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Revisiting the Small-Firm Effect on Entrepreneurship: Evidence from Firm Dissolutions

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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 advantage over small firms in providing internal opportunities to retain entrepreneurial talent. We test this claim in a setting where firm dissolution extinguishes internal opportunities, using a new hand-collected data set of career histories in the automatic speech recognition (ASR) industry. For nondefunct 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 indicate that this effect is unlikely to be driven by the early departure of higher-skilled workers who anticipate the firm's demise. Finally, we find preliminary evidence consistent with the notion that large organizations may not only retain but also "mold" workers into entrepreneurs. 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.

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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 (Dobrev and Barnett 2005, Kacperczyk 2012). 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 the frequent finding that smaller firms spawn entrepreneurs at a higher rate (Elfenbein et al. 2010, Gompers et al. 2005, Sørensen 2007). 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 his finding that larger firms in several industries generate more spin-offs, not fewer.

We propose that the available empirical evidence is consistent with an alternative mechanism: that large organizations might in fact offer more attractive internal opportunities to retain potential entrepreneurs—who might have little choice but to leave a smaller company. First, scholars have increasingly documented that the rate of entrepreneurial entry decreases when internal opportunity structure appears more enticing (Hellman 2007, Kacperczyk 2012, Klepper 2007, Sørensen and Sharkey 2014). A large body of organizational and strategy research 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)—since they 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). Even if larger firms may be myopic or slow to react, their superior stock of resources and routines gives them the *option* to 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 limited. Other research additionally implies that, because of their influence and market power (Schuler et al. 2002), large firms may

have better guards against employees' departures for entrepreneurship. Finally, the opportunity cost of entering entrepreneurship is likely higher for employees of larger than smaller firms because employment in large organizations has been linked with significant advantages, such as stability (e.g., Osterman et al. 2001), premium wages, and status (e.g., Brown and Medoff 1989). Thus, it is difficult to discount the possibility that this alternative mechanism could drive the frequent observation that large firms generate lower rates of 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 global automatic speech recognition industry. We identify a number of firms that dissolved, thereby displacing a large number of technical and nontechnical workers and thus extinguishing internal career opportunities. We track these employees' postdissolution occupational choices and relate them to the size of the dissolved firm. Moreover, our empirical approach enables us to compare the occupational choices of employees emanating from defunct firms to those of employees at nondefunct 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

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, Sørensen and Fassiotto 2011). A well-established finding is that entrepreneurs tend to emerge from smaller firms (Dobrev and Barnett 2005, Elfenbein et al. 2010, Gompers et al. 2005, Sørensen 2007). 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 and resources 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 (Kacperczyk and Younkin 2015, Rider et al. 2016) as well as the survival and success of a new venture (Astebro and Thompson 2011).

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). 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 nonroutinized tasks, linked to creativity (Kohn and Schooler 1982). Because such personality traits are 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 is thought to take place via interactions with coworkers and entrepreneurial peers within the workplace. For example, 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 is 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. Employees in entrepreneurial firms are exposed

to information about opportunities for markets and products (Elfenbein et al. 2010, Sørensen 2007). Similarly, scholars have argued that smaller firm size facilitates interaction with suppliers and buyers, providing access to the sort of heterogeneous information that facilitates new-venture founding (Dobrev and Barnett 2005, Shane 2003). Gompers et al. (2005, p. 612) argue that employees in smaller workplaces 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 et al. (2010, p. 20) observed that "[m]ore work is necessary to show that employment in small firms leads individuals to develop better networks that facilitate entrepreneurship." Similarly, Sørensen and Fassiotto (2011, p. 1325) noted that "entrepreneurial 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." 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 entrepreneurial ventures emanating from smaller organizations need not necessarily reflect that such firms are better "training grounds" for entrepreneurs. Rather, the observed empirical finding is also consistent with the following explanation: large firms might provide more attractive internal opportunities and therefore be more likely to lock up entrepreneurial talent and resources, and thus prevent the formation of entrepreneurial spin-offs.

An increasing number of studies have shown that internal options influence the decision to enter entrepreneurship. Scholars have linked attractive options in paid employment to a higher opportunity cost of becoming an entrepreneur (Amit et al. 1995). Numerous studies have suggested that the attractiveness of the internal opportunity structure reduces the likelihood of transitioning to entrepreneurship (Anton and Yao 1995, Hellman 2007). Kacperczyk (2012) finds that employees forgo transition when they are engaged in the implementation of new businesses within an established firm. Sørensen and Sharkey (2014) operationalize the notion of opportunity structure 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 will be more likely to lose employees to potentially lucrative paths such as entrepreneurship.

There is a rationale to expect that large, established firms might create an internal opportunity structure that is particularly appealing to employees with entrepreneurial inclinations. First, a large literature suggests that as firms grow and mature, they gain advantage in executing new projects and assimilating employee-generated ideas. Large organizations are characterized by ample resources, well-specified routines, established competencies, product development experience, and accumulated knowledge (Cohen and Levinthal 1989, Galbraith 1973, March 1991, Stinchcombe 1965, Sørensen and Stuart 2000). Such firms also have more products in development and in the market 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 spread via diversified portfolios (Dobrev and Carroll 2003). Similarly, since large firms can afford to shelter employees from considerable risks associated with commercializing a new venture and redeploy those who failed at new projects to other tasks and jobs within the firm (Gromb and Scharfstein 2002). These attributes of large, mature firms facilitate efficient accommodation and execution of new, employee-generated projects.

Second, large organizations may be more effective in retaining prospective entrepreneurs because they can better guard against employee departure. Because of their influence, resources, and market power, large firms have the ability to lobby public policy and respond to the legal environment (Schuler et al. 2002). Given their resources, large firms might more easily enforce noncompete agreements, which reduce job mobility (Marx et al. 2009). Such influence is likely to play a critical role in preventing employees from leaving to start their own ventures. Instead, talented workers in large, established firms may be more inclined to keep their attachment to current employment.

Finally, exit from larger firms into entrepreneurship is likely associated with higher opportunity costs. Scholars have long established that, relative to small firms, large organizations tend to provide more stable, long-term employment with generous benefits (Osterman et al. 2001), status advantage (Bidwell et al. 2015), or premium wages (Brown and Medoff 1989, Oi and Idson 1999). In a similar vein, large firms are characterized

by more developed internal labor markets, which offer attractive opportunities for promotion, as an employee advances through the levels of the corporate hierarchy, each associated with increasingly higher rewards (Sørensen 1977). These rich advancement prospects in large organizations increase the cost of leaving for entrepreneurship, therefore reducing the probability that a worker leaves a larger employer to launch a new venture.

