# REVISITING THE SMALL-FIRM EFFECT ON ENTREPRENEURSHIP: EVIDENCE FROM FIRM DISSOLUTIONS

Aleksandra (Olenka) Kacperczyk

Matt Marx*

**Abstract:**

A frequent claim in the entrepreneurship literature is that employees learn to become entrepreneurs during paid employment. We revisit this mechanism in the context of the well-established finding that smaller firms generate higher rates of entrepreneurship. We propose a novel mechanism responsible for higher rates of entrepreneurship emanating from smaller firms: Large firms might have a relative advantage over small firms both in fostering and in retaining entrepreneurial talent. We test this claim in a setting where firm dissolution extinguishes internal opportunities, using a new hand-collected dataset of career histories in the automatic speech recognition (ASR) industry. For non-defunct firms, we replicate the "small-firm effect." However, the "small-firm effect" no longer holds within the subsample of defunct firms: entrepreneurship rates among individuals present at firm dissolution are in fact higher for larger firms. Additional analyses show that this effect is amplified for dissolved firms that are more innovative and that are spinoffs themselves. More broadly, the study emphasizes the need to consider a novel mechanism responsible for transition into entrepreneurship – the role of opportunities available to employees in incumbent firms.

* Both authors contributed equally.

## INTRODUCTION

A fundamental question in entrepreneurship is who becomes an entrepreneur and why. Research has suggested that entrepreneurs typically emerge from established firms and that prior career history has a significant impact on the decision to become an entrepreneur (Aldrich and Ruef, 2006; Dobrev and Barnett, 2005). Scholars have argued that the transition into entrepreneurship is driven by workers' experience in prior firms, in part because employees learn how to be entrepreneurs during paid employment. Because the transmission of entrepreneurial skills, aspirations, or knowledge is difficult to measure directly, scholars continue to debate which types of organizations and resources are more conducive to molding future entrepreneurs (e.g., Audia and Rider, 2006; Sørensen and Fassiotto, 2011).

These challenges are particularly salient in the context of a common finding that smaller firms spawn higher rates of entrepreneurship (Elfenbein, Hamilton, and Zenger, 2010; Gompers, Lerner, and Scharfstein, 2005; Sørensen, 2007; Wagner, 2004). Researchers have interpreted such findings to suggest that smaller organizations facilitate entrepreneurial entry because they are well positioned to equip employees with entrepreneurial skills, knowledge, and resources, whereas larger organizations have a stultifying effect on entrepreneurial ambitions. However, direct evidence for these supposed mechanisms is wanting. For example, Klepper (2009) argued that the existing theories are unable to explain why larger firms should generate fewer spinoffs.

We propose that the available empirical evidence is consistent with an alternative mechanism: that large organizations might in fact be better equipped both to mold—and yet retain—potential entrepreneurs. Larger firms may foster and retain entrepreneurial workers who might have little choice but to leave a smaller company. Consistent with our argument, a large body of organizational and strategy research suggests that large firms are equipped with superior access to information (Agarwal *et al.*, 2004) and ample spare resources (Penrose, 1959), commonly linked to an employee's pursuit of new ideas, ventures, and internal projects (Cyert and March, 1963; Schumpeter, 1950). Other research additionally implies that entrepreneurial talent may be subject to stronger retention in larger than in smaller firms because the former offer more support for the would-be entrepreneur's idea (Cohen and Klepper 1996;

Damanpour, 1992). Even if larger firms may be myopic or slow to react, their superior stock of resources and routines gives them the *option* to enable (and fund) such employee-generated initiatives. By contrast, a smaller firm may simply be unable to do so because its resources to support employees with new ideas are constrained. Given that the hazard of entrepreneurship decreases when internal opportunities to pursue new ideas, and advance one's career in paid employment, appear enticing (Anton and Yao, 1995; Hellman, 2007; Kacperczyk, 2012; Klepper, 2007), internal options in large firms might play a central role in reducing the rates of entrepreneurship emanating from those firms. Thus, it is difficult to discount the possibility that this alternative mechanism could drive the frequent observation that large firms generate lower rates of entrepreneurial ventures.

Disentangling the mechanisms underlying the influence of firm size on entrepreneurship presents a formidable challenge because researchers can rarely estimate such influence net of the impact of opportunities available to employees within paid employment. For example, because the availability and attractiveness of internal opportunities will likely vary over time and correlate with firm size, firm-fixed effect estimators fail to address this alternative. An ideal research design would be one in which such opportunities exert *zero* influence on the decision to become an entrepreneur. In our study, we focus on the organizational event that extinguishes internal opportunities: the dissolution of a firm. When a firm dissolves, workers are faced with the following occupational choices: They may seek employment at an established firm; they may remain unemployed; or, they may start a new firm. Because dissolved firms offer no retention opportunities to their former employees, it is possible to estimate more precisely the mechanisms behind the impact of firm size on the immediate decision to become an entrepreneur.

We test our claims in the empirical setting of the global automatic speech recognition (ASR) industry. We identify a number of firms that dissolved, thereby displacing a large number of technical and non-technical workers and extinguishing internal career opportunities. We track these employees' post-dissolution occupational choices and relate them to the size of the dissolved firm. Moreover, with our empirical approach it is possible to analytically compare the occupational choices of employees emanating from defunct firms to those of employees at non-defunct firms. For the latter group, internal

opportunities remain a viable mechanism that may influence an employee's occupational choice. With this research design, we are better able to draw causal inferences about the effect of small firms on an employee's transition to entrepreneurship.

## THEORY

### Prior Research: The Small-Firm Effect and Entrepreneurship

A growing line of research has examined the attributes and characteristics of prior employment to predict the likelihood of an employee's transition into entrepreneurship (for reviews, see Audia and Rider, 2006; and Sørensen and Fassiotto, 2011). A well-established finding is that entrepreneurs tend to emerge from smaller firms (Dobrev and Barnett, 2005; Elfenbein, Hamilton, and Zenger, 2010; Gompers, Lerner, and Scharfstein, 2005; Sørensen, 2007; Wagner, 2004). Scholars have interpreted this empirical pattern as evidence that smaller firms act as "training grounds" for would-be entrepreneurs. The general argument follows that, while working in smaller firms, employees acquire the skills, resources, and beliefs that foster entrepreneurship.

One argument within this body of work suggests that smaller firms expose employees to a greater variety of roles, commercial activities, and tasks in multiple functional areas. Such organizations are generally characterized by less stable structures, less routinized roles, and less developed internal labor markets (Baum and Oliver, 1991; Stinchcombe, 1965). These structures encourage employees to rotate through different functional responsibilities and to perform a wider range of jobs and tasks. An accumulation of varied skills and experiences is thought to predict transition to entrepreneurship, consistent with the "jack-of-all-trades" notion (Lazear, 2004). That is, knowledge in a variety of functional areas increases the probability of becoming an entrepreneur as well as the survival and success of a new venture (Astebro and Thompson, 2011; Wagner, 2004).

A related line of reasoning suggests that smaller firms may generate higher rates of entrepreneurship because they foster the values, attitudes, and aspirations generally conducive to entrepreneurial entry. A number of studies in sociology, organization theory, and strategy have linked

smaller organizations to autonomy, independence, and flexibility (Hamilton, 2000; Halaby, 2003; Astebro and Thompson, 2011). For example, past research has suggested that smaller organizations facilitate risk taking and autonomy because they are less routinized and less committed to established activities. Scholars have further invoked research on work conditions and personality to argue that employees in smaller, less bureaucratic firms have a stronger tendency to engage in complex and non-routinized tasks, linked to intellectual flexibility and creativity (Kohn and Schooler, 1982; Spenner, 1988). Because such personality traits are typically associated with the propensity to transition into entrepreneurship (McClelland, 1965), this argument has frequently been used to explain the higher rates of entrepreneurs spawned by smaller firms. The transmission of entrepreneurial attitudes and beliefs is thought to take place via interactions with coworkers and entrepreneurial peers within the workplace. For example, a number of studies have shown that workers reveal a higher likelihood of transitioning to entrepreneurship, when exposed to peers with past entrepreneurial experience (Kacperczyk, 2013; Nanda and Sørensen, 2010; Stuart and Ding, 2006). Employees in such organizations are more likely to become entrepreneurs because social influence might be easier to transmit within a smaller firm.

Finally, past studies have claimed that entrepreneurs emerge from smaller firms because such environments systematically expose workers to entrepreneurial opportunities. For example, employees in entrepreneurial firms gain exposure to valuable information about novel opportunities for markets and products (Elfenbein, Hamilton, and Zenger, 2010; Sørensen, 2007). Similarly, scholars have argued that smaller firm size facilitates employees' interaction with suppliers and buyers, providing access to the sort of heterogeneous information that has been shown to facilitate new-venture founding (Dobrev and Barnett, 2005; Shane, 2003). For example, Gompers, Lerner, and Scharfstein (2005: 612) argue that employees in a smaller workplace are better positioned to gain exposure to "a network of suppliers and customers who are used to dealing with startup companies." In short, the extant empirical evidence can be easily interpreted as indicating that employees are more likely to acquire the skills, knowledge, and resources conducive to entrepreneurship in smaller rather than in larger firms.

Although the association between prior experience at a smaller firm and entrepreneurship has

been established by a number of scholars in multiple disciplines, evidence for specific mechanisms underlying these empirical patterns has been in shorter supply. In fact, past studies have highlighted the conceptual and empirical limitations of the existing accounts. Elfenbein, Hamilton, and Zenger observed that "[m]ore work is necessary to show that employment in small firms leads individuals to develop better networks that facilitate entrepreneurship" (2010: 20). Similarly, Sørensen and Fassiotto noted that "[E]ntrepreneurial skills are difficult to measure and, indeed, to conceptualize clearly. Therefore, in the absence of a clear specification of 'what it takes' to be an entrepreneur, these types of learning accounts of the entrepreneurial entry decision are on shaky empirical ground" (2011: 1325). The lack of direct evidence that the transfer of entrepreneurial skills, resources, and beliefs indeed takes place in smaller organizations motivates our exploration of an alternative mechanism.

**Internal Opportunities in Large Organizations**

We propose that higher rates of entrepreneurship in smaller organizations need not necessarily reflect the abundance of opportunities in such firms. Rather, the observed empirical finding also is consistent with the following explanation: Large firms might serve as a breeding ground for the talent, information, and resources conducive to entrepreneurship, yet they are also more likely to lock up entrepreneurial talent and resources and thus prevent the formation of entrepreneurial spinoffs.

First, large organizations might foster entrepreneurial talent because they provide workers with superior access to information about novel, attractive opportunities that are germane to entrepreneurship. Scholars have argued that firm size is correlated with significant information advantage (Agarwal *et al*., 2004) due in part to a larger talent pool (Josefy *et al*., 2015), advanced information processing routines (Tushman and Anderson 1986), and superior access to networks of suppliers, customers, and alliance partners (Demirkan, Deeds, and Demirkan, 2013). Because large firms are simply stocked with more employees, they might generate opportunities for exchange and circulation of ideas. Along similar lines, because the talent pool is more extensive in larger firms, more workers with relevant expertise might co-found or join a startup, making the option of entrepreneurship more attractive *ex-ante* to employees in

larger firms. Given that access to superior information, expertise and knowledge is central to organizational founding (Gompers, Lerner, and Scharfstein, 2005; Klepper, 2007; Stinchcombe 1965), employees in large organizations are likely put at an advantage, when they decide to found a new venture.

Moreover, large organizations are disproportionately endowed with resources; as firms grow, they become less susceptible to resource allocation constraints (Lin, Yang, and Demirkan, 2007). Resource advantage may afford larger firms the opportunity to mold entrepreneurial employees because the availability of slack resources has been linked to employee experimentation and tolerance for failure (e.g., Cyert and March, 1963; Penrose, 1959; Schumpeter, 1950). Although scholars have associated firm size with numerous liabilities, including bureaucratization, complexity, and rigidity (Hannan and Freeman, 1984; Shaver and Mezias, 2009; Weber, 1978), evidence exists to also suggest that spare resources in large firms reduce performance standards, encouraging worker's ability and willingness to innovate (Haveman, 1993; Jelinek and Schoonhoven, 1990). In a similar vein, large firms have been characterized by more developed internal labor markets (Baron, Davis-Blake, and Bielby, 1986; Piore and Doeringer, 1971), which can more effectively shelter individuals from considerable risks associated with new-venture formation, since they can redeploy employees who fail at new projects to other tasks and jobs within the firm (Kirzner, 1973).

