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Testing the Waters: Founding Team Composition and Search Heuristics in Academic Entrepreneurial Ventures

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Abstract

Entrepreneurial action often stems from individual judgment about the value potential of market opportunities. Where entrepreneurs direct their search for and evaluate profitable opportunities has long received scholarly consideration.

Attention has been increasingly directed toward how search is conducted, with a distinction between "cognitive" search, where actors are driven by a prior belief about the linkage between actions and outcomes (i.e., "learning–*before*–doing") and "experiential search," in which the solution must be realized through experimentation, trial–by–error, or "learning–*by*–doing." We examine founders' experiential search for market applications in uncertain technological environments. In doing so we seek to uncover how founder background, experience, and depth of knowledge affect the firm's degree of experiential search.

We examine a sample of technology–oriented start–ups founded by researchers from six major U.S. research universities to investigate the role of experiential search in university technology commercialization. In our context of academic entrepreneurship, we find that founding teams that draw from multiple disciplinary perspectives in selecting a market application to pursue exhibit a broader cognitive map of the technological landscape and thus expend more effort in the experiential search process than do teams with less varied backgrounds. Conversely, teams that include individuals with prior commercial experience conduct less experiential search, although this evidence is less strong. The inclusion of students appears to lead to greater experiential search by the founding team. Our findings add new understanding to the application of search heuristics by entrepreneurial firms in technology commercialization.

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1 Introduction

Entrepreneurial action often stems from individual judgment about the potential value of market opportunities. How entrepreneurs search for and evaluate profitable opportunities has received increasing scholarly attention (Haynie, Shepherd, and McMullen 2009, McMullen and Shepherd 2006), with a recent emphasis on the role of entrepreneurs' prior knowledge, experience, and expertise on their opportunity beliefs (Gruber, Kim, and Brinckmann 2015, Wood, McKelvie, and Haynie 2014). Recent studies of technology–based ventures suggest rewards to search—ventures that identify multiple opportunities prior to commercialization appear to increase their chances of survival and growth, for example Gruber, MacMillan, and Thompson (2008, 2013b). When search is most costly, such as in novel or uncertain situations, there is a trade–off between acquiring more information and "satisficing," or accepting an "adequate" rather than an optimal solution (Nelson and Winter 1982). The risks involved in this tradeoff can be especially salient for the resource–strapped entrepreneurial venture (Katila, Chen, and Piezunka 2012, Li, Maggitti, Smith, Tesluk, and Katila 2013).

Organizational search has been argued to involve two dimensions, *where* and *how* (Gavetti and Levinthal 2000, Lopez-Vega, Tell, and Vanhaverbeke 2016). The question of where search occurs, or the location or distance of search activities has received considerable attention. For example, March and Simon (1958) depict search as occurring within a "neighborhood." Levinthal (1997; p. 937) formalizes this notion by modeling search as a "walk over the rugged landscape of alternative forms" within a firm's immediate neighborhood. Local search can also explain the incremental evolution of a firm's organizational routines (Nelson and Winter 1982). Such local search can lead organizations to exhibit myopic behavior, discounting distant locations, times, or places (Levinthal and March 1993).

More distant search can lead to more novel solutions. For example, in a study of citations to a random sample of U.S. patents issued in 1990, Fleming and Sorensen (2001) find that a greater number of patent sub–classes referenced in the focal patent (signifying greater search) is associated with a greater number of patent citations, or greater impact. Katila and Ahuja (2002) and Katila (2002) find that more distant search is positively related to product innovation for a sample of industrial robotics firms. Furr, Cavarretta, and Garg (2012) show that founding teams consisting mainly of domain outsiders bringing a novel perspective are more likely to produce competence–destroying technological change, presumably because they engage in more distant search. Breadth of search has also been found to be positively related to innovative outcomes in several studies (Laursen and Salter 2006, Leiponen and Helfat 2010, Love, Roper, and Vahter 2014)

How firms search has received increasing scholarly attention. Gavetti and Levinthal (2000) propose that firms often engage in both (a) "forward–looking" search through experimentation or learning–by–doing (Levitt and March 1988), and (b) "backward–looking," or cognitive search. Unlike experiential search, cognition does not involve experimentation or learning–by–doing, rather cognitive search is driven by suppositions and abstract representations (Lopez-Vega, Tell, and Vanhaverbeke 2016) and "learning–before–doing" (Pisano 1994).