Smaller firms, by contrast, might struggle to generate advancement opportunities and retain entrepreneurial talent. First, smaller organizations suffer from constraints on internal resources, which likely decrease their ability to promote employee-generated ideas. In particular, the lack of 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. A corollary of this claim is the possibility that, relative to their large, established counterparts, smaller firms face greater difficulties when accumulating valuable knowledge assets.

Moreover, small firms lack the routines and processes necessary to bring new ideas to market (Stinchcombe 1965, Galbraith 1973). For example, informal information structure tends to be poorly developed in firms that are less well established, mainly because social interactions in the firm have not matured. Similarly, small firms are unlikely to be equipped with external networks of clients, supporters, and customers (Hallen 2008), which reduces their ability to access valuable know-how. Lending support to this claim, Sorenson and Audia (2000) found that nascent entrepreneurs tend to locate close to their prior employers to acquire the necessary knowledge. Others have similarly shown that smaller firms face significant challenges when raising capital or competing for qualified labor and navigating complex government regulations (Aldrich and Auster 1986). The absence of stable routines and processes in small organizations limits the availability and attractiveness of internal opportunities to accommodate the pursuit of employee-generated projects. Hence, small firms may overall be less appealing to employees seeking to commercialize their own ideas.

Finally, leaving a smaller employer in pursuit of entrepreneurship might impose lower opportunity costs, since the kinds of internal options that prospective entrepreneurs leave behind are generally less attractive in smaller than in larger organizations. Smaller firms create less stable employment because they suffer from the liability of smallness and the consequent high mortality rates ((Baum and Oliver 1991, Freeman et al. 1983). Smaller and younger firms also provide their employees with poor-quality jobs, characterized by the lack of health care coverage and weaker retirement plans (Litwin and Phan 2013). Similarly, smaller organizations offer lower wages to their workers, being acutely constrained by limited financial resources (Brown and Medoff 1989, Osterman et al. 2001, Troske 1999). Resource constraints and weak influence also make it challenging to effectively lock entrepreneurial talent in a small firm. Since they cannot afford litigation costs, in case an employee leaves to found a spin-off, such firms are unlikely to effectively reduce employee mobility and the resulting knowledge spillovers. Collectively, these different studies imply that smaller firms may generally lack the types of information processes, resources, and influence needed to retain workers with entrepreneurial inclinations.

Given the past literature, one cannot easily dismiss the possibility that large firms might be more likely to retain entrepreneurial talent by providing enticing opportunities internally. Because past research has not ruled out this alternative explanation, our study addresses this important shortcoming by exploring a novel causal process at work when smaller organizations generate higher rates of entrepreneurship.

Organizational Dissolution and the Impact of Firm Size on Entrepreneurship

The core of our argument is that inequality in the internal opportunity structure across larger and smaller firms may confound the negative effect of firm size on entrepreneurial rates. Therefore, the impact of size should be examined absent of such opportunities. 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 options are by definition vanquished. Our argument is simple: when workers' career calculus is not influenced by the attractiveness of the opportunity structure within their current employment—which might bias individuals at large firms against transitioning to entrepreneurship—it is possible to assess the processes underlying the purported small-firm effect on entrepreneurship. Our baseline expectation is that larger firms will generate lower rates of entrepreneurship if such firms indeed have an advantage in providing more attractive opportunities that retain entrepreneurial talent more effectively. However, we also expect this effect to disappear following a firm's dissolution, which will, by default, equalize the disproportionate options across small and large organizations.

Data and Methods

Drawing credible causal inferences about the mechanisms we hypothesized raises empirical challenges. First,

internal opportunities are rarely visible to researchers. More importantly, even if these 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 with a novel research design, which helps alleviate concerns that plagued past studies: 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 such internal options are unlikely to affect occupational choice. One possibility would be to analyze 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 postdissolution 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 nondefunct 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 (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]

Moreover, 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 chief executive officer (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 data set of career histories in the automatic speech recognition (ASR) industry. Although ASR technology has become more salient recently with the popularity of applications including Siri, the industry dates back several decades. The first speech recognition product, created in 1922, was Radio Rex, a mechanical dog that would emerge from a doghouse in response to detecting the 500 MHz frequency corresponding to the "eh" vowel. More capable speech recognition systems were developed in the early 1950s, when AT&T and IBM undertook independent research efforts with quite different aims. IBM, then a typewriter company, sought to build a "talking typewriter," whereas 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 United Kingdom and Japan. Most research was undertaken by large research labs, though in 1970 the startup Threshold Technology was spun out of RCA Labs. Not until nearly three decades after IBM and AT&T commenced their own research efforts did the U.S. government began to fund basic research via the Defense Advanced Research Projects Agency, sponsoring annual "bake-offs" 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 and 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, 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., Klepper and Sleeper 2005). Workers 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 audio. That the industry requires substantial human capital is relevant because the opportunity cost of leaving paid employment for entrepreneurship is likely higher for specialized workers who have attractive opportunities within paid employment. Barriers to entry in ASR are high because growing a new venture and competing with other firms may require 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 and dry cleaners) 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). 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 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. Further details regarding the ASR firm data are in Marx et al. (2014). Our sample includes 8,940 firms, of which 1,448 go defunct during the study period. The next step was to collect the list of workers from several sources, beginning with the newsletters themselves.

Industry Newsletters. A research assistant recoded the newsletters 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 and 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.

Conference Proceedings. Several convocations of ASR researchers are held annually, including Eurospeech and the International Conference on Acoustic Speech and Signal Processing. From the proceedings of these conferences, author names and affiliations were extracted, noting the date of the conference. Although 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 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 studies have used patents to establish the sequence and timing of inventors' employment (e.g., Agrawal et al. 2006, Almeida and Kogut 1999). 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 patent data from Lai et al. (2011), a list of inventors with patents in the industry was constructed. This involved extracting all patents for de novo firms, but only patents in United States Patent and Trademark Office Class 704 for de alio entrants (Data Processing: Speech Signal Processing). For these inventors, all of their patents at any firm and in any class were extracted as one source regarding 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.