But while larger firms are more likely to breed the kind of talent, opportunities, and resources that foster entrepreneurship, they may also be more able to retain would-be entrepreneurs. The extant literature lends credence to this possibility by suggesting that larger organizations offer richer and more attractive options to their employees. Such internal options exert a crucial influence on the decision to enter entrepreneurship. Scholars have linked attractive options in paid employment to a higher opportunity cost of becoming an entrepreneur (Amit, Muller, and Cockburn, 1995). Numerous studies have further suggested that the attractiveness of the internal opportunity structure reduces the likelihood of transitioning to entrepreneurship (Anton and Yao, 1995; Hellman, 2007; Kacperczyk, 2012; Pakes and Nitzan, 1983). Sørensen & Sharkey (2014) operationalize the notion of opportunity structures by measuring the wage ceiling in a given firm, finding that employees at firms with a higher maximum wage

have lower rates of entrepreneurship. Their result reinforces the notion that the decision to become an entrepreneur depends critically on the opportunities available in the current firm; hence, firms that have less to offer their employees, including small firms likely with fewer resources, will be more likely to lose employees to potentially lucrative paths such as entrepreneurship.

There is a strong rationale to expect that internal options are more enticing in larger than in smaller firms because the latter have significant advantage for executing new projects and assimilating employee-generated ideas. Numerous studies found that firm size is correlated with established routines, competencies, and product development experience (Damanpour, 1992; Penrose, 1959; Schumpeter 1950). There is further evidence that large firms have more products in development and in the market in part because the cost of R&D can be recouped more quickly due to economies of scope, scale, and learning (e.g., Baumol, 1959; Cohen and Klepper, 1996), and because the risk of new product-development is often spread via diversified portfolios (Dobrev and Carroll, 2003). Finally, large organizations may have better guards against employees' departures for entrepreneurship. Because of their influence, resources, and market power, large organizations have the ability to effectively lobby public policies (Schuler, Rehbein, and Cramer, 2002) and respond to the legal environment (Dobbin *et al*., 1993), more generally. Given their resources, large firms might more easily enforce non-compete or other employment agreements, which reduce job mobility (Marx, Strumsky, and Fleming, 2009). Hence, such influence likely plays a critical role in preventing employees from walking out of the door to start their own ventures.

By contrast, smaller firms are constrained by scarce resources, a smaller talent pool, and limited access to valuable information. Small organizations are less likely to have external networks of clients, supporters, and customers (Hallen, 2008), which reduces their ability to access valuable know-how. Indeed, Sorenson and Audia (2000) found that nascent entrepreneurs tend to locate close to their prior employers in order to acquire the necessary knowledge – consistent with the claim that smaller startups are systematically faced with difficulties when accumulating valuable knowledge assets. Along the same lines, others have found that smaller organizations face significant challenges when raising capital, or

competing for qualified labor and navigating complex government regulations (Aldrich and Auster, 1986). Hence, constraints on financial and human resources might limit the ability of employees in small firms to develop their own projects independent of managerial supervision, or to draw on organizational resources in case they transition to entrepreneurship.

In addition, employees with entrepreneurial potential are less likely to be subject to retention in smaller firms. Unlike their larger counterparts, smaller organizations are less well equipped to promote and accommodate employee-generated ideas given their limited resources. Employees seeking to commercialize their own ideas might therefore find such organizations less appealing and less attractive. Similarly, smaller firms might be less effective in locking entrepreneurial talent because they cannot afford litigation costs, in case an employee leaves to found a spinoff. Simply put, the opportunity cost of leaving for entrepreneurship might be lower for employees of smaller than of larger firms. Collectively, these different studies imply that smaller firms may generally lack the types of information processes and resources that breed and retain entrepreneurial talent.

Given the past literature, one cannot easily dismiss the possibility that large firms might not only foster entrepreneurial talent but also be more adept at retaining such talent. Because past research has not ruled out this alternative explanation behind the small-firm effect, our study explores a novel causal process that might be at work when smaller organizations appear to be responsible for higher rates of entrepreneurship.

**Organizational Dissolution and the Impact of Firm Size on Entrepreneurship**

Differences in the internal opportunity structure of larger and smaller firms may confound the negative effect of firm size on entrepreneurial rates. Therefore, the impact of firm size on entrepreneurship should be examined in a context in which internal opportunities are absent and entrepreneurial talent is not subject to retention. One organizational event that leads to the extinction of internal opportunities is the dissolution of a firm. Prior research has used firm dissolution to explore a range of occupational choices (e.g., Haveman and Cohen, 1994), but few studies have linked organizational dissolution to an

employee's decision to transition into entrepreneurship. Hence, we focus on the entrepreneurial rates emanating from dissolved firms in which internal opportunities are by definition vanquished. Our argument is simple: When workers' career calculus is not influenced by the attractiveness of opportunities within their current employment – which might bias individuals at large firms against transitioning to entrepreneurship – it is possible to examine the processes underlying the purported small-firm effect on entrepreneurship. If larger firms indeed have an advantage in fostering and retaining entrepreneurial talent, our baseline expectation is that smaller firms will generate higher rates of entrepreneurship. However, we also expect this tendency to reverse following a firm's dissolution, which removes internal options and reduces the opportunity cost of leaving for entrepreneurship. A firm dissolution releases numerous resources, including intellectual property, information, employees, and customers (Hiatt, Sine and Tolbert, 2009; Haveman and Cohen, 1994) – all of which might be conducive to entrepreneurial entry. Because those resources are more abundant in larger than in smaller firms, we expect employees of the former to be more likely to enter entrepreneurship, following a firm dissolution. Hence, we predict that:

> H1: *Entrepreneurial rates for employees emanating from smaller firms will be higher than entrepreneurial rates for employees emanating from larger firms.*
>
> H2: *Following firm dissolution, entrepreneurial rates for employees emanating from larger firms will be higher than entrepreneurial rates for employees emanating from smaller firms.*

The notion that large organizations are better positioned to both generate as well as retain the kinds of resources, knowledge, and talent conducive to entrepreneurial entry is central to our argument. If this mechanism drives the positive effect of firm size on entrepreneurship, employees in organizations and positions enabling such transmission should reveal a higher likelihood of entrepreneurial transition. First, the positive effect of firm size on entrepreneurship for defunct firms will be amplified in more innovative parent firms: By default, employees will be more likely to engage in new-project development in large organizations with a greater focus on innovation. The predicted effect will be stronger when resources earmarked for new-project development, including technical know-how, are more readily available in larger firms. Hence, we expect the positive impact of firm size on entrepreneurial entry to be

systematically greater in parent firms that are more innovative.

> H3a: *Following firm dissolution, the positive impact of firm size on entrepreneurial rates for defunct firms will be amplified for more innovative parent firms.*

Moreover, we consider whether the impact of firm size on entrepreneurial rates varies systematically depending on whether the parent firm is an intra-industry "spinoff." Researchers have suggested that spinoffs are equipped with better-quality know-how because they inherit distinctive knowledge (e.g., Agarwal *et al*., 2004; Klepper and Sleeper, 2005). Ample resources and new technology are often transferred to intra-industry spinoffs (for a review see Klepper, 2009) and the latter tend to outperform *de novo* startups as well as incumbent firms in part because they exploit the inherited knowledge (e.g., Klepper, 2007; McKendrick, Wade, and Jaffe, 2006; Phillips, 2002). For example, Klepper (2007) found that prominent automobile firms generated longer-lived spinoffs, presumably due to their heritage. If larger firms generate lower rates of entrepreneurship because they are better equipped with technological know-how, the positive effect of firm size on entrepreneurship for defunct firms will be amplified for parent firms that are themselves intra-industry spinoffs.

> H3b: *Following firm dissolution, the positive impact of firm size on entrepreneurial rates for defunct firms will be amplified for parent firms that are intra-industry spinoffs.*

Finally, we expect the positive effect of firm size on entrepreneurship to increase for workers in the types of organizational roles and positions conducive to the acquisition of technological knowledge, skills, and resources. Past research indicates that employees in technological roles are particularly likely to pursue entrepreneurship, because they are more easily exposed to new technologies and ideas that are often leveraged and commercialized via startups (Anton and Yao, 1995; Shane, 2003). Hence:

> H3c: *Following firm dissolution, the positive impact of firm size on entrepreneurial rates for defunct firms will be amplified for workers in technical roles.*

## DATA AND METHODS

### Empirical Strategy: Organizational Dissolution and Internal Opportunities

Drawing credible causal inferences about the mechanisms we hypothesized raises empirical challenges. First, internal opportunities are rarely visible to researchers. More importantly, even if internal options

can be observed it is still nontrivial to account for the differential attractiveness of such across firms and to different workers. Plausible inferences would require a large-scale sample in which internal opportunities could be precisely measured over time and across firms. Given such challenges, few researchers have attempted to examine the potential impact of internal opportunities across large and small firms on entrepreneurial rates. Here, we extend the scarce research on the role of internal options in driving entrepreneurship, by focusing on the internal opportunity structure. With this novel approach, we address the fundamental challenge limiting prior research: the possibility that less attractive opportunities within smaller firms may cloud prior causal inferences.

Because internal opportunities are notoriously difficult to measure, a cleaner way to estimate the effect of firm size on entrepreneurship rates is to identify a setting in which internal opportunities are unlikely to affect occupational choice. One possibility would be to analyze the entrepreneurial transitions of workers who are terminated or otherwise involuntarily discharged by their employer. Aside from the difficulty of obtaining data on the reason for termination, such ex-employees' choices might be confounded with the potential for stigmatization in the labor market (Gibbons and Katz, 1991). Instead, we focus on the dissolution of the firm, a setting where the employer does not have discretion with whom to discharge and thus labor-market stigma is less likely to confound identification. Hence, we examine entrepreneurship rates emanating from firms in which internal opportunities are by definition absent. We further track post-dissolution occupational choices, both the transition to entrepreneurship as well as obtaining employment at established organizations. Accordingly, we are able to compare the rates of entrepreneurship from defunct firms to the rates of entrepreneurship emanating from non-defunct firms. Before proceeding, we note three potential threats to identification.

First, even though ex-employees of failed firms are less likely to be stigmatized than individuals terminated at the discretion of a firm continuing to operate, such labor-market discrimination is nonetheless plausible (Hambrick and Mason, 1984; Sutton and Callahan, 1987). Given that said stigma would likely be stronger for employees of small firms, where one could more reasonably ascribe failure to the actions of individual employees, one concern might be that ex-employees of smaller defunct firms

tend to become entrepreneurs because they are blocked from opportunities within paid employment. Though plausible, this possibility would bias against our expected finding.[1]

Second, dissolved firms may be systematically different from non-dissolved firms. One could argue that large firms fail infrequently; those that do are likely to differ profoundly. Such unobserved differences may be problematic to the extent that they lead to a spurious correlation between firm size and the rate of entrepreneurship. We undertake a set of additional analyses to alleviate the concern that our effect is mainly driven by workers' selection into likely-to-fail firms.

Third, in an ideal experiment the evaporation of internal opportunities would be exogenous to the employees remaining at the time of firm dissolution. Reliable inference would be questionable if employees could calibrate the timing of the firm's dissolution according to their own external opportunities. While this seems unlikely for most employees, it is possible that the CEO of an ailing firm may be able to exercise some discretion in timing the shutdown (subject to negotiations with the board). Accordingly, in our analyses we establish that results are not driven by the CEOs of defunct firms.

