociological Study in Commericalized Recreation and City Life*. University of Chicago Press: Chicago, IL.

Evans, M. (1989), 'Immigrant entrepreneurship: Effects of ethnic market size and isolated labor pool,' *American Sociological Review*, **54**, 950–962.

Frazier, E. F. (1949), *The Negro in the United States*. MacMillan: New York.

Freeman, J. (1982), 'Organizational life cycles and natural selection processes,' *Research in Organizational Behavior*, **4**, 1–32.

Gartner, W. and S. Shane (1995), 'Measuring entrepreneurship over time,' *Journal of Business Venturing*, **10**, 283–301.

Granovetter, M. (1974), *Getting a Job: A Study of Contacts and Careers*. Harvard University Press: Cambridge.

Hannan, M. T. (1988), 'Social change, organizational diversity and individual careers,' in M. Riley (ed.), *Social Change and the Life Course*. Sage: Newbury Park.

Hannan, M. T. and G. Carroll (1992), *The Dynamics of Organizational Populations*. Oxford University Press: New York.

Hannan, M. T. and J. Freeman (1984), 'Structural intertia and organizational change,' *American Sociological Review*, **49**, 149–164.

Hannan, M. T. and J. Freeman (1989), *Organizational Ecology*. Harvard University Press: Cambridge.

Hannan, M., M. D. Burton and J. N. Baron (1995), 'Inertia and change in the early years: Employment relations in young, high technology firms,' working paper, Stanford University.

Haveman, H. A. and L. Cohen (1994), 'The ecological dynamics of careers: the impact of organizational founding, dissolution, and merger on job mobility,' *American Journal of Sociology*, **100**, 104–152.

Heckman, J. J. (1978), 'Simple statistical models for discrete panel data developed and applied to test the hy pothesis of true state dependence against the hypothesis of spurious state dependence,' *Annals de l'INSEE*, **30**, 227–269.

Heckman, J. J. (1979), 'Sample selection bias as a specification error,' *Econometrica*, **47**, 153–161.

Henderson, R. (1993), 'Underinvestment and incompetence as responses to radical innovation:

evidence from the photolithographic alignment equipment industry,' *RAND Journal of Economics*, **24**, 248–270.

Henderson, R., A. Jaffe and M. Trajtenberg (1998), 'Universities as a source of commercial technology: A detailed analysis of university patenting 1965–1988,' *Review of Economics and Statistics*, **65**, 119–127.

Higgins, M. and R. Gulati (2000), 'Getting off to a good start: the effects of top management team affiliations on prestige of investment banks and IPO success,' working paper, Harvard Business School.

Hughes, E. C. (1958), *Men and Their Work*. Free Press: New York.

Jaffe, A. M. F. and B. Barks (1997), 'Evidence from patents and patent citations on the impact of NASA and other federal labs on commercial innovation,' NBER working paper 6044.

Jaffe, A. and M. Trajtenberg (1998), 'International knowledge flows: evidence from patent citations,' NBER working paper 6507.

Jensen, R. and M. Thursby (2001), 'Proofs and prototypes for sale: The tale of university licensing,' *American Economic Review*, **91**, 240–259.

Kaish, S. and B. Gilad (1991), 'Characteristics of opportunities search of entrepreneurs vs. executives: sources, interests, general alertness,' *Journal of Business Venturing*, **6**, 45–61.

Kennedy, P. (1992), *A Guide to Econometrics*. MIT Press: Cambridge, MA.

Larson, A. (1992), 'Network dyads in entrepreneurial settings: A study of the governance exchange processes,' *Administrative Science Quarterly*, **37**, 76–104.

Latour, B. (1987), *Science in Action*. Harvard University Press: Cambridge, MA.

Low, M. B. and I. C. MacMillan (1988), 'Entrepreneurship: Past Research and Future Challenges,' *Journal of Management*, **14**: 139–161.

McClelland, D. (1961), *The Achieving Society*. D. Van Nostrand: Princeton, NJ.