There are 7,874 workers who held a job at an ASR firm—either a de novo ASR company or one performing ASR-related activities within a de alio firm. The career histories were extended to include jobs outside the ASR industry. Non-ASR firm characteristics were retrieved from the proprietary National Establishment Time Series panel of Dun and Bradstreet (D&B) data (Walls and Associates 2010). 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 resolving nicknames. Names were then sorted by first initial and last name, and further variations checked by hand to resolve spelling inconsistencies, hyphenated names, etc. Although our data are not a complete census of ASR workers, the coverage of executives and inventors is exhaustive. Information on human resources or other back-office support workers may be less complete, though ZoomInfo contained a large number of outside-facing workers, including marketing and sales personnel and quality-assurance testers. Overall, 30% of ASR workers held nontechnical roles, but even if coverage of nontechnical workers were incomplete, it would unlikely bias our results. Nontechnical workers are generally less likely to transition into entrepreneurship and thus less subject to the mechanisms we describe (Dobrev and Barnett 2005).

Dependent Variable

Our dependent variable captures new-firm foundings (whether within the ASR industry or outside). As an example, consider Karl-Heinz Land, who held jobs at five 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 was coded as 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 find 510 such entrepreneurial events.

Explanatory Variable

Our key explanatory variable is the logged size of the worker's prior employer, measured as the number of employees in a given year. We count employees primarily using the Dun and Bradstreet head count (Walls and Associates 2010). For non-U.S. firms and a small number of U.S. firms where D&B data are not available, we use the count of employees we collected from various sources. For robustness, we replace the Dun and Bradstreet measure for de alio firms with our own employee count (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 firm-level, state-level, and worker-level covariates. Following prior research, we compute firm age as of the observation year and include a logged measure to mitigate the influence of outliers. Dummies for de alio and intraindustry spin-offs 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 at least one patent in an organization, and 0 otherwise. Moreover, we control for state-level enforcement of postemployment noncompete agreements in the United States by constructing a time-varying dummy variable, coded 1 if a state enforced noncompete covenants at time t and 0 otherwise, by implementing the coding of Stuart and Sorenson (2003). Finally, we include controls for worker's organizational tenure, measured by the number of years spent at that firm, logged to mitigate the influence of outliers. In unreported analyses, we included the quadratic term of tenure, but this resulted in an inferior fit and an insignificant coefficient. 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 85,500 first names determined by GenderChecker.com to be assigned to one gender. A research assistant searched for photos and personal pronouns using the combined first and last names of the workers in our sample whose first names were not listed on GenderChecker.com. Gender was determined for 95% of workers; results are robust to eliminating the variable. All time-variant variables are measured at time t.

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. We drop workers for whom job spells were separated by more than two years in cases when the individual's career history was gathered from the trade journals or conference proceedings, which lack information on non-ASR jobs. The final number of observations is 20,670 moves.

Model Specification

Because the dependent variable is dichotomous, we use a logistic regression model. The dependent variable is defined as an individual's transition to entrepreneurship and coded as 1 if an individual founded a new organization and 0 otherwise. Throughout all model specifications, the error terms are clustered at the organization's level (clustering at the individual level yields similar results). All models include year dummies to mitigate the influence of temporal shocks. Linear probability 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 prior findings, workers at smaller firms are more likely to become entrepreneurs. This univariate analysis does not control for confounding factors, which we explore in Table 2.

In column (1) of Table 2, we explore the association between our variables and the transition to entrepreneurship. To do so, we restrict our risk set to the defunct firms as well as nondefunct firms that can be matched with defunct firms according to size. We implement coarsened exact matching (CEM; Iacus et al. 2009) with cut points at the median, third quartile, top decile, and top percentile. Doing so reduces the overall sample to 18,994 observations, addressing the potential concern that a number of employees at very large firms do not become entrepreneurs because of a relative wealth of internal opportunities. Firm-level covariates influence entrepreneurship in several ways. Firm age is negatively correlated with the hazard of becoming an entrepreneur, whereas being an ASR spin-off is associated positively. The results further reveal the impact of individual-level covariates on entrepreneurship. CEOs are at higher risk of becoming entrepreneurs. Female workers and those in technical roles are less likely to start new ventures. Consistent with past research (e.g., Elfenbein et al. 2010, Kacperczyk 2012, Sørensen 2007), our results indicate a negative coefficient on firm size, significant at the 5% level. The number of jobs is positively associated with the transition into entrepreneurship. Exponentiating the coefficient on firm size suggests that larger organizations reduce the founding rate of start-ups: the odds ratio of becoming an entrepreneur is 5% lower for a one standard deviation increase in logged firm size. The economic significance of the firm size effect on entrepreneurship is comparable to that found in other studies. For example, using the Danish register, 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%. Using data on scientists and engineers, Elfenbein et al. (2010) show that individuals in firms with 1–25 employees transition into self-employment at a rate more than three times the average rate in the sample. These estimates are robust to event-history analyses as well as the exclusion of outliers (i.e., firms that spawned more than three spin-offs, any firm with more than one spin-off, or the top quartile of firms by size). This replication suggests that our data set is not markedly different from those in prior cross-industry studies, at least regarding the small-firm effect on entrepreneurship. The results in column (1) are robust both to not using CEM and to using CEM with matches based on (1) firm size by quartiles, (2) equally spaced buckets (5, 10, or 20 buckets—all yielded similar results), or (3) an entirely hands-off approach in which CEM automatically determines how the matching should occur. Finally, the results are stronger when we exclude non-ASR spin-offs from the dependent variable (there are 202 ASR spin-offs).

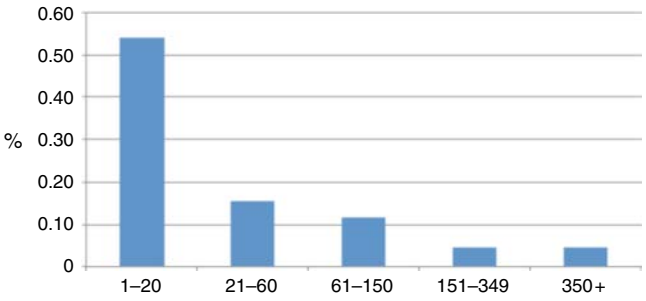
Having replicated prior findings regarding firm size and transition to entrepreneurship, we employ our primary empirical strategy of restricting analysis to workers who lost their jobs when firms failed. As mentioned earlier, failed firms are those ceasing independent operations. Dissolution occurs primarily when a firm is liquidated, as in the case of General Magic's June 2002 bankruptcy and layoff of its 80 employees, or occasionally 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 2009, with comments in the press release by Telesoft CEO Bruce Markham but not from ThinkEngine. Moreover, two ThinkEngine executives founded CallMiner shortly thereafter. (Less than 1% of ASR firms dissolved in a fire sale; controlling for this yields similar results.)