**Empirical Context**

For our study we use a new, hand-collected dataset of career histories in the automatic-speech recognition (ASR) industry. While ASR technology has become more salient recently with the popularity of applications including Siri and Dragon NaturallySpeaking, the industry dates back several decades. Arguably the first speech recognition product was "Radio Rex", a mechanical dog that would merge from a doghouse in response to detecting the 500 MHz frequency corresponding to the 'eh' vowel. The primitive system not only had a one-word vocabulary ("Rex") but did not work reliably for female or youth speakers, whose vocal tracts were not modeled. More capable speech recognition systems began to be developed in the early 1950s, when AT&T and IBM undertook independent research efforts with quite

[1] One might argue that the more relevant form of discrimination against ex-employees of defunct firms is by venture capitalists and other resource providers. We note, however, that external funding is hardly a requirement for *starting* a new firm; indeed, most ASR firms did not raise venture capital.

different aims. IBM, then a typewriter company, sought to build a "talking typewriter" while AT&T was more focused on automating telephonic operator services. Correspondingly, AT&T Bell Laboratories demonstrated a system capable of recognizing the digits 0-9. Unlike modern systems, however, the digits needed to be spoken one at a time (i.e., in isolation).

Other research labs and universities followed suit, and by the 1960s efforts were underway in the UK and Japan. Most research was undertaken by labs of diversified companies, though in 1970 Threshold Technology was spun out of RCA Labs as the first company wholly focused on commercializing the technology. It was not until nearly three decades after IBM and AT&T commenced their own research efforts that the U.S. government began to fund basic research in speech recognition via the Defense Advanced Research Projects Agency, sponsoring annual "bakeoffs" to evaluate the performance of grant recipients' technologies.

The industry grew substantially in the 1990s, at least in terms of population density as many *de novo* startups obtained venture capital funding. However, investor expectations frequently fell short when the technology did not live up to expectations, leading both Kurzweil Technologies and Lernout & Hauspie to falsify revenue figures. Founders Jo Lernout and Pol Hauspie along with Kurzweil CEO Bernard Bradstreet served jail time for securities fraud. Still, companies like SpeechWorks and Nuance Communications completed initial public offerings, and the technology was widely adopted for telephone self-service applications, replacing touch-tone input. Indeed, the technology has been used for many purposes including desktop dictation, Web searching on mobile phones, transcription of audio broadcasts, command-and-control of household devices, and control of mobile phones (e.g., Siri and Cortana).

The ASR industry is an attractive setting for this study, and we join a line of work that exploits a single industry to shed light on high-tech entrepreneurship (e.g., Khessina and Carroll, 2008; Klepper and Sleeper, 2005). Workers in the ASR industry tend to be highly skilled and specialized since many speech recognition engineers obtain a Ph.D in the field or spend years learning the algorithms used to build a phonetic representation of a stream of audio. That the industry requires substantial human capital is relevant because the opportunity cost of leaving paid employment in pursuit of entrepreneurship is likely

higher for specialized workers who have attractive opportunities within paid employment. Moreover, barriers to entry in ASR are relatively high because growing a new venture and competing with other firms requires substantial capital and qualified personnel. Hence, relative to industries with lower human capital, ASR workers might be more likely to consider internal opportunities as a viable alternative to entrepreneurship. Hence, our conclusions are probably most applicable to technology-based industries; it may be that workers with lower levels of human capital or in industries where starting a firm is simpler (i.e., restaurants) may exhibit different patterns.

**Data Sources**

The first step in assembling career histories in the ASR industry was to create a list of firms. One of the authors, along with several research assistants, hand-coded more than 10,000 pages of several industry newsletters spanning the years 1981-2010. Since 1984, each year is covered by multiple newsletters except for 1986 and 1992. (Commercial activity before 1980 was limited; results are robust to dropping pre-1980 observations). Trade journals were 30-50 pages in length and contained no advertising. While we cannot guarantee that these trade journals covered every firm that has ever been founded in the industry, they contained reports on even obscure, short-lived firms. Hence, our data-collection process was unlikely to systematically exclude smaller organizations; indeed, organizations with fewer than 10 employees constitute 25% of our sample.

ASR firms are deemed active as of the first month they appear in a trade journal. Firms are deemed dissolved when so reported in the trade journals. If the trade journals did not explicitly report a firm dissolution, we checked corporate websites to see whether they were active as of December 2010. If not, we consulted various Internet resources to determine the date of exit. Any firms found not to be in operation as of December 2010 but for whom an exact exit date could not be found were labeled as having exited the month after their final coverage in the newsletters. Having assembled the list of firms in the industry, the next step was to collect the list of workers. These were sourced from several sources, beginning with the newsletters themselves.

***Industry Newsletters***. After the industry newsletters had been coded to retrieve the names of firms in the industry, a research assistant re-coded them to extract employment histories. Articles were deeply sourced, often interviewing company principals and generally listing a contact name. These trade journals are a reliable source of information on outward-facing workers including executives, sales and marketing personnel as well as prominent technologists. An advantage of the trade journals is that they tend to mention workers repeatedly over time, while a disadvantage is that the trade journals generally do not mention jobs held outside of the industry by these workers. (We fill in non-ASR jobs from other sources.)

***Conference Proceedings***. Several annual convocations of ASR researchers are held annually, including Eurospeech and the International Conference on Acoustic Speech and Signal Processing (ICASSP). From the proceedings of these conferences, author names and affiliations were extracted, noting the date of the conference. While most attendees are from universities, firms also send researchers to the conferences. Like the trade journals, these do not report jobs held at non-ASR firms.

***Capital IQ.*** We retrieved biographies for founders and other executives of all ASR firms and coded them to obtain information on other firms where those executives worked, including non-ASR firms. Where dates were missing from the biographies, these were filled in wherever possible using internet sources.

***U.S. Patents.*** Many mobility studies have used patents to establish the sequence and timing of inventors' employment (Agrawal, Cockburn, and McHale 2006; Almeida and Kogut 1999; Breschi and Lissoni 2009; Tratjenberg, Shiff, and Melamed 2006). Assuming that names can be disambiguated, patents are an attractive data source because career histories can be tracked across multiple firms where they have patented. A disadvantage is that patents are not submitted at regular intervals (as with the ASR conferences), a limitation compensated for by combining patent data with other sources. Using the Dataverse patent data (Lai, *et al.*, 2011), a list of inventors with patents in the ASR industry was constructed. This involved extracting all patents for *de novo* firms, but for *de alio* entrants, only patents in USPTO class 704 (Data Processing: Speech Signal Processing). For these ASR inventors, all of their patents at any firm and in any class were extracted as one source of information about non-ASR jobs.

***Internet Sources.*** Internet sources including ZoomInfo, Bloomberg BusinessWeek, CrunchBase, elsnet (an ASR historical repository), and company websites were used for two purposes. First, they yielded additional names of people who worked in the ASR industry. ZoomInfo was particularly useful in this respect as it automatically assembles career histories from Internet-based sources including press releases, company websites, and 10-K filings. All workers captured by ZoomInfo for *de novo* ASR firms (i.e., companies focused primarily on speech recognition) were extracted. As with the trade journals, these sources are probably best at capturing outward-facing personnel likely to be listed on company websites or quoted in the media. Second, ZoomInfo and other Internet sources were useful for establishment employment histories for names collected from various sources.

Our sample includes 7,841 workers who held a job at one or more firms in the speech recognition industry—again, either at a *de novo* ASR company or performing ASR-related activities within a *de alio* firm. The career histories were then extended to include jobs outside the ASR industry. Non-ASR firm characteristics were retrieved from the NETS panel of Dun & Bradstreet data (Walls & Associates, 2013). All firm names, including firms outside the ASR industry, were checked by hand so that like firms were assigned the same unique identifier. The next step was to disambiguate worker names between the patent, conference, trade journal, and Internet sources. This was done first by automatically pruning name suffixes and prefixes such as “Dr.” and “Jr.” and then resolving nicknames such as “Bob” and “Robert.” Names were then sorted by first initial and last name, further variations checked by hand to resolve spelling inconsistencies, hyphenated names, etc. Although this does not represent a complete census of ASR workers, the data probably represent well executives and inventors. Coverage of HR or other “back office” support workers may be less complete, though ZoomInfo contained a large number of employees in non-executive, non-technical roles as well as less prominent technical workers like QA staff.

**Dependent Variable**

Our dependent variable captures founding a new firm (whether within the ASR industry or outside). As an example, consider the career of Karl-Heinz Land, who has held five jobs at the following firms:

Business Objects (March 1994–January 1996), Microstrategy (March 1996–January 2000), Angel.com (June 2000–March 2001), VoiceObjects (April 2001–May 2006), and GrandCentrix (October 2007–present). Of those firms, Angel.com and VoiceObjects are in the ASR industry, but we analyze all transitions from one firm to another. As Land founded the ASR firm VoiceObjects and had previously worked at the ASR firm Angel.com, our dependent variable coded "1" for the transition from Angel.com to VoiceObjects. Jonathan Taylor founded the ASR company Voxeo after leaving MediaGate, which was not an ASR company. Jonathan VerMeulen founded the non-ASR company Optisave after leaving the ASR company Price Interactive. All such founding events are considered. We identify 603 such entrepreneurial events.

**Explanatory Variable**

Our key explanatory variable is the size of the worker's prior firm, measured as the number of employees in a given year. We count employees primarily by using headcount reported by Dun & Bradstreet (Walls & Associates, 2010). For non-U.S. firms and a small number of U.S. firms where Dun & Bradstreet is not available, we instead use the count of employees we collected from various sources. For robustness, we replace the Dun & Bradstreet measure for *de alio* firms with our own employee count (in order to more accurately portray the number of ASR-related opportunities as opposed to all opportunities in a large multidivisional firm) – but we find the same results. Finally, our results are recovered even when we exclude non-U.S. firms.

**Control Variables**

Our analysis accounts for both firm-level and worker-level covariates. Following prior research, we capture the year of entry and compute firm age as of the observation year. Dummies for *de alio* and intra-industry spinoffs within the ASR industry are also included. We additionally control for the annual number of unique patents in the focal firm. Worker-level controls include the number of firms where the individual worked to date, including both ASR and non-ASR firms. The count of patents at the prior firm is also captured and coded as "1" if a worker holds more than one patent in an organization, and "0"

otherwise. Moreover, we control for worker's organizational tenure, measured by the number of years spent at that firm. We interpolate workers' ages by subtracting the year of their first job from 2013 and adding 21 as a likely age of entering the workforce. We also capture whether the employee was a CEO or had a technical role, as identified by matching for keywords ("engineering", "software", "Chief Executive", etc.) in the worker's job title.

Finally, we generated a gender indicator by matching first names against a list of approximately 85,500 first names determined by GenderChecker.com to be reliably assigned to one gender. A research assistant then searched for photos and personal pronouns using the combined first and last names of the workers in our sample whose first names were not found among the list from GenderChecker.com. In all, gender was determined for 95% of ASR workers; results are robust to eliminating the variable.

Descriptive statistics are in Table 1. Observations are moves from one firm to another, so workers who are only ever observed at a single firm are excluded. Moreover, we drop dyads separated by more than two years in cases when the individual's entire career history was gathered from the trade journals or conference proceedings, which lack information on non-ASR jobs. The final number of observations is 26,463 moves.

**Model Specification**

Because the dependent variable is dichotomous, the following logistic regression model is estimated to assess the effect of firm size on entrepreneurship:

$$k = \log \frac{p}{1 - p} = a + C'b$$

where κ represents the linear transformation of the log of the probability, $p$, of the dependent variable occurring divided by the probability of the variable not occurring. The dependent variable is defined as an individual's transition to entrepreneurship and coded "1" if an individual founded a new organization, and "0" otherwise. The model estimates are a constant $\alpha$ and $\beta$, estimated coefficients of X, a vector of the independent and control covariates. Throughout all model specifications the error terms are

clustered at the organization's level to account for autocorrelation.[2] Linear models return similar results.

## RESULTS

We begin by replicating prior results regarding firm size and the likelihood of becoming an entrepreneur (e.g., Elfenbein *et al*., 2010; Gompers *et al*., 2005; Kacperczyk, 2012; Sørensen, 2007). Figure 1 shows that, consistent with the findings of prior scholars, workers at smaller firms are considerably more likely to transition to entrepreneurship. This univariate analysis does not control for possibly confounding factors, which we explore in Table 2. Table 1 reports descriptive statistics and correlations for the main variables for the full sample and the target sample (i.e., defunct firms).