Merton, R. K. (1973a), *The Sociology of Science*. University of Chicago Press: Chicago, IL.

Merton, R. K. (1973b), 'The Matthew effect in science,' in N. W. Storer (ed.), *The Sociology of Science*. University of Chicago: Chicago, IL, pp. 439–459.

Nelson, R. R. and S. G. Winter (1982), *An Evolutionary Theory of Economic Change*. Harvard University Press: Cambridge, MA.

Neyman, E. (1977), 'Scientific career, scientific generation, scientific labor market,' in S. S. Blume (ed.), *Perspectives in the Sociology of Science*. John Wiley and Sons: New York, pp. 71–129.

Nohria, N. (1992), 'Information and search in the creation of new business ventures: the case of the 128 Venture Group,' in N. Nohria and R. G. Eccles (eds), *Networks and Organizations*. Harvard Business School Press: Boston, MA, pp. 240–261.

Olson, M. (1986), 'Comment on general discussion,' in S. Lindenberg, J. S. Coleman and S. Nowak (eds), *Approaches to Social Theory*, Vol. A. Russell Sage: New York.

Perrow, C. (1979), *Complex Organizations*. McGraw-Hill: New York.

Podolny, J. and T. Stuart (1995), 'A role-based ecology of technolgical change,' *American Journal of Sociology*, **100**, 1224–1260.

Reynolds, P. and S. White (1997), *The Entrepreneurial Process*. Greenwood Press: Greenwich, CT.

Rosenkopf, L. and A. Nerkar (2001), 'Beyond local search: boundary spanning, exploration, and impact in the optical disc industry,' *Strategic Management Journal*, **22**, 287–306

Schumpeter, J. (1934), *Theory of Economic Development*. Harper & Row: New York.

Shane, S. (2000), 'Prior knowledge and the discovery of entrepreneurial opportunities,' *Organization Science*, **11**, 448–469.

Shane, S. (2001), 'Technology opportunities and new firm formation,' *Management Science*, **47**, 205–220.

Shane, S. and D. M. Cable (2002), 'Network ties, reputation, and the financing of new ventures,' *Management Science*, **48**, 364–381.

Shane, S. and S. Venkataraman (2000), 'The promise of entrepreneurship as a field of research,' *Academy of Management Review*, **25**, 217–226.

Sorensen, J. B. (1999), 'Executive migration and interorganizational competition,' *Social Science Research*, **28**, 298–315.

Sorensen, J. B. and T. Stuart (2000), 'Aging, obsolescence, and organizational innovation,' *Administrative Science Quarterly*, **45**, 81–112.

Stinchcombe, A. (1965), 'Organizations and social structure,' in J. G. March (ed.), *Administrative Science Quarterly*. Rand McNally: Chicago, IL.

Strauss, A. L. (1959), *Mirrors and Masks*. Free Press: New York.

Stuart, T., H. Hoang and R. C. Hybels (1999), 'Interorganizational endorsements and the performance of entreprenurial ventures,' *Administrative Science Quarterly*, **44**, 315–349.

Thornton, P. (1999), 'The sociology of entrepreneurship,' *Annual Review of Sociology*, **25**, 19–46.

Tushman, M. and P. Anderson (1986), 'Technological discontinuities and organizational environments,' *Administrative Science Quarterly*, **31**, 439–465.

Utterback, J. (1994), *Mastering the Dynamics of Innovation*. Harvard Business School Press: Boston, MA.

Waldinger, R. D., H. E. Aldrich and R. Ward (1990), *Immigrant Entrepreneurs: Immigrant and Ethnic Business in Western Industrial Societies*. Sage: Beverly Hills, CA.

Zucker, L., M. Darby and M. Brewer (1998), 'Intellectual human capital and the birth of US biotechnology enterprises,' *American Economic Review*, **88**, 290–305.

Zuckerman, E. (1999), 'The categorical imperative: security analysts and the legitimacy discount,' *American Journal of Sociology*, **104**, 1398–1438.