As our identification strategy depends on the removal of internal-to-the-firm opportunities, it is not sufficient to use as the subset of our analysis employees of firms that eventually went defunct. 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 1,418 employees who were present

Table 1 Descriptive Statistics

Variables	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Panel A: Job transitions from all firms																		
(1) *Founded new firm*	0.017	0.129	0.000	1.000	1.000													
(2) *Prior firm size* (ln)	4.427	2.707	0.693	11.070	−0.030	1.000												
(3) *Noncompetes*	0.691	0.462	0.000	1.000	0.010	−0.106	1.000											
(4) *Firm age* (ln)	1.422	1.293	0.000	4.673	−0.043	0.319	−0.159	1.000										
(5) *Prior firm was ASR spin-off*	0.227	0.419	0.000	1.000	0.004	0.005	−0.151	0.079	1.000									
(6) *Prior firm was de alio ASR entrant*	0.165	0.372	0.000	1.000	−0.021	0.252	−0.103	0.328	−0.143	1.000								
(7) *Prior firm # of patents to date* (ln)	1.047	1.768	0.000	6.409	−0.013	0.144	−0.010	0.042	0.084	0.252	1.000							
(8) *Prior firm # of patents per technical worker*	0.804	1.794	0.000	9.246	−0.003	0.044	0.084	−0.190	0.124	−0.082	0.767	1.000						
(9) *Worker age* (ln)	3.405	0.252	3.045	4.248	0.016	−0.060	0.012	0.010	0.029	−0.135	−0.081	−0.006	1.000					
(10) *Worker has patents to date*	0.078	0.268	0.000	1.000	−0.017	0.026	−0.038	0.081	−0.131	0.356	0.273	−0.013	−0.094	1.000				
(11) *Worker tenure al firm* (ln)	1.483	0.721	0.000	3.788	−0.009	0.106	−0.078	0.250	−0.004	0.363	0.153	−0.034	−0.118	0.200	1.000			
(12) *Worker was CEO*	0.042	0.201	0.000	1.000	0.039	−0.092	0.042	−0.132	0.022	−0.043	−0.015	0.042	0.065	−0.051	0.009	1.000		
(13) *Worker had technical role*	0.479	0.500	0.000	1.000	−0.028	0.110	−0.015	0.126	−0.054	0.198	0.221	0.068	−0.106	0.270	0.127	−0.186	1.000	
(14) *Worker was female*	0.196	0.397	0.000	1.000	−0.035	−0.024	−0.028	−0.003	0.052	−0.077	−0.097	−0.062	−0.076	−0.094	−0.039	−0.033	−0.155	1.000
(15) *Worker # of jobs to date* (ln)	1.470	0.641	0.000	4.625	0.019	0.006	0.043	−0.045	0.102	−0.257	−0.149	0.029	0.599	−0.348	−0.252	0.029	−0.068	−0.042
Panel B: Firm dissolutions																		
(1) *Founded new firm*	0.019	0.137	0.000	1.000	1.000													
(2) *Prior firm size* (ln)	3.432	2.287	0.693	8.853	0.038	1.000												
(3) *Noncompetes*	0.717	0.451	0.000	1.000	−0.001	0.031	1.000											
(4) *Firm age* (ln)	6.005	7.282	1.000	99.000	−0.015	0.152	0.066	1.000										
(5) *Prior firm was ASR spin-off*	0.047	0.212	0.000	1.000	−0.012	−0.025	−0.031	−0.137	1.000									
(6) *Prior firm was de alio ASR entrant*	0.014	0.116	0.000	1.000	−0.016	0.040	−0.145	0.010	−0.026	1.000								
(7) *Prior firm # of patents to date* (ln)	0.144	0.403	0.000	2.639	−0.011	0.188	−0.023	0.159	0.082	0.011	1.000							
(8) *Prior firm # of patents per technical worker*	0.112	0.312	0.000	2.322	−0.010	0.146	−0.033	0.006	0.040	−0.017	0.815	1.000						
(9) *Worker age*	3.360	0.217	3.045	4.248	0.022	−0.009	0.023	0.068	0.034	−0.093	−0.005	0.012	1.000					
(10) *Worker has patents to date*	0.166	0.373	0.000	1.000	−0.020	0.107	−0.044	−0.005	0.100	−0.027	0.710	0.741	0.041	1.000				
(11) *Worker tenure al firm*	1.397	0.679	0.074	3.723	−0.017	0.092	0.018	0.405	−0.028	0.120	0.023	0.002	0.034	−0.017	1.000			
(12) *Worker was CEO*	0.036	0.187	0.000	1.000	0.015	−0.054	−0.007	−0.094	0.093	0.103	−0.069	−0.070	0.077	−0.056	0.066	1.000		
(13) *Worker had technical role*	0.463	0.499	0.000	1.000	−0.034	0.039	−0.030	0.024	0.019	−0.062	0.342	0.357	−0.041	0.388	−0.055	−0.175	1.000	
(14) *Worker was female*	0.203	0.402	0.000	1.000	−0.041	−0.020	−0.013	−0.009	−0.030	0.046	−0.112	−0.121	−0.064	−0.171	0.019	−0.055	−0.186	1.000
(15) *Worker # of jobs to date* (ln)	0.911	0.688	0.000	4.127	0.048	−0.037	−0.024	−0.134	0.048	−0.093	0.128	0.145	0.628	0.184	−0.321	0.033	0.064	−0.094

Figure 1 (Color online) Likelihood of an Employee Becoming an Entrepreneur, by Firm Size



at the time of their employers' demise. Whereas in the overall data set 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.