[Insert Figure 1 and Table 1 about here]

In Column 1 of Table 2, we explore the association between our variables and the transition to entrepreneurship. Firm-level covariates influence entrepreneurship in several ways. Consistent with past research (e.g., Elfenbein *et al*., 2010; Kacperczyk, 2012; Sørensen, 2007), we find that that firm age is negatively correlated with the hazard of becoming an entrepreneur. Moreover, parent firms that themselves are ASR spinoffs generate higher rates of entrepreneurs, suggesting the role of technical knowledge in driving entrepreneurial rates. Relatedly, the results show a negative and significant coefficient on parent firms that are *de alio* entrants. The results further reveal the impact of individual-level covariates on entrepreneurship. Workers in the CEO position and those with longer firm tenure are at higher risk of becoming entrepreneurs. Female workers and those in technical roles are less likely to start new ventures. Consistent with prior literature, the coefficient on firm size is negative and with statistical significance at the 0.1% level ($p<0.001$), providing support for our baseline hypothesis (H1). Exponentiating the coefficient on firm size suggests that larger organizations reduce the founding rate of startups: the odds ratio of becoming an entrepreneur is 11.1 percent lower for each standard-deviation increase in logged firm size. The economic significance of the firm size effect on entrepreneurship is

[2] For robustness, we cluster standard errors by individual and find similar results.

comparable to that found in other studies. For example, using the Danish Integrated Database for Labor Market Research, Sørensen (2007) finds that a one standard-deviation increase in employer size (relative to the industry's size distribution) lowers the rate of entrepreneurship by almost 18 percent. Using data on scientists and engineers, Elfenbein, Hamilton, and Zenger (2010) show that individuals in firms of size 1–25 employees transition into self-employment at a rate that is more than three times the average rate in the sample. This replication suggests that our dataset is not markedly different from those in prior cross-industry studies, at least regarding the small-firm effect on entrepreneurship.

Subsequent columns test the robustness of these findings to alternative specifications. Column 2 confirms that our replication of the small-firm effect in our full sample of firms is not primarily driven by a handful of outliers that spawned disproportionately many entrepreneurs. We exclude from this model firms that spawned more than three spinoffs, including IBM (8), Stanford Research International[3] (6), and Nuance Communications (4). The coefficient on firm size when omitting these firms (8% of observations) retains the magnitude from Column 1 as well as similar statistical significance, confirming that our replication of the small-firm effect is not driven by an unusual concentration of entrepreneurial activity among a small number of "parent" firms. (Moreover, an unreported model excluding *any* firm with more than one spinoff yields results similar to those in Column 1). In Column 3, we address the concern that the result might be an artifact of analyzing a subset of the database with smaller firms (as defunct firms may be smaller than successful ones). Here, we restrict our risk set to the defunct firms as well as non-defunct firms that can be matched with defunct firms according to size. We implement Coarsened Exact Matching (Iacus, King, and Porro, 2009) with cutpoints at the median, third quartile, top decile, and top percentile. Doing so excludes a relatively small fraction of observations from the full sample, addressing a potential concern that the results in Column 2 might be driven by a number of employees at very large firms not becoming entrepreneurs due to a relative wealth of internal opportunities. The results in Column 3 are recovered regardless of whether we match on firm size by quartiles, equally spaced buckets

[3] SRI is a private firm with no commercial relationship to Stanford University.

(whether 5 buckets, 10, and 20—all yielded similar results), or an entirely hands-off approach in which the CEM software automatically determines how the matching should occur.

Finally, in Column 4, we re-estimate the baseline specification of Model 1 with the event-history analyses. These analyses account for temporal variation in the probability of transition to the focal outcome (McFadden, 1973). We model the hazard rate with semiparametric Cox model, a common approach to conduct event-history analyses (e.g., Box-Steffensmeier and Jones, 2004). We define duration as time (in years) elapsed since an individual entered the sample or the time since the last transition. Because repetitions of events are possible, an individual was re-entered into the risk set once he or she chose to transition to entrepreneurship. A concern with this design is the potential lack of independence between repeated transitions, as second transitions are likely to be influenced by and therefore differ from first transitions, possibly leading to biased estimates. We assuage this concern by re-estimating models to examine time to first transition only, with similar results. Moreover, because virtually all individuals are represented more than once, this may lead to inflated *t*-statistics of the effects of individual-level characteristics. We therefore adjust for clustering standard errors at the individual level to provide robust variance estimates (Lin and Wei, 1989). The results in Model 4 are robust: the coefficient of firm size is negative and statistically significant at the 0.1% level ($p<0.001$). In additional (unreported) analyses, we also re-estimate Models 2-3 using the event-history analysis. All results are all robust to the alternative specification.

[Insert Table 2 about here]

**Analyses of Dissolved Firms**

Having replicated prior findings regarding firm size and transition to entrepreneurship, in Table 3 we employ our primary empirical strategy of restricting analysis to workers who lost their jobs when firms failed. As mentioned earlier, failed firms are those ceasing independent operations. Dissolution can occur either when a firm is liquidated, as in the case of General Magic's June 2002 bankruptcy and layoff of its eighty employees, or in the case of a "fire sale" where employees are not transferred to the acquirer. As an example of the latter, Telesoft acquired "certain assets and intellectual property rights" of ThinkEngine

Networks in March of 2009, with comments in the press release by Telesoft CEO Bruce Markham but not from ThinkEngine. Moreover, two ThinkEngine executives founded CallMiner shortly thereafter.

As our identification strategy depends on the removal of internal-to-the-firm opportunities, it is not sufficient to subset our analysis to employees of defunct firms. Rather, our risk set is composed only of those employees who were still present at the time of the dissolution (specifically, we find a record of their employment at the firm in the same or prior year of the demise, and we do not find a record of that same employee at another firm immediately prior to the demise). We found 2,244 employees who were present at the time of their employers' demise. Whereas in the overall dataset each worker may have multiple observations (and at multiple firms), in this analysis we consider only one observation per person: The job taken following the demise of the firm.

Columns 1-3 in Table 3 report the results of logistic regressions re-estimated for a target subsample of defunct firms to assess the sign of firm-size coefficient within this subsample. The results show that technical and female workers continue to be more likely to become entrepreneurs, as in the full sample. Adding the covariate for firm size in Column 2 reveals that, in sharp contrast to Table 2, employees who remained at larger firms until their dissolution were *more* likely to become entrepreneurs. Moreover, the coefficient on firm size is statistically significant at the 5% level ($p<0.035$). Exponentiating the coefficient on firm size indicates that a one standard deviation increase in logged firm size is associated with a 12.7% increase in the odds ratio of becoming an entrepreneur—almost precisely the inverse of the results from Table 2. This reversal from the result in the full population supports H2, suggesting that large organizations equip their employees with resources, skills, and knowledge conducive to entrepreneurship and that such employees are more likely to be retained in the firm.[4]

[4] Our results differ from Sørensen's (2007) "displaced" workers, among whom he finds patterns similar to the full population. It is difficult for us to compare these results, as his regression analyses are unreported. We note however that in our first attempt to perform such an analysis using Dun & Bradstreet markers for defunct firms, we found results similar to Sørensen (2007) but noticed that many of the firms labeled defunct by D&B either had been acquired or were still in operation. As we had access to the names of the firms, we were able to inspect them individually online to establish their corporate history and outcomes. That said, another explanation for the differences in our findings regarding displaced workers may be our focus on a high-tech industry, whereas the Danish census data covers myriad industries of varying technological intensity.

[Insert Table 3 about here]

We further hypothesized that the impact of firm size on entrepreneurial transitions following firm dissolution will be amplified for parent firms that are more innovative and that themselves are technological spinoffs; and workers in technical roles. In Column 3, we interact firm size with those three measures. The results presented in Column 3 offer partial support to our predictions. First, lending support to H3a, findings indicate that the positive effect of firm size on entrepreneurship is amplified for more innovative parent organizations. We measure innovativeness as the number of patents per technical worker. Adjusting for the number of employees in technical roles (and thus at risk of patenting) affords a better measure of innovativeness, whereas an unadjusted count of patents may be correlated with firm size.

The coefficient on the number of patents per technical worker interacted with firm size is positive and significant at the 5% level ($p<0.035$), which we interpret as support for H3a. Moreover, Column 3 shows a positive and statistically significant interaction term with size for firms that were spinoffs within the ASR industry ($p<0.026$), lending support to H3b. However, we do not find support for the notion that the influence of firm size on entrepreneurship is relatively stronger for employees in technical positions; the coefficient is negative and only weakly statistically significant ($p<0.066$).

Of course, interpreting interaction terms in non-linear models is not straightforward. Following Greene (2009), in Figure 2 we explore the marginal effect of the interaction term graphically by plotting predicted probabilities for various values of the interacted variables, with other covariates held constant. Panel A graphs the predicted transition to entrepreneurship by firm size and firm innovativeness for low, medium, and high values of the number of patents per technical worker. Graphing the interaction terms reveals that the effect of firm size on transition to entrepreneurship increases most progressively for highest levels of firm innovativeness. Panel B graphs the predicted effect of firm size on transition to entrepreneurship by whether the parent firm is a spinoff. As seen in this figure, the effect of firm size on transition to entrepreneurship becomes progressively more positive for the parent firms that are spinoffs,

consistent with our hypothesis H3b.[5]

[Insert Figure 2 about here]

In Column 4 of Table 3, we re-estimate the baseline specification in Column 3 on the full sample of defunct and non-defunct firms. Here, we interact firm size with a dummy indicating whether a firm was defunct to directly assess the effect of firm size on entrepreneurship across defunct and non-defunct firms. As when analyzing the full sample in Table 2, the coefficient on firm size is negative and statistically significant at similar levels. Consistent with our prediction, the interaction term is positive and highly significant ($p<0.001$), suggesting that the association between firm size and transition to entrepreneurship is amplified for defunct firms relative to non-defunct firms. This finding confirms the result from Column 2 estimated on a subsample of defunct firms. In unreported results, we re-estimate the model for the entire sample but now matching firms with respect to size, with consistent results.

Overall we are able to replicate the commonly-found "small-firm effect," but when we restrict our analyses to observe workers in dissolved firms alone, the results reverse. We find that employees of smaller organizations are *less* likely to transition to entrepreneurship, when faced with a firm dissolution and the accompanying extinction of their internal opportunities. These results suggest that higher rates of entrepreneurship emanating from smaller firms might not necessarily reflect the training and retention of entrepreneurial employees. Rather, we expect that larger organizations will both mold employees into entrepreneurs yet offer more appealing internal opportunities to retain them.

**Alternative Explanations**

An important concern is that our results might reflect systematic sorting. This argument may seem particularly credible because established firms vary in the extent to which they reveal entrepreneurial tendencies and such tendencies may have a direct impact not only on the retention but also the selection

[5] In unreported analyses available from the authors, we used the algorithm for interaction terms in non-linear models, as recommended by Ai and Norton (2003). This method computes the correct marginal effect of a change in two interacted variables by calculating the cross-partial derivatives required to evaluate a single two-way interaction effect for each observation. Our results were robust to this correction.

of entrepreneurial workforce (Driori, Ellis and Shapira, 2013). First, individuals with systematically different characteristics may self-sort into organizations that are at higher risk of dissolution. For example, risk-taking employees might both choose to work in likely-to-dissolve firms and to become entrepreneurs, following the dissolution. Second, larger firms may be generally more likely to attract highly skilled employees, given their ability to provide tangible and intangible rewards, such as higher compensation (Brown and Medoff, 1989; Troske, 1999) or status benefits (Bidwell *et al*., 2014). To the extent that high-human-capital workers might be more likely to enter entrepreneurship (Carnahan, Agarwal, and Campbell, 2012), sorting by quality could explain our results.