Column (2) in Table 1 further replicates the results in column (1) for a target subsample of defunct firms to assess the sign of firm size coefficient within this subsample. As expected, the coefficient on firm size is no longer negative. In fact, in sharp contrast to column (1), the sign of the coefficient reverses and is statistically significant at the 5% level ($p < 0.05$), indicating that employees who remained at larger firms until their dissolution were no longer *less* likely to become entrepreneurs. Exponentiating the coefficient on firm size indicates that a one standard deviation increase in logged firm size is associated with a 15% increase in the odds ratio of becoming an entrepreneur.

Robustness Checks

Dissolution Timing. 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) of Table 2, we reestimate the baseline model within the subsample of defunct firms and 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 no statistical significance.

Falsification. In additional analyses, we attempt to falsify our results. Given that we observed a positive effect of firm size on transition to entrepreneurship, we now assess whether this result 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), large nondefunct firms will nonetheless exhibit greater probability than dissolved firms to redeploy at least some of the workers. To the extent that the potential effect of firm size on entrepreneurship reflects the extinction of internal opportunities accompanying firm dissolution, employees of failed divisions should be less likely than employees of defunct firms to transition. 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 (4) of Table 2, we explore this possibility by assessing whether the result is truly due to the extinction of internal opportunities accompanying firm dissolution. 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 479 employees who were present at the time their firm exited the ASR industry but continued to operate elsewhere. Although exiting the industry will reduce internal opportunities as jobs are eliminated, it does not 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 drive 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. In fact, the positive effect of firm size we observed for defunct firms disappears consistent with the claim that when large firms exit from the ASR but continue to operate in other industries, they still provide employees with internal opportunities. However, the negative effect we find is not statistically significant—perhaps because many opportunities might be in different industries and not all employees can and are allowed to take advantage of them. Hence, some employees will become entrepreneurs.[2]

Because Models (2)—(4) are estimated on the target subsample, in column (5) we reestimated these results on the full sample. Here, we include three interaction terms in one model. First, we interact firm size with a defunct-firm indicator to estimate the differential effect of firm size on entrepreneurship across defunct and nondefunct

Table 2 Likelihood of a Worker Transitioning from Employment to Entrepreneurship

	(1)	(2)	(3)	(4)	(5)
Variables	Full sample	Defunct firms	Defunct firms	Firms that exited ASR	Full sample
Prior firm size (ln)	−0.0521*	0.1459*	0.1478*	−0.0077	−0.0662*
	(0.025)	(0.070)	(0.072)	(0.249)	(0.027)
Noncompetes enforceable	−0.0252	0.0078	0.0101	−0.7769	−0.0438
	(0.142)	(0.391)	(0.392)	(0.625)	(0.141)
Prior firm age (ln)	−0.1548**	−0.1054	−0.1065	−1.6980**	−0.1498**
	(0.052)	(0.228)	(0.228)	(0.579)	(0.052)
Prior firm was ASR spin-off	−0.0521*	0.1459*	0.1478*	−0.0077	−0.0662*
	(0.025)	(0.070)	(0.072)	(0.249)	(0.027)
Prior firm # of patents to date (ln)	−0.0628	0.1062	0.1089	−0.3646+	−0.0562
	(0.043)	(0.754)	(0.751)	(0.206)	(0.044)
Worker age	0.5421+	−0.2489	−0.2445	6.7832***	0.4862+
	(0.280)	(1.079)	(1.083)	(1.876)	(0.289)
Worker has a patent to date	−0.4112	−0.8836	−0.8855	2.9987*	−0.4902
	(0.300)	(0.959)	(0.956)	(1.462)	(0.327)
Worker tenure at firm	−0.0908	0.0409	0.0437	−0.0560	−0.0989
	(0.089)	(0.312)	(0.313)	(0.951)	(0.088)
Worker was CEO	0.5327**	0.2694	0.4513	−0.2618	0.5446
	(0.201)	(0.803)	(0.953)	(1.021)	(0.361)
Worker had technical role	−0.3761**	−0.6887	−0.6876	−1.8400	−0.3734**
	(0.142)	(0.441)	(0.440)	(1.262)	(0.142)
Worker was female	−0.9054***	−1.0991+	−1.0986+		−0.9000***
	(0.196)	(0.646)	(0.646)		(0.196)
Worker # of jobs to date (ln)	0.1954+	0.9470*	0.9430*	−0.7079	0.2447+
	(0.116)	(0.443)	(0.445)	(0.846)	(0.130)
Prior firm was de alio ASR entrant	−0.0679			−3.6188**	−0.0910
	(0.230)			(1.132)	(0.260)
Defunct firm					−0.6609+
					(0.353)
Firm exited ASR					1.1722+
					(0.648)
Prior firm size (ln) ∗ *Defunct firm*					0.2037**
					(0.070)
Prior firm size (ln) ∗ *Worker was CEO*			−0.0625		−0.0069
			(0.190)		(0.103)
Prior firm size (ln) ∗ *Firm exited ASR*					−0.2255
					(0.145)
Constant	−6.1368***	−3.8837	−3.9014	−22.0703***	−5.9672***
	(0.973)	(3.437)	(3.453)	(5.958)	(0.986)
Log pseudolikelihood	−1,589.8898	−147.7948	−147.7835	−29.99932	−1,585.0627
Number of entrepreneurial events	510	37	37	13	510
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	18,994	1,418	1,418	479	18,994

Notes. Robust standard errors are in parentheses. Models (2) and (3) drop *Prior firm was de alio ASR* entrant because of limited variation in the variable. Model (4) drops the *Female* dummy for similar reasons. $^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

firms directly. Second, we interact firm size with the CEO-role indicator to estimate whether the effect of size on entrepreneurship differs across CEOs and non-CEOs. Finally, we interact firm size with ASR-exit indicator. As when analyzing the subsample of defunct firms, the interaction of firm size with the defunct firm remains positive and statistically significant at the 1% level: the negative effect of firm size on entrepreneurship is weaker in defunct firms, consistent with findings in column (2). Moreover, the interaction of firm size and the CEO role is not statistically significant, consistent with findings in column (3). Finally, the interaction of firm size and ASR-exit indicator is negative but not significant at conventional levels, consistent with findings in column (4). This suggests that the negative effect of firm size on entrepreneurship is uniform across nondefunct firms and

firms that existed the ASR industry. Overall, we are able to replicate results in columns (2)—(4) on the full sample.

Noncompete Enforcement. Although we include a control for noncompete enforcement, in unreported analyses we reestimated the models for the defunct-firm subsample with state fixed effects to mitigate the potential unobserved variation in the enforcement across states. This reduces the sample size by about 30% because many states reveal no variation in entrepreneurial transition. But despite this reduction, the coefficient remains positive and significant at the 10% level. Based on these analyses, we conclude that our results are unlikely to arise due to state-level variation in noncompete covenants.

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, we no longer find the negative effect. Rather, our results show 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.

Alternative Explanation: Internal Attrition in Defunct Firms

An alternative explanation of our findings may be that large, dissolved firms generate higher rates of entrepreneurship due to disproportional attrition of talented workers in firms that dissolve. Workers may anticipate firm failure, and those with most valuable skills and richest opportunities are the ones who would leave first (Pfeffer and Sutton 2006). By contrast, those with fewer alternatives and less valuable skills will remain in the firm until it dissolves. Following a firm's dissolution, if it were truly the least valuable employees who stayed until the end, they might have difficulty finding new employment and thus enter into self-employment. We offer two tests to assess this potential alternative explanation for our results.

Functional Roles in Parent Firms. First, we consider functional roles held by workers who left defunct firms to become entrepreneurs. If internal attrition drives our results, founders from defunct firms should be more likely than founders from nondefunct firms to have occupied lower-skilled positions in the parent firm. In a high-tech industry, lower-skilled positions are typically those that do not require technical skills, and hence include positions in administration, sales, or marketing. This should be especially true in large organizations, which have more diverse operations and thus may have more administrative and support personnel lacking technical skills. Table 3, panel A, reports the share of founders in each spin-off who occupied various roles in their parent organizations. Because, by the above reasoning, this concern may be amplified in larger parent firms, we limit our analysis to spin-offs whose parents were at or above median size (though our findings are similar when analyzing all spin-offs). For each role, we test the difference of means to compare the percentage of founders across defunct and nondefunct firms. As can be seen, there is little difference in the share of founders in each start-up by functional role across defunct and nondefunct parent firms, and in no case are the differences statistically significant. Founders from defunct and nondefunct firms are equally likely to have previously occupied lower-skilled functions, including nonmanagerial roles in sales, marketing, or administration.

Table 3 Internal Attrition Analyses

Panel A: Difference-of-means tests for previous roles of spin-off founders, defunct vs. nondefunct parents. $N = 217$ spin-offs

% of founders with previous role	Parent not defunct	Parent defunct	$p<$
Nonmanagerial (administrative)	0.032	0.022	0.713
Nonmanagerial (general)	0.516	0.488	0.739
Technical	0.389	0.466	0.364
Sales	0.122	0.111	0.828
Marketing	0.092	0.111	0.683
Nontechnical	0.709	0.711	0.986
Executives	0.402	0.444	0.626
Nontechnical, nonmanagerial	0.191	0.155	0.557

Panel B: Spin-off performance, defunct vs. nondefunct parents. All models have founding-year fixed effects

	(1)	(2)	(3)
Variables	Patents/ year	Peak annual sales per employee	Funding raised (all sources)
Parent defunct	1.6222*	2.1694*	0.3147
	(0.765)	(0.978)	(0.201)
# *founders* (ln)	−1.4270	2.0100	4.2733***
	(1.562)	(1.581)	(0.436)
Noncompetes enforceable	−0.5171	1.1227+	−0.5665***
	(0.564)	(0.637)	(0.148)
Parent # patents (ln)	0.3150**	0.2304	−0.0771*
	(0.113)	(0.148)	(0.030)
Parent was ASR spin-off	−1.8751	−0.1553	−0.1729
	(1.175)	(1.485)	(0.311)
Parent was de alio ASR entrant	−2.3543**	−0.2511	0.6870**
	(0.855)	(0.982)	(0.224)
Parent ever raised VC	0.4702	−0.0251	0.3184
	(0.952)	(1.173)	(0.254)
Spin-off lifespan		0.1100+	0.0321*
		(0.062)	(0.014)
Constant	4.6556+	9.9154**	−2.6828***
	(2.462)	(2.849)	(0.646)
Observations	217	79	217
R-squared	0.202	0.580	0.639

Note. Standard errors are in parentheses. $^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Spin-off Outcomes. Second, we examine spin-off performance outcomes as a function of parent firm characteristics. If our results are driven by disproportionate attrition of high-skilled workers in defunct firms, then spin-offs generated by such firms ought to experience worse performance outcomes than spin-offs generated by nondefunct firms. We investigate this possibility by estimating the association between defunct parent firm and spin-off performance. Given the focus on larger firms, we estimate the baseline specifications on the subsample of firms whose size is above or at the median size in our sample (results are robust in the full sample). We measure performance by (1) the number of patents per year, (2) peak annual sales per employee, and (3) total funding raised. All models include founding-year fixed effects as well as covariates that control for the characteristics of spin-offs. Our independent variable is a dummy equal to 1 if the parent firm is defunct and 0 otherwise. Results in panel B of Table 3 show that not only is the coefficient on firm size no longer negative, but large, defunct parents are in fact associated with both patenting and sales outcomes. Specifically, spin-offs generated by defunct firms have more patents per year (column (1)) and, for firms where sales data are available, higher peak annual sales per employee (column (2); also robust to not dividing by the number of employees). Last, we compare the total amount of funding raised from all sources, including Small Business Innovation Research and other government grants, venture capital, and "strategic" investments from corporations. Although we do not see a statistically significant difference between spin-offs of defunct versus nondefunct parents, the coefficient on the defunct parent measure is positive. This is consistent with the earlier findings that spin-offs from larger, defunct parents do not underperform relative to their counterparts. Overall, these results fail to provide support for internal attrition, thus weakening the plausibility of this alternative explanation.

Attrition Prior to Dissolution. More generally, a concern might be that dissolution is preceded by internal attrition and that attrition rates are likely to correlate with firm size. For example, it might be that small firms have higher attrition rates prior to dissolution because smaller firms have fewer resources to retain their workers during challenging periods. Although such disproportionate attrition would only be problematic if it correlates with the propensity to enter entrepreneurship, we nevertheless assess this possibility empirically. In particular, in additional analyses (unreported), we estimate the propensity of a worker leaving the firm preceding the demise. Within the subsample of workers who left prior to the demise the coefficient on firm size is positive but not statistically significant at conventional levels. When we replicate this result on the full sample, our results are consistent: the coefficient on the interaction term between firm size and the period preceding the demise is not statistically significant at conventional levels. Hence, these results suggest that tendency to leave a to-be-dissolved firm does not correlate with size of that firm.