In additional analyses, we rule out these alternative explanations in two ways. First, we examine whether the positive effect of firm size on transition to entrepreneurship holds for firms that leave the focal industry but continue to operate in other industries. Like dissolved firms, such organizations likely exit the focal industry due to poor performance. However, unlike dissolved firms in which opportunities are by default extinct, those organizations may still provide at least some of their employees with employment opportunities elsewhere in the firm. Though layoffs may follow when a firm leaves an industry and shuts down a division (Hoskisson and Hitt, 1994; Worrell, Davidson and Sharma, 1991), large firms will nonetheless exhibit greater probability than dissolved firms to redeploy at least some of the workers. Indeed, past studies have shown that larger firms redeploy high-performing employees into other jobs when an internal venture fails (Gromb and Scharfstein, 2003). To the extent that the potential effect of firm size on entrepreneurship rates reflects the extinction of internal opportunities accompanying firm dissolution – as opposed to sorting – employees of failed divisions should be less likely than employees of defunct firms to transition into entrepreneurship. Hence, we expect the predicted effect of firm size on entrepreneurial rates to be mitigated for those firms that failed in the focal industry but continued operating in other industries.

In Column 1 of Table 4, we explore this possibility by assessing whether the result is truly due to the extinction of internal opportunities accompanying firm dissolution as opposed to more general characteristics correlated with firm propensity to fail. For this test, we first restrict the set of firms to those

that left the ASR industry but continued operating in other industries. For example, in 1995 Northern Telecom, which had been one of the pioneers in the ASR field, decided to leave the industry (but, of course, continued to operate in other markets and is still a going concern). We identify 1,509 employees who were present at the time their firm exited the ASR industry but continued to operate elsewhere. While exiting the industry will reduce internal opportunities as jobs are eliminated, it does not necessarily extinguish them as some workers may still find positions elsewhere in the firm. We expect our findings to hold weakly at best in this sample if internal opportunities were the mechanism behind the main effect. Indeed, subsampling workers present at the time their firm exited the ASR industry fails to replicate the positive correlation between firm size and entry into entrepreneurship ($p<0.936$).

Second, we tackle the selection question by differentiating between the employees still with the company at the time of its demise and those who left prior to the firm's failure. One might wonder whether firms that eventually failed simply attract less entrepreneurial (or lower quality) workers and thus the results of Table 3 are explained by sorting. If this were the case, we would expect the rates of entrepreneurship from smaller firms to be lower not only among employees whose job transition was forced by firm failure but among *all* employees of the failed firm, even prior to the firm dissolution. If, however, our theory holds, we would expect sharp differences between employees of failed firms who left prior to the demise vs. those whose job transitions were forced by the firm's dissolution. Specifically, the positive effect of firm size on entrepreneurship for defunct firms would be weaker at best for employees of failed firms who left *prior to* the demise and thus had an option to stay at the firm.

We assess this explanation in Column 2 of Table 4, considering only employees of defunct firms who left *prior* to the demise, as their internal opportunities were not similarly extinguished. As shown in the contrast between Tables 2 and 3, it appears that employees of small firms are more likely to become entrepreneurs until we restrict the sample to workers whose job transition was forced by firm failure. The coefficient on firm size in Column 2, while positive, fails to achieve statistical significance at conventional levels ($p<0.153$). Overall, the findings in Table 4 provide support for the main argument – suggesting that the positive effect of firm size on entrepreneurship is unlikely to arise due to self-sorting

of entrepreneurial employees into firms at high risk of eventual dissolution.

We conducted additional robustness checks to rule out alternative explanations. First, our identification strategy assumes that the timing of the firm's dissolution is exogenous to the employees of the firm at the time of dissolution. But if the shutdown were somehow calibrated to the availability of external opportunities of these employees, our approach could be frustrated. While most employees might be unable to influence the timing of their firm's demise, the CEO is likely in the best position to negotiate with investors, creditors, and the board of directors regarding when to liquidate the firm. Our results could be called into question if they were driven primarily by CEOs' transitions into entrepreneurship. Accordingly, in Column 3, we interact the firm-size variable with the dummy indicating whether an employee occupied the CEO position at the time of firm demise. Findings show a negative interaction term but with weak statistic significance ($p<0.268$).

[Insert Table 4 about here]

**DISCUSSION**

Entrepreneurs emerge from existing organizations where they acquire the skills, aspirations, and knowledge conducive to founding a venture (Audia and Rider, 2006; Dobrev and Barnett, 2005; Sørensen and Fassiotto, 2011). Within this stream of work, there is consistent evidence that smaller firms generate higher rates of entrepreneurship, an empirical pattern commonly labeled "the small-firm effect" (Dobrev and Barnett, 2005; Elfenbein, Hamilton, and Zenger, 2010; Gompers, Lerner, and Scharfstein, 2005; Sørensen, 2007). Our study offers novel evidence regarding processes underlying this effect.

We propose that the well-known impact of firm size on entrepreneurship might reflect an alternative causal process. Large organizations might foster entrepreneurial talent but also retain such employees – being better positioned to provide access to valuable information and resources that facilitate the creation of new ideas as well as the retention of entrepreneurial workers. Conversely, smaller, less-established organizations offer less attractive and less viable opportunities for internal development and career advancement more broadly, reducing the opportunity cost of leaving current employment in pursuit of entrepreneurship. Thus, employees of smaller firms are at higher risk of transitioning to

entrepreneurship.

Although disentangling these two mechanisms has been difficult in past research, the design of our study overcomes that challenge by leveraging firm dissolution to compare the rates of entrepreneurship across both defunct and non-defunct firms. Because internal opportunities are absent in dissolved firms, it is possible to test the causal mechanisms at work with greater precision. That is, with our research design, we are able to estimate the effect of firm size on entrepreneurship net of the confounding impact of opportunities to pursue new ideas inside an established organization. Consistent with our predictions, we find that when separation from an employer is induced by dissolution – thus extinguishing opportunities within the firm – employees emanating from smaller organizations are less likely to start new ventures. Because firm dissolution eliminates internal options for career advancement, we interpret these findings as evidence that the widely replicated "small-firm effect" on entrepreneurship is driven by the internal career-opportunity structure of such firms.

We additionally find evidence that higher rates of entrepreneurship emanating from large and dissolved firms arise because large firms hold relative advantage in their ability to transmit to employees the types of knowledge, resources, or skills that are conducive to founding a venture. First, the positive impact of firm size on entrepreneurship is amplified in more innovative parent firms – or those with a higher number of patents per technical worker. We further find that the positive effect of the firm size is systematically stronger among parent firms that are themselves intra-industry spinoffs, consistent with the notion that resources and technical know-how are more available in spinoff firms. Finally, our results show no support for the impact of technical role within an established firm on entrepreneurial transition. Building on this non-finding, future research might further investigate the effect of organizational roles and positions (e.g., Dobrev and Barnett, 2005), examining in greater detail what types of positions in a large firm are may enhance an employee's inclination to leave for entrepreneurship.

In a series of additional analyses, we mitigate an important concern that our results may reflect systematic sorting by workers into firms that are inherently more likely to dissolve. First, we show that the results no longer hold once we consider organizations that ceased their operations in the ASR industry

but continued operating in other industries. Despite their failure, such firms could possibly provide internal options to workers elsewhere within the company. Similarly, we fail to replicate our findings for the subsample of workers who were employed at firms that eventually failed but who left prior to the demise. These results indicate that prior to the evaporation of internal opportunities, employees originating from smaller firms are as likely to transition to entrepreneurship as employees originating from larger firms. Taken together, these findings provide compelling evidence that the main empirical pattern we document is unlikely to reflect systematic selection of individuals into firms at risk of dissolution.

Our findings also dovetail with other mechanisms evoked in the past literature. First, the extant theories have suggested that industry leaders are responsible for generating the highest rates of spinoffs (e.g., Klepper, 2007; Klepper and Sleeper, 2005). Our theory similarly implies that the opportunity cost of leaving paid employment might be higher for workers in larger firms because opportunities forgone in such firms are generally more attractive. If so, one might expect intra-industry spinoffs from larger firms to be more successful than those from smaller firms. We conducted supplemental analyses to explore this regularity. The results lend support to this conjecture: intra-industry ASR spinoffs from larger companies exhibit lower hazard of failure than spinoffs from smaller companies ($p<0.01$). In additional analyses, we also found that intra-industry spinoffs from larger ASR companies are more likely to cite the patents of the parent firm: the count of backward citations in each startup's patent portfolio that point to one of its parent's patents is higher for intra-industry spinoffs generated by larger parents. Consistent with our theory, this finding suggests that entrepreneurs utilize the parent's technological knowledge available at the larger parent firms ($p<0.001$). These analyses validate our claim that large firms offer opportunities and resources conducive to entrepreneurship, but future research should profitably explore this question in greater detail, shedding more light on how the parent-firm size might affect the survival and the characteristics of intra-industry spinoffs.

Our emphasis on opportunity structure in paid employment as an antecedent of entrepreneurial entry also relates to the research ethnic entrepreneurship. Researchers have shown that ethnic groups are

more likely to transition to entrepreneurship in part because of blocked mobility in paid employment (Glazer and Moynihan, 1963) as well as systematic disadvantage in the labor market associated with the immigrant status (Aldrich and Waldiner, 1990; Light and Rosenstein, 1995). Our approach is also consistent with the work on entrepreneurship in developing countries, which documents that unstable labor markets and limited job opportunities play an important role in fostering entrepreneurial entry (Acs and Virgill, 2010). However, our study differs from this literature in that we consider high-human capital workers (rather than unskilled labor) who generally face high opportunity cost of leaving paid employment.

Although our findings are likely to hold in other contexts, there are important scope conditions associated with our theory. In particular, the theory presented here is well-suited to explaining variation in entrepreneurial rates in a high-tech sector in which workers are equipped with substantial human capital. As mentioned above, many workers in the ASR industry require significant resources to get a startup underway, with two implications for the entrepreneurial process. First, starting a company in the ASR industry requires gathering external resources in order to launch, including technical expertise and possibly capital. Consequently, barriers to entry may be higher here than in an industry with lower human capital requirements. Second, to the extent that the would-be entrepreneur has signed non-disclosure or non-compete agreements with their prior employer, the fear that a larger company may more aggressively enforce such contracts may dissuade workers from leaving to start their own company. In sum, the theory presented here is most generalizable to other high-tech, knowledge-intensive contexts, where internal opportunities might substitute for entrepreneurial entry. By contrast, our findings may be less applicable to non-technical, lower-skilled settings, where the opportunity cost of leaving paid employment is relatively low and thus internal opportunities are less central to the decision to become an entrepreneur. It may be more common to see the traditional version of the small-firm effect in industries with less aggressive human capital requirements, even when firm dissolution is taken into account. More generally, our study focuses on a single industry and hence findings should be interpreted with caution.

More research on the effect of firm size on entrepreneurial spinoffs is needed. We have theorized

that smaller firms may spawn more entrepreneurs because they reduce the opportunity cost of becoming an entrepreneur, offering less attractive opportunities. But other limitations prevalent in smaller firms may also be responsible for generating higher rates of entrepreneurship. Smaller organizations, which by default have fewer employees than larger incumbents, may offer limited options to build internal networks, crucial for initiating and developing new ideas (Tsai, 2001; Tsai and Ghoshal, 1998). Therefore, future research could profitably address whether intra-organizational networks are limited in smaller firms and how such limitations might push employees to pursue new ideas via entrepreneurship.

Similarly, future research should explore other important mechanisms that might be associated with the effect of firm size on entrepreneurship. One such mechanism is structural inertia: when organizations grow and mature, structural inertia is likely triggered –reducing a firm's flexibility to change its practices, products, and structures (Doberv, Kim and Carroll, 2003; Hannan and Freeman, 1977; 1984). In additional analyses (unreported), we investigated whether the positive effect of firm size was partly due to structural inertia, commonly observed in larger firms. To this end, we assessed whether the impact of firm size on entrepreneurship was stronger in younger firms – which are less subject to inertia pressures. However, our analyses revealed a uniform effect of firm size across firm age, providing no evidence that structural inertia might be driving our finding ($p<0.1$). This result is broadly consistent with other empirical studies, which cast doubt on inertia in large organizations (e.g., Baker and Cullen 1993; Dobrev, Kim, and Hannan, 2001; Greve, 2010).