Auxiliary Results: Entrepreneurial "Molding"

These findings are consistent with our prediction that negative impact of firm size on entrepreneurial entry is no longer present once internal opportunities have been accounted for. In fact, our findings indicate that larger, dissolved firms are more likely to facilitate entry into entrepreneurship. In this section, we begin to explore possible mechanisms behind this positive effect of firm size. The positive coefficient on firm size may reflect the tendency of larger firms not only to retain but also to *mold* entrepreneurial talent. Although scholars have associated firm size with numerous liabilities, including bureaucratization, complexity, and rigidity, there is nonetheless evidence that large firms can encourage the willingness to innovate (Jelinek and Schoonhoven 1990). This line of work has argued that firm size is correlated with significant information advantage due to advanced information processing routines and superior access to suppliers, customers, and alliance partners (Agarwal et al. 2004). Because large firms have more employees, they might generate opportunities for exchange and circulation of ideas. If large firms facilitate innovation, their dissolution will likely foster entrepreneurial entry by releasing ample resources (Hoetker and Agarwal 2007, Hiatt et al. 2009). In the exploratory analyses, we assess the potential for this mechanism by interacting size with cross-sectional characteristics.

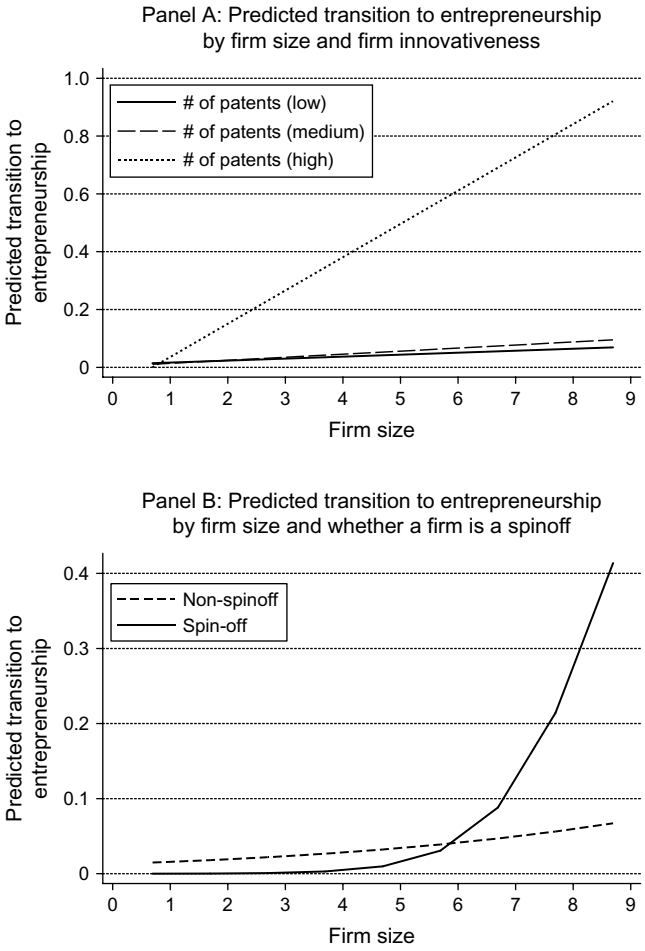
Innovative Parent Firms. First, we might expect the positive impact of firm size on entrepreneurial entry to be higher in parent firms that are more innovative. We interact defunct firm size with the number of patents per technical worker. (Adjusting for the number of employees in technical roles and thus at risk of patenting affords a better measure of innovativeness, whereas an unadjusted patent count may correlate with firm size.) Column (1) of Table 4 indicates that the positive effect of firm size on entrepreneurship is amplified for more innovative parents. The coefficient on the number of patents per technical worker interacted with firm size is positive and significant at the 5% level ($p < 0.05$), which we interpret as suggestive of the molding mechanism. Of course, interpreting interaction terms in nonlinear models is not straightforward. Following Greene (2010), 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 of Figure 2 does this for low, medium, and high values of patents per technical

Table 4 Likelihood of Transitioning from Employment to Entrepreneurship: Molding Mechanism

Variables	(1)
Prior firm size (ln)	0.2050**
	(0.075)
Noncompetes enforceable	−0.0259
	(0.402)
Prior firm age (ln)	−0.0790
	(0.243)
Prior firm was ASR spin-off	−5.9250**
	(2.091)
Prior firm # of patents to date (ln)	−0.4767
	(0.692)
Worker age	−0.0447
	(1.080)
Worker has a patent to date	−0.5150
	(0.923)
Worker tenure at firm	0.0364
	(0.321)
Worker was CEO	0.3037
	(0.836)
Worker had technical role	0.9063
	(0.760)
Worker was female	−1.0731+
	(0.651)
Worker # of jobs to date (ln)	0.9692*
	(0.445)
Number of patents per worker	−2.6665
	(1.755)
Number of patents per worker ∗ Firm size	0.6403*
	(0.281)
Prior firm was ASR spin-off ∗ Firm size	0.9948**
	(0.359)
Worker had technical role ∗ Firm size	−0.4603+
	(0.240)
Constant	−5.0303
	(3.500)
Log pseudolikelihood	−142.7716
Number of entrepreneurial events	37
Year dummies	Yes
Observations	1,418

Note. Robust standard errors are in parentheses.
$^{+}p < 0.1$; $^{*}p < 0.05$; $^{**}p < 0.01$.

Figure 2 Interaction Effects for Predicted Transition to Entrepreneurship



worker. Graphing interaction terms reveals that the effect of firm size on transition to entrepreneurship increases most strongly in the most innovative parent firms.