In sum, this study contributes to work on the impact of organizational environments on the transition to entrepreneurship by offering a novel account of the "small-firm effect." Although prior research has commonly suggested that smaller firms foster entrepreneurship by equipping their employees with skills, knowledge, and resources conducive to entrepreneurship, we show evidence that this effect may instead arise due to the less attractive career-advancement opportunities found inside smaller firms. Our findings suggest that large organizations hold a relative advantage at generating entrepreneurial talent, but that such talent is more effectively retained internally.

**REFERENCES**


Acs, Z. and N. Virgill. 2010. Entrepreneurship in Developing Countries. *Foundations and Trends in Entrepreneurship,* 6: 1-68.

Agarwal, R., Echambadi, R., Franco, A.M., Sarkar, M.B. 2004. Knowledge transfer through inheritance: Spin-out generation, development and survival. *Academy of Management Journal*. 47: 501–522.

Ai, C. and E. Norton, 2003. Interaction terms in logit and probit models. *Economic Letters* 80:123-129.

Aldrich, H. E. Auster, E., 1986. Even Dwarfs Started Small: Liabilities of Age and Size and Their Strategic Implications. *Research in Organizational Behavior,* 8: 165-198.

Aldrich, H.E., Ruef, M. 2006. *Organizations Evolving*, (2nd edn). Sage: Thousand Oaks, CA.

Amit, R., Muller, E., and Cockburn, I. 1995. Opportunity Costs and Entrepreneurial Activity. *Journal of Business Venturing*, (10): 2, 95-106.

Anton, J.J., D.A. Yao. 1995. Startups, spinoffs, and internal projects. *Journal of Law, Economics, & Organization* 11(2): 362-378.

Aldrich H, Waldinger R. 1990. Ethnicity and entrepreneurship. *Annual Review of Sociology* 16: 111–35

Astebro, T. & P. Thompson, 2011. Entrepreneurs, Jacks of all trades or Hobos? *Research Policy* 40(5): 637-649.

Audia, P. & C. Rider, 2006. Entrepreneurs as organizational products revisited. In R. Baum, et al. (eds.), *The Psychology of Entrepreneurship*: 113–130. Mahwah, NJ: Lawrence Erlbaum Associates.

Baker, D. D. & Cullen, J. B. 1993. Administrative reorganization and configurational context - The contingent effects of age, size and change in size. *Academy of Management Journal*, 36: 1251–1277.

Baron, J.N., Davis-Blake, A., Bielby, W., 1986. The structure of opportunity: how promotion ladders vary within and among organizations. *Administrative Science Quarterly* 31: 248–273.

Baumol, W. J. 1959. *Business Behavior, Value and Growth*. New York: The Macmillan Company.

Bidwell, M., Won, S., Barbulescu, R., and Mollick, E. (in press). I used to work at Goldman Sachs! How Firms Benefit from Organizational Status in the Market for Human Capital. *Strategic Management Journal*.

Box-Steffensmeier, J. M., and B. S. Jones. 2004. *Event History Modeling: A Guide for Social Scientists.* New York: Cambridge University Press.

Brown, C., Medoff, C. 1989. The Employer Size-Wage Effect. *Journal of Political Economy* 97: 1027–1059.

Burton, M. D., J. B. Sørensen, C.M. Beckman. 2002. Coming from good stock: Career histories and new venture formation. *Social Structure and Organizations Revisited*. 19: 229-262.

Carnahan, S., Agarwal, R., & Campbell, B. A., 2012. Heterogeneity in turnover: The effect of relative compensation dispersion of firms on the mobility and entrepreneurship of extreme performers. *Strategic Management Journal*, 33(12), 1411–1430.

Cohen W, M. Klepper, S. 1996. Firm size and the nature of innovation within the industries: the case of process and product R&D. *The Review of Economics and Statistics* 232–243.

Cohen, W. M., Levinthal, D.A. 1989. Innovation and learning: The two faces of R&D. *Economic Journal* 99: 569-596.

Cohen, W.M., Levin, R.C. and Mowery, D.C. 1987. Firm Size and R&D Intensity: A Re- Examination. *Journal of Industrial Economics*, 35(4), 543-65.

Cyert, R., and J. March, 1963. *A Behavioral Theory of the Firm*, 2 ed. Englewood Cliffs, NJ: Prentice Hall.

Damanpour, F, 1992. Organizational size and innovation. *Organization Studies*. 13: 375–402.

Demirkan, I., Deeds, D. L. Demirkan, S. 2013. Exploring the role of network characteristics, knowledge quality, and inertia on the evolution of scientific networks. *Journal of Management*, 39: 1462–1489.

Dobbin, F., Sutton, J. R., Meyer, J. W., Scott, R. 1993. Equal opportunity law and the construction of internal labor markets. *American Journal of Sociology*, 396–427.

Dobrev, S. D. & W. P. Barnett, 2005. Organizational roles and the transition to entrepreneurship. *Academy of Management Journal*, 48: 433–449.

Dobrev, S. D., Carroll, G. R. 2003. Size (and competition) among organizations: Modeling scale-based selection among automobile producers in four major countries, 1885-1981. *Strategic Management Journal*, 24: 541–558.

Dobrev, S. D., Kim, T.-Y. Hannan, M. T. 2001. Dynamics of niche width and resource partitioning. *American Journal of Sociology*, 106: 1299–1337.

Drori I, Ellis S, Shapira Z. 2013. *The Evolution of a New Industry: A Genealogical Approach*. Stanford, CA: Stanford University Press.

Elfenbein, D. W., B. H. Hamilton, and R. Z. Zenger, 2010. The small firm effect and the entrepreneurial spawning of scientists and engineers. *Management Science*, 56: 659–681.

Fritsch, M. and Meschede, M. 2001. Product Innovation, Process Innovation, and Size. *Review of Industrial Organization*, 19, 335-50

Gibbons, R. S., and L. F. Katz, 1991. Layoffs and Lemons. *Journal of Labor Economics* 9(4):351.

Glazer, N. and D. P. Moynihan. 1963. *Beyond the Melting Pot*. Cambridge, MA: MIT Press.

Gompers, P., J. Lerner, and D. S. Scharfstein, 2005. Entrepreneurial spawning: Public corporations and the genesis of new ventures, 1986 to 1999. *Journal of Finance*, 60(2): 577–614.

Greene, W. 2009. Testing Hypotheses About Interaction Terms in Nonlinear Models. *Working paper, New York University (2009)*.

Greve, H. R. 2010. Positional rigidity: Low performance and resource acquisition in large and small firms. *Strategic Management Journal*, 32: 103–114

Gromb, D., Scharfstein, D. S., Entrepreneurship in Equilibrium. 2002. *NBER Working Paper No. w9001*. Available at SSRN: http://ssrn.com/abstract=315998

Halaby, C. N. 1988. Action and information in the job mobility process: The search decision. *American Sociological Review*, 9-25.

Halaby, C. N., 2003. Where Job Values Come From: Family and Schooling Background, Cognitive Ability, and Gender. *American Sociological Review*, 68(2): 251-278.

Hallen, B., 2008. The Causes and Consequences of the Initial Network Positions of New Organizations: From Whom do Entrepreneurs Receive Investments. *Administrative Science Quarterly* 53(4): 685-718.

Hambrick, D. C. and P. A. Mason 1984. Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review*, 9(2), pp. 193–206.

Hamilton, B.H., 2000. Does Entrepreneurship Pay? An Empirical Analysis of the Returns to Self-Employment. *Journal of Political Economy*, 108(3): 604-631,

Hannan, M. T. Freeman, J. 1977. The population ecology of organizations. *American Journal of Sociology*, 929–964.

Hannan, M. T., Freeman, J. 1984. Structural inertia and organizational change. *American Sociological Review*, 149–164.

Haveman, H. A.1993. Organizational size and change: Diversification in the savings and loan industry after deregulation. *Administrative Science Quarterly***,** 20-50.

Haveman, H., 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.

Hellman, T., 2007. When do employees become entrepreneurs? *Management Science* 53: 919–933.

Henderson, R. and Cockburn, I. 1996. Scale, Scope, and Spillovers: The Determinants of Research Productivity in Drug Discovery. *RAND Journal of Economics*, 27(1), 32-59.

Hiatt, S.R., Sine, W.D., Tolbert, P.S. 2009. From Pabst to Pepsi: The deinstitutionalization of social practices and the emergence of entrepreneurial opportunities. *Administrative Science Quarterly*, 54: 635-667.

Hoskisson, R. E., Hitt, M. A. 1994. *Downscoping: How to Tame the Diversified Firm*. Oxford University Press New York.

Iacus, S., G. King, and G. Porro, 2009. CEM: Software for Coarsened Exact Matching. *Journal of Statistical Software*, 30.

Jelinek, M. & C. B. Schoonhoven, 1990. *The Innovation Marathon: Lessons from High Technology Firms*. Oxford: Blackwell.

Josefy, M., Kuban, S., Ireland, D., Hitt, M. 2015. All things great versus small: Organizational size, the theory of the firm and a changing environment. *Academy of Management Annals. Forthcoming.*

Kacperczyk, A. J. 2012. Opportunity structures in established firms: Entrepreneurship versus intrapreneurship in mutual funds. *Administrative Science Quarterly*, 57(3): 484-521.

Kacperczyk, A. J. 2013. Social Influence and Entrepreneurship: The Effect of University Peers on Entrepreneurial Entry. *Organization Science* 24(3): 664-683.

Khessina, O.M., Carroll, G.R. 2008. Product Demography of De Novo and De Alio Firms in the Optical Disk Drive Industry, 1983-1999. *Organization Science*, 19: 25-38.

Kirzner, I. M. 1973. *Competition and Entrepreneurship*. Chicago, IL, University of Chicago Press.

Klepper, S. 2007. Disagreements, Spinoffs, and the Evolution of Detroit as the Capital of the U.S. Automobile Industry. *Management Science*. 53(4): 616-631.

Klepper, S. 2009. Spinoffs: a review and synthesis. *European Management Review*, 6:159–171.

Kohn, M. L., & C. Schooler, 1982. Job conditions and personality: A longitudinal assessment of their reciprocal effects. *American Journal of Sociology*, 87: 1257–1286.

Lai, R. and D. Doolin, A. D'Amour, A. Yu, Y. Sun, V. Torvik, D. Doolin, G. Cheng, L. Fleming, forthcoming " Disambiguation and co-authorship networks of the U.S. Patent Inventor Database, 1975-2010" forthcoming in *Research Policy*.

Lazear, E. P., 2004. Balanced skills and entrepreneurship. *American Economic Review*, 94: 208–211.

Light I, Rosenstein C. 1995. *Race, Ethnicity, and Entrepreneurship in Urban America.* New York: Aldine De Gruyter

Lin, Z., Yang, H. Demirkan, I. 2007. The performance consequences of ambidexterity in strategic alliance formations: Empirical investigation and computational theorizing. *Management Science, 53:*1645–1658.

Lin, D. Y., and L. J. Wei 1989. The robust inference for the Cox proportional hazards model. *Journal of the American Statistical Association*, 84: 1047–1078.

Lunn, J. 1987. An Empirical Analysis of Firm Process and Product Patenting. *Applied Economics*, 19(6), 743-51.

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organizational Science* 2: 71–87.

Marx, Strumsky, and Fleming. 2009. Mobility, Skills, and the Michigan Non- Compete Experiment." *Management Science*, Vol. 55, No. 6.

Marx, M. & D. Hsu. Technology Commercialization Strategy Dynamics and Entrepreneurial Performance: Evidence from the Speech Recognition Industry. *MIT Sloan Working Paper.*

McClelland, D. 1965. Toward a theory of motive acquisition." *American Psychologist*, 20(5): 321-333.

McFadden, D. L. 1973. Conditional logit analysis of qualitative choice behavior. In P. Zarembka (ed.), *Frontiers of Econometrics*: 105–142. New York: Academic Press.

McKendrick, D.J., Wage, J.B., Jaffee, J. A Good Riddance? Spinoffs and the Technological Performance

of Parent Firms. *Organization Science* 20(6): 979-992.

Nanda, R. & J. Sørensen, 2010. Workplace peers & entrepreneurship. *Management Science* 56(7): 1116.

Nelson, R. R., Winter, S.G. 1982. *An Evolutionary Theory of Economic Change.* Cambridge, MA: Belknap Press.

Pakes, A., Nitzan. S. 1983. Optimum Contract for Research Personnel, Research Employment, and the Establishment of Rival Enterprises. *Journal of Labor Economics* 1(4): 345-365.

Penrose, E.T. 1959. *The Theory of the Growth of the Firm*. New York: John Wiley.

Phillps, 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(3): 474-506.

Piore, Michael J., Doeringer, P. 1971. *Internal Labor Markets and Manpower Adjustment*. New York: D.C. Heath and Company.

Schuler, D. A., Rehbein, K., Cramer, R. D. 2002. Pursuing strategic advantage through political means: A multivariate approach. *Academy of Management Journal*, 45: 659–672.

Schumpeter, J.A. 1950. *Capitalism, Socialism and Democracy*. London: George Allen & Unwin, Ltd.

Shane, S. A., 2003. *A General Theory of Entrepreneurship*. Cheltenham: Edward Elgar.

Shaver, J. M., Mezias, J. M. 2009. Diseconomies of managing in acquisitions: Evidence from civil lawsuits. *Organization Science*, 20: 206–222.

Sørensen, J. B., 2007. Bureaucracy and entrepreneurship: Workplace effects on entrepreneurial entry. *Administrative Science Quarterly*, 52: 387–412.

Sørensen, J. & Sharkey, A. 2014. "Entrepreneurship as a Mobility Process." *American Sociological Review.* 79(2): 328-349.

Sørensen, J. & M. Fassiotto. 2011. "Organizations as Fonts of Entrepreneurship." *Organization Science*. 22(5): 1322-1331.

Sorenson, O. & P. Audia, 2000. The Social Structure of Entrepreneurial Activity: Geographic Concentration of Footwear Production in the United States, 1940–1989. *American Journal of Sociology* 106 (2): 424-462.

Spenner, K. 1988. Technological change, skill requirements and education: the case for uncertainty. In R. M. Cyert and D. C. Mowery (Eds.), *The Economic and Employment Effects of Technological Change* (pp. 131-184). New York: Ballinger.

Stinchcombe, A. L., 1965. Social structure and organizations. In J. G. March (ed.), *Handbook of Organizations:* 142–193. Chicago: Rand McNally.

Stuart, T. & W. Ding, 2006. When Do Scientists Become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Sciences. *American Journal of Sociology* 112(1): 97-144.

Sutton, R. I. & Callahan, A. L. 1987. The stigma of bankruptcy: Spoiled organizational image and its management. *Academy of Management Journal*, 30: 405-436.

Troske, K.R. 1999. Evidence on the employer-size wage premium from worker- establishment matched data. *Review of Economics and Statistics*, 81 (1): 1- 12.

Tsai, W. 2001. Knowledge transfer in intra-organizational networks: Effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal*, 44, 996-1004.

Tsai, W., Ghoshal, S. 1998. Social capital and value creation: The role of intra-firm networks. *Academy of Management Journal*. 41, 464-476.

Tushman, M. L. Anderson, P. 1986. Technological discontinuities and organizational environments. *Administrative Science Quarterly*, 439–465.

Walls & Associates, 2010 National Establishment Time-Series (NETS) Database©, October 2011.

Wagner, J. 2004. Are Young and Small Firms Hothouses for Nascent Entrepreneurs? Evidence from German Micro Data. *Applied Economics Quarterly*, 50(4): 379–391.

White, H. C. 1970. Matching, vacancies, and mobility. The Journal of Political Economy, 97-105.

Worrell, D. L., Davidson, W., Sharma, V. 1991. Layoff Announcements and Stockholder Wealth. *Academy of Management Journal* 34 (3): 662-678.

Zucker, L. G., M. R. Darby, et al. 1998. Intellectual Human Capital and the Birth of the US Biotechnology Industry. *American Economic Review* 88(1): 290-306.

## Table 1. Descriptive Statistics

### Panel A: job transitions from all firms, n=26,463

| | | Mean | Std. Dev. | Min | Max | 1) | 2) | 3) | 4) | 5) | 6) | 7) | 8) | 9) | 10) | 11) | 12) | 13) | 14) | 15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1) | founded new firm | 0.026 | 0.160 | 0.000 | 1.000 | 1.000 | | | | | | | | | | | | | | |
| 2) | prior firm size (L) | 4.510 | 2.763 | 0.693 | 15.110 | -0.081 | 1.000 | | | | | | | | | | | | | |
| 3) | prior firm year of entry | 1994.7 | 12.7 | 1900.0 | 2014.0 | 0.087 | -0.367 | 1.000 | | | | | | | | | | | | |
| 4) | prior firm age (L) | 1.350 | 1.317 | 0.000 | 4.736 | -0.130 | 0.340 | -0.716 | 1.000 | | | | | | | | | | | |
| 5) | prior firm was ASR spinoff | 0.181 | 0.385 | 0.000 | 1.000 | 0.021 | -0.020 | 0.055 | 0.109 | 1.000 | | | | | | | | | | |
| 6) | prior firm was de alio ASR entrant | 0.167 | 0.373 | 0.000 | 1.000 | -0.059 | 0.271 | -0.414 | 0.344 | -0.128 | 1.000 | | | | | | | | | |
| 7) | prior firm # of patents to date (L) | 0.846 | 1.593 | 0.000 | 6.409 | -0.016 | 0.127 | -0.100 | 0.077 | 0.107 | 0.235 | 1.000 | | | | | | | | |
| 8) | prior firm # of patents per technical worker (L) | 0.634 | 1.568 | 0.000 | 9.246 | 0.0207 | 0.0305 | 0.0844 | -0.1355 | 0.1366 | -0.071 | 0.7686 | 1 | | | | | | | |
| 9) | worker age | 31.032 | 8.630 | 21.000 | 70.000 | 0.034 | -0.071 | 0.168 | 0.009 | 0.014 | -0.129 | -0.083 | -0.018 | 1.000 | | | | | | |
| 10) | worker has patents to date | 0.065 | 0.247 | 0.000 | 1.000 | -0.025 | 0.009 | -0.079 | 0.055 | -0.097 | 0.285 | 0.275 | 0.016 | -0.076 | 1.000 | | | | | |
| 11) | worker tenure at firm | 4.899 | 4.742 | 0.000 | 72.000 | -0.008 | 0.116 | -0.355 | 0.241 | -0.027 | 0.371 | 0.146 | -0.018 | -0.055 | 0.160 | 1.000 | | | | |
| 12) | worker was CEO | 0.044 | 0.206 | 0.000 | 1.000 | 0.197 | -0.101 | 0.112 | -0.128 | 0.011 | -0.053 | -0.034 | 0.015 | 0.089 | -0.049 | -0.005 | 1.000 | | | |
| 13) | worker had technical role | 0.496 | 0.500 | 0.000 | 1.000 | -0.084 | 0.128 | -0.213 | 0.150 | -0.044 | 0.207 | 0.232 | 0.096 | -0.126 | 0.233 | 0.158 | -0.199 | 1.000 | | |
| 14) | worker was female | 0.185 | 0.388 | 0.000 | 1.000 | -0.047 | -0.020 | 0.069 | -0.002 | 0.058 | -0.066 | -0.079 | -0.053 | -0.080 | -0.079 | -0.063 | -0.034 | -0.157 | 1.000 | |
| 15) | worker # of jobs to date (L) | 1.524 | 0.638 | 0.000 | 4.625 | 0.027 | 0.007 | 0.127 | -0.015 | 0.044 | -0.220 | -0.142 | 0.011 | 0.603 | -0.312 | -0.134 | 0.038 | -0.043 | -0.0515 | 1.000 |

### Panel B: job transitions following a firm dissolution, n=2,244

| | | Mean | Std. Dev. | Min | Max | 1) | 2) | 3) | 4) | 5) | 6) | 7) | 8) | 9) | 10) | 11) | 12) | 13) | 14) | 15) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1) | founded new firm | 0.020 | 0.140 | 0.000 | 1.000 | 1.000 | | | | | | | | | | | | | | |
| 2) | prior firm size (L) | 3.459 | 2.316 | 0.693 | 13.981 | 0.036 | 1.000 | | | | | | | | | | | | | |
| 3) | prior firm year of entry | 1994.5 | 9.6 | 1900.0 | 2010.0 | -0.002 | -0.185 | 1.000 | | | | | | | | | | | | |
| 4) | prior firm age (L) | 5.692 | 6.979 | 1.000 | 99.000 | -0.014 | 0.159 | -0.612 | 1.000 | | | | | | | | | | | |
| 5) | prior firm was ASR spinoff | 0.053 | 0.224 | 0.000 | 1.000 | -0.021 | -0.028 | 0.087 | -0.114 | 1.000 | | | | | | | | | | |
| 6) | prior firm was de alio ASR entrant | 0.013 | 0.113 | 0.000 | 1.000 | 0.008 | 0.040 | 0.026 | 0.009 | -0.027 | 1.000 | | | | | | | | | |
| 7) | prior firm # of patents to date (L) | 0.164 | 0.420 | 0.000 | 2.639 | -0.030 | 0.202 | -0.249 | 0.170 | 0.068 | 0.022 | 1.000 | | | | | | | | |
| 8) | prior firm # of patents per technical worker (L) | 0.137 | 0.343 | 0.000 | 2.322 | -0.032 | 0.145 | -0.114 | -0.008 | 0.035 | -0.014 | 0.813 | 1.000 | | | | | | | |
| 9) | worker age | 29.520 | 7.014 | 21.000 | 70.000 | 0.005 | -0.027 | 0.128 | 0.040 | 0.040 | -0.089 | -0.013 | 0.006 | 1.000 | | | | | | |
| 10) | worker has patents to date | 0.197 | 0.398 | 0.000 | 1.000 | -0.022 | 0.122 | -0.167 | 0.005 | 0.068 | -0.005 | 0.714 | 0.756 | 0.038 | 1.000 | | | | | |
| 11) | worker tenure at firm | 4.104 | 4.034 | 0.000 | 40.462 | -0.018 | 0.071 | -0.332 | 0.315 | -0.036 | 0.089 | 0.054 | 0.052 | 0.068 | 0.033 | 1.000 | | | | |
| 12) | worker was CEO | 0.036 | 0.188 | 0.000 | 1.000 | 0.032 | -0.059 | 0.056 | -0.093 | 0.057 | 0.070 | -0.076 | -0.078 | 0.075 | -0.076 | 0.053 | 1.000 | | | |
| 13) | worker had technical role | 0.484 | 0.500 | 0.000 | 1.000 | -0.043 | 0.044 | -0.135 | 0.031 | 0.013 | -0.028 | 0.367 | 0.387 | -0.061 | 0.412 | -0.028 | -0.184 | 1.000 | | |
| 14) | worker was female | 0.193 | 0.395 | 0.000 | 1.000 | -0.047 | -0.016 | 0.094 | -0.002 | -0.024 | 0.044 | -0.111 | -0.109 | -0.053 | -0.167 | -0.024 | -0.037 | -0.186 | 1.000 | |
| 15) | worker # of jobs to date (L) | 0.924 | 0.666 | 0.000 | 4.127 | 0.035 | -0.036 | 0.244 | -0.114 | 0.075 | -0.089 | 0.120 | 0.126 | 0.601 | 0.174 | -0.268 | 0.028 | 0.048 | -0.0874 | 1.000 |