Parent Firms Are Themselves Spin-offs. Moreover, we consider whether the impact of firm size on entrepreneurial rates varies systematically depending on whether the parent firm is an intraindustry spin-off. We consider only intraindustry spin-offs because technological know-how and knowledge are most likely to be transferred within a single industry (for a review, see Klepper 2009) and the latter tend to outperform de novo start-ups as well as incumbent firms in part because they exploit the inherited knowledge (e.g., Klepper 2007). If large 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 could be amplified for parent firms that are themselves intraindustry spin-offs. To assess this relationship, we interact the dissolved firm size with a dummy variable indicating that the parent firm was generated via spin-off within the ASR industry. In Table 4, column (1), a positive and statistically significant interaction term with size for firms that were spin-offs within the ASR industry ($p < 0.01$) is consistent with the notion that dissolved firms that were spin-offs are more likely to spur entrepreneurship. Panel B of Figure 2 graphs the predicted effect of firm size on transition to entrepreneurship by whether the parent firm is a spin-off; indeed, the effect of firm size on entrepreneurship is more positive for the parent firms that are spin-offs, likewise suggestive that large firms could "mold" entrepreneurs (results are robust to Ai and Norton's 2003 *inteff* correction).

Workers in Technical Roles. We might expect the positive effect of firm size on entrepreneurship to

increase for workers in organizational roles conducive to the acquisition of technological knowledge. Those 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 start-ups (Anton and Yao 1995, Shane 2003). We interact parent firm size with a dummy indicating whether an employee occupied a technical role with the parent firm, but we do not find support for this notion, as the coefficient is negative with weak significance ($p < 0.1$).

Cofounders. The positive effect of firm size on entrepreneurship, upon dissolution, might reflect greater cofounding opportunities at the time of firm demise. Because large organizations disperse more workers, the share of potential cofounders increases with size of the dissolved firm: thus increasing the likelihood of founding a new venture. To probe this mechanism deeper, we identified entrepreneurs who cofounded with prior employees. Excluding these cases from our models is immaterial to our results (available upon request).

Taken together, these results lend some credence to the notion that higher rates of entrepreneurship emanating from smaller firms might reflect the fact that larger organizations not only retain would-be entrepreneurs, but also mold employees into entrepreneurs.[3] That said, we interpret this evidence cautiously. Future research should seek to establish more deeply what might explain a higher rate of entrepreneurship in large firms, controlling for internal opportunities.

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 et al. 2010, Gompers et al. 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 process: the inequality of internal opportunity structure in large and small organizations. Large organizations provide more enticing internal opportunities to retain entrepreneurial talent—being better endowed with the kinds of resources that increase the opportunity cost of leaving for entrepreneurship. 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. Thus, employees of smaller firms are more likely to transition to entrepreneurship.

Although disentangling these two mechanisms has been difficult, the design of our study overcomes that challenge by leveraging firm dissolution to compare the rates of entrepreneurship across both defunct and nondefunct firms. Because internal opportunities are absent in dissolved firms, it is possible to test the causal mechanisms 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 disproportionate opportunities inside. 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, 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.

In a series of additional analyses, we further mitigate the concern that our results may reflect disproportionate attrition of talented workers in large, defunct firms. We rule out this concern by first showing that founders from defunct and nondefunct firms are equally likely to have previously occupied potentially lower-skilled functions. Moreover, spin-offs from larger, defunct firms were associated with better performance outcomes (patenting and sales), consistent with other studies documenting that industry leaders are responsible for generating the highest rates of spin-offs (e.g., Klepper 2007, Klepper and Sleeper 2005). Our findings can also be falsified in that we show that they no longer hold when internal opportunities continue to persist: we were unable to replicate these findings when we considered organizations that ceased their operations in the ASR industry but continued operating in other industries. Despite their failure, such firms could provide internal options to workers elsewhere within the company.

Not only are we unable to replicate the "small-firm effect" for the subsample of defunct firms, but also we find a *positive* effect of firm size on transition into entrepreneurship. One reason might be that large firms hold relative advantage in their ability not only to retain but also to mold entrepreneurial workers. Our analyses indicate that this indeed might be the case. We find that the positive impact of firm size on entrepreneurship is amplified in more innovative parent firms and those parent firms that are themselves intraindustry spin-offs, since resources are generally more available in spin-off firms. A caveat is that our results should be interpreted only as suggestive, opening avenues for future investigation. Providing conclusive, causal evidence is a challenging task that requires detailed data on the companies' operations and processes, while also taking advantage of exogenous variation in these organizational attributes.

Making ground on these causal processes is a promising avenue for future research.

We expect our findings to hold in other contexts, but there are scope conditions associated with our theory that may be best suited to explaining variation in entrepreneurial rates in high-tech sectors where workers have high human capital. Many ASR workers require significant resources to get a start-up underway, with two implications for the entrepreneurial process. First, starting a company in the ASR industry requires gathering external resources 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 nondisclosure or noncompete 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 nontechnical, 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.

Finally, our study has measured firm size by the number of employees. We use head count rather than alternative measures (e.g., revenues) to be consistent with past studies on the small-firm effect. However, future studies may explore alternative measures. One avenue of inquiry could assess whether our results might hold when revenues are being measured. To the extent that revenues may capture different firm dynamics than head count, future research may reveal new insights. Scholars may also explore any potential nonlinearities. It may be worthwhile to unpack whether the observed effects are subject to different mechanisms when organizations are exceptionally large. Investigating the subtleties of organizational size may shed new light on our understanding when established firms generate spin-offs.

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 suggested that smaller firms foster entrepreneurship by equipping employees with skills, knowledge, and resources conducive to entrepreneurship, we show that this effect may instead arise as a result of the less attractive career-advancement opportunities found inside smaller firms. Our findings suggest that large organizations hold a relative advantage at effectively retaining entrepreneurial talent internally.

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Endnotes

[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. But external funding is hardly a requirement for *starting* a new firm. Of the 651 firms in the ASR industry, 153 obtained venture capital.

[2]The insignificant results may also reflect a small number of events: we find only 13 cases of ASR divestments in the sample we study. Hence, these results should be interpreted with caution.

[3]Our main findings are also consistent with sorting whereby large firms attract entrepreneurial employees, providing attractive rewards. However, this would imply that our effects should persist for the subsample of firms that exited ASR industries: workers with entrepreneurial inclinations should be as likely to sort into firms that go defunct as into firms that divest. Yet in columns (4) and (5) of Table 2 we do not find support for this notion. Moreover, in unreported analyses (available on request), we rule out the possibility that our results are driven by workers who joined large firms via entrepreneurial acquisitions. Hence, additional findings suggest that sorting is unlikely.

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