**Table 2. Likelihood of a worker transitioning from employment to entrepreneurship.**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| prior firm size (L) | -0.1166*** | -0.1120*** | -0.0985*** | -0.0859*** |
| | (0.023) | (0.023) | (0.024) | (0.019) |
| prior firm year of entry | 0.0001 | 0.0009 | 0.0004 | -0.1289*** |
| | (0.008) | (0.008) | (0.009) | (0.007) |
| prior firm age (L) | -0.8477*** | -0.7938*** | -0.8525*** | -2.0970*** |
| | (0.078) | (0.069) | (0.091) | (0.095) |
| prior firm was ASR spinoff | 0.5817*** | 0.6228*** | 0.5917*** | 0.4238*** |
| | (0.104) | (0.102) | (0.109) | (0.098) |
| prior firm was de alio ASR entrant | -0.7692** | -0.7780** | -0.6678* | -0.5365* |
| | (0.260) | (0.258) | (0.277) | (0.212) |
| prior firm # of patents to date (L) | 0.0382 | 0.0308 | 0.0277 | -0.0488+ |
| | (0.028) | (0.029) | (0.029) | (0.028) |
| worker's age (L) | -0.0500 | -0.0771 | -0.0930 | 0.0667 |
| | (0.222) | (0.221) | (0.236) | (0.221) |
| worker has a patent to date | 0.3810 | 0.3633 | 0.3652 | 0.6189** |
| | (0.247) | (0.248) | (0.249) | (0.237) |
| worker's tenure at firm | 0.0534*** | 0.0546*** | 0.0596*** | 0.0031 |
| | (0.010) | (0.010) | (0.011) | (0.012) |
| worker was CEO | 1.5483*** | 1.5256*** | 1.4550*** | 1.4114*** |
| | (0.114) | (0.113) | (0.120) | (0.096) |
| worker had technical role | -0.5981*** | -0.5989*** | -0.6927*** | -0.5490*** |
| | (0.112) | (0.114) | (0.119) | (0.112) |
| worker was female | -0.9848*** | -0.9612*** | -0.9780*** | -1.1783*** |
| | (0.159) | (0.158) | (0.166) | (0.190) |
| worker's # of jobs to date (L) | 0.1312 | 0.1355 | 0.1565 | 0.7887*** |
| | (0.108) | (0.107) | (0.114) | (0.115) |
| Constant | -3.0746 | -4.5715 | -3.6852 | - |
| | (15.561) | (15.227) | (17.019) | - |
| Observations | 26,463 | 24,082 | 22,042 | 78,803 |

Robust standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Notes: Observations are individual job moves. Column 1 utilizes the full dataset, while Column 2 excludes moves from three ASR firms, each of which spawned more than three spinoffs. Column 3 matches observations by size against defunct firms. Column 4 re-estimates Model 1 using the event-history analysis.

**Table 3. Likelihood of a worker transitioning from employment to entrepreneurship: Defunct firms**

| | defunct firms | | | all firms |
|---|---|---|---|---|
| **Variables** | employees at demise | | | |
| | (1) | (2) | (3) | (4) |
| prior firm size (L) | | 0.1204* | 0.1580* | -0.1420*** |
| | | (0.057) | (0.064) | (0.025) |
| prior firm year of entry | -0.0313+ | -0.0279 | -0.0266 | -0.0004 |
| | (0.018) | (0.020) | (0.019) | (0.008) |
| prior firm age (L) | -0.2188 | -0.2346 | -0.2424 | -0.8431*** |
| | (0.205) | (0.206) | (0.211) | (0.076) |
| prior firm was ASR spinoff | -1.1285 | -1.1033 | -4.2208*** | 0.5862*** |
| | (0.982) | (0.962) | (1.172) | (0.103) |
| prior firm was de alio ASR entrant | 0.9618 | 0.9281 | 1.0159 | -0.7651** |
| | (1.009) | (1.016) | (1.013) | (0.260) |
| prior firm # of patents to date (L) | -0.5907 | -0.6946 | -0.7502 | 0.0394 |
| | (1.039) | (0.978) | (0.751) | (0.029) |
| worker age (L) | -0.6113 | -0.6282 | -0.6414 | -0.0221 |
| | (0.792) | (0.797) | (0.832) | (0.227) |
| worker has a patent to date | 0.1591 | 0.1365 | 0.4217 | 0.4000 |
| | (0.700) | (0.678) | (0.568) | (0.258) |
| worker's tenure at firm | -0.0144 | -0.0157 | -0.0115 | 0.0508*** |
| | (0.047) | (0.049) | (0.050) | (0.010) |
| worker was CEO | 0.2647 | 0.3611 | 0.4025 | 1.5464*** |
| | (0.643) | (0.646) | (0.662) | (0.115) |
| worker had technical role | -0.8361+ | -0.8093+ | 0.4645 | -0.5988*** |
| | (0.460) | (0.449) | (0.643) | (0.112) |
| worker was female | -1.2558* | -1.2526* | -1.2407* | -0.9795*** |
| | (0.630) | (0.632) | (0.630) | (0.159) |
| worker's # of jobs to date (L) | 0.7691* | 0.7928* | 0.8253* | 0.1072 |
| | (0.323) | (0.324) | (0.346) | (0.118) |
| prior firm # of patents per technical worker (L) | | | -3.1866+ | |
| | | | (1.744) | |
| prior firm # of patents per technical worker (L) * prior firm size (L) | | | 0.6032* | |
| | | | (0.247) | |
| prior firm was ASR spinoff * prior firm size (L) | | | 0.6261** | |
| | | | (0.208) | |
| worker had technical role * prior firm size (L) | | | -0.3634+ | |
| | | | (0.197) | |
| prior firm defunct * prior firm size (L) | | | | 0.3026*** |
| | | | | (0.063) |
| prior firm defunct | | | | -1.1623*** |
| | | | | (0.318) |
| Constant | 60.5546+ | 53.4456 | 50.6848 | -1.9807 |
| | (36.609) | (39.451) | (37.668) | (15.534) |
| Observations | 2,244 | 2,244 | 2,244 | 26,463 |

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

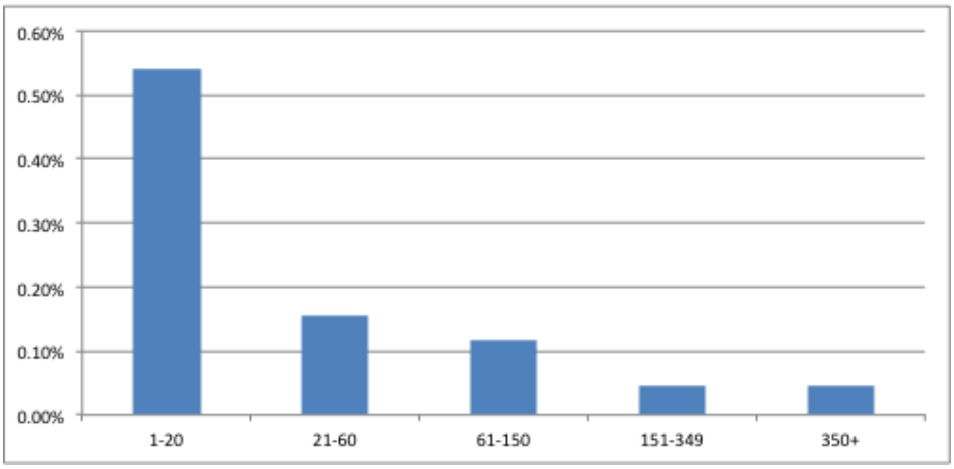
**Table 4. Robustness tests of the likelihood of a worker transitioning to entrepreneurship**

| | firms exiting ASR | defunct firms | |
|---|---|---|---|
| **Variables** | | **employees not at demise** | **at demise** |
| | **(1)** | **(2)** | **(3)** |
| prior firm size (L) | -0.0121 | 0.0985 | 0.1248* |
| | (0.158) | (0.069) | (0.060) |
| prior firm year of entry | -0.0585 | -0.0113 | -0.0281 |
| | (0.074) | (0.020) | (0.020) |
| prior firm age (L) | -1.2436*** | -0.4906* | -0.2393 |
| | (0.250) | (0.194) | (0.207) |
| prior firm was ASR spinoff | -0.8144 | 0.0129 | -1.0955 |
| | (0.784) | (0.760) | (0.970) |
| prior firm was de alio ASR entrant | -1.9754*** | 2.3478*** | 0.9259 |
| | (0.573) | (0.493) | (1.014) |
| prior firm # of patents to date (L) | -0.1740 | -0.7965 | -0.6927 |
| | (0.249) | (1.071) | (0.974) |
| worker's age (L) | 3.2628* | -0.0990 | -0.6166 |
| | (1.436) | (0.803) | (0.800) |
| worker has a patent to date | 1.8377* | 0.1504 | 0.1319 |
| | (0.749) | (0.874) | (0.677) |
| worker's tenure at firm | 0.0254 | 0.0689* | -0.0155 |
| | (0.056) | (0.034) | (0.049) |
| worker was CEO | -0.3270 | 1.0737+ | 0.6326 |
| | (0.837) | (0.604) | (0.669) |
| worker had technical role | -1.9464** | -0.0403 | -0.8083+ |
| | (0.715) | (0.436) | (0.449) |
| worker was female | -1.0840 | -0.1641 | -1.2548* |
| | (1.292) | (0.500) | (0.632) |
| worker's # of jobs to date (L) | -0.1955 | -0.1466 | 0.7857* |
| | (0.602) | (0.348) | (0.327) |
| worker was ceo * prior firm size (L) | | | -0.0946 |
| | | | (0.110) |
| Constant | 105.4330 | 19.2597 | 53.7790 |
| | (147.569) | (39.611) | (39.438) |
| Observations | 1,509 | 1,452 | 2,244 |

Robust standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Column 1 limits the sample to workers who were at firms that left the ASR industry but continued to operate; Column 2 limits the sample to employees who worked at firms that failed but *prior* to their failure. Column 3 again considers employees who were at the firm at the time of its demise.

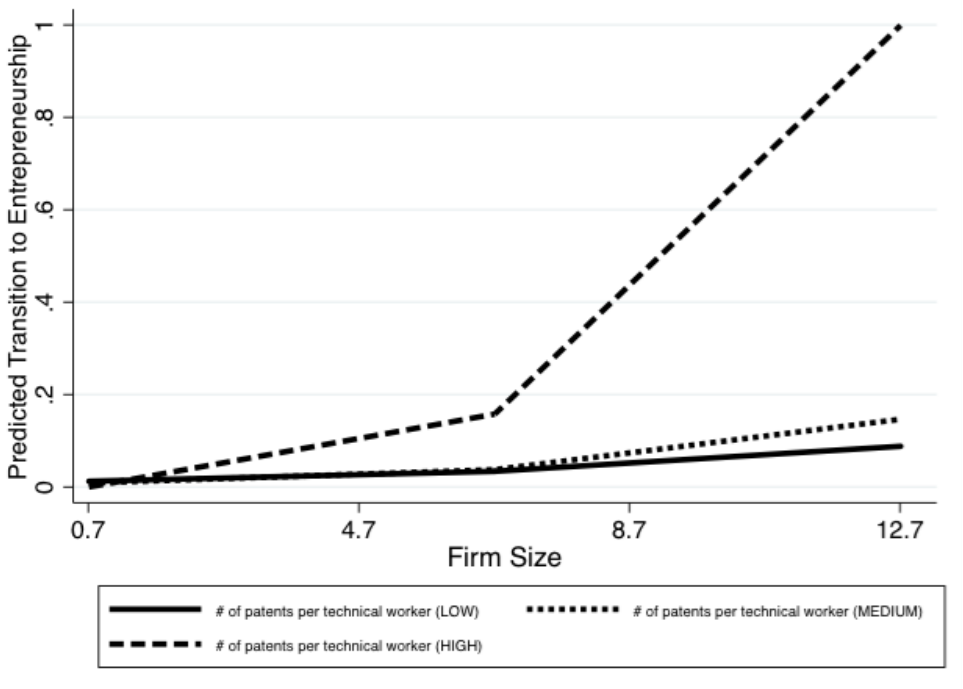
**Figure 1: Likelihood of an employee becoming an entrepreneur, by firm size.**




Notes: quartiles are evenly populated.

**Figure 2: Predicted Transition to Entrepreneurship by Firm Size**

**Panel A** *Predicted Transition to Entrepreneurship by Firm Size and Firm Innovativeness*




**Panel B** *Predicted Transition to Entrepreneurship by Firm Size and whether a Firm is a Spinoff*