We examine a sample of technology–oriented start–ups founded by researchers from six major U.S. research universities to investigate the effect of founding team composition on the manner in which the firm conducts search, with an emphasis on cognitive vs. experiential search in technology commercialization. Academic entrepreneurship often involves a high level of uncertainty in the development and commercialization of embryonic technologies arising from academic research (Jensen and Thursby 2001, Mowery, Nelson, Sampat, and Ziedonis 2004, Ziedonis 2007).[1] Academic entrepreneurship thus provides a very good setting, therefore, to examine the heuristics used in search as described by Gavetti and Levinthal (2000) and Lopez-Vega, Tell, and Vanhaverbeke (2016) as commercialization often requires at least a partial implementation of a market application (e.g., a prototype, lab–scale experimental result, beta–version of a software application) in order to evaluate its efficacy.[2]

In the next section we discuss cognitive and experiential search heuristics for market applications and develop hypotheses applied to technology–driven entrepreneurship. We then describe our data and methodology in Section 3. The results of our empirical analysis are reported in Section 4. We discuss our results, address limitations, and conclude in Section 5.

[1]The embryonic nature of university inventions is such that any one invention often has multiple possible market applications; for example, Shane (2000) describes eight different market segments that could be reached from the application of a single MIT technology (3D Printing).

[2]We refer to "technology–based" and "academic" startup interchangeably, and follow Shane (2004) by classifying those startups as *de novo* ventures established by faculty, research staff and/or students, who found the firm to directly exploit knowledge emerging from their scientific research.

2 Theoretical Framework and Hypotheses

Potential market applications arising from new technologies are often not self–evident, but require ongoing structuring and sensemaking to evaluate the likelihood of success and render them "market ready" (Weick 1990, Zahra, Velde, and Larraneta 2007). As discussed in the previous section, the organizational learning literature has conceptualized the identification of market opportunities as an organizational "search" problem (Gruber, MacMillan, and Thompson 2008). Nelson and Winter (1982) characterize the activities undertaken to ascertain the technological and economic characteristics of a new technology as belonging to a "search strategy." The likelihood of discovering a successful market application rises with increased search efforts (Li, Maggitti, Smith, Tesluk, and Katila 2013).

In a world of complete information and rational decision–making, entrepreneurs are able to observe a complete "landscape" and identify the most profitable combination of technological applications and market opportunities (Gruber, MacMillan, and Thompson 2008). As Herbert Simon points out however, individuals are "boundedly rational," that is, "intendedly rational but limitedly so" (Simon 1955, Williamson 1985). This limitation suggests that individuals cannot costlessly arrive at the optimum solution—uncertainty, complexity, cognitive impediments, and other factors restrict individuals' ability to identify the most profitable path. The result often leads to "satisficing" (Simon 1956), or search until a solution that satisfies a pre–set criterion is identified.

Organizational theorists have argued that firms often engage in less–risky "local" search, or search near their existing knowledge domains, for a number of reasons. For example, Stuart and Podolny (1996) suggest that local search builds on technological capabilities developed in prior searches. In their characterization of the firm as a "collection of routines," Nelson and Winter (1982) posit that search building on existing routines would evolve towards a nearby solution. Cohen and Levinthal (1990) argue that the knowledge investments a firm makes to develop an "absorptive capacity" in a particular technological area leadsead to an advantage in nearby applications in solution space. These arguments are supported by Helfat (1994) who found that R&D performed by U.S. petroleum firms closely followed domains of previous R&D efforts.

The manner by which firms obtain external knowledge features prominently in a number of organizational innovation and learning perspectives. Nickerson and Zenger (2004) relate search complexity to forms of governance. According to these scholars, complex problems require a theory to guide its search for a solution. Such problems are addressed more effectively in a governance form that facilitates sharing of ideas for theory and heuristic–driven search, such as hierarchical forms of governance. In contrast, simple problems can more efficiently be solved through decentralized, trial–and–error search that is more effectively conducted through more market forms of organization.

In an investigation of how firms develop dynamic capabilities, Zollo and Winter (2002) describe an experiential process of learning–by–doing that contrasts with "cognitive processes" of "articulation and codification of collective knowledge" (p. 340). Pisano (1994) argues that the latter process is more effective in chemistry–based drug development efforts by pharmaceutical firms due to deep theoretical knowledge. Experiments and learning–by–doing feature more prominently in biology–based efforts where knowledge of interactions is not as strong.

Gavetti and Levinthal (2000) classify theory driven or "cognitive" search as "forward–looking" and driven by an individual's mental model of actions and outcomes. In contrast, learning–by-doing or "'experiential" search is "backward–looking," as it is conducted experimentally rather than through employing a mental model. Building on this distinction, Lopez-Vega, Tell, and Vanhaverbeke (2016) develop a framework of search paths in which they disaggregate the means of search into "experiential" and "cognitive" and further by location (local and distant). They characterize cognitive search as creating new theories or using established theories to derive predictions and make representations, whereas, experiential search is experimentation or trial–and–error refinement. Felin and Zenger (2009) apply these concepts to an entrepreneurial setting. They envision entrepreneurs as "theorists" who apply cognitive models, or imagination, to provide guidance in search for new products and markets. Observations and experiences are antecedents to theorizing according to these scholars.[3]

The emerging "lean start–up" approach to entrepreneurship (Blank 2013, Reis 2011) follows a similar tack. Blank and Eckhardt (2023) argues that the "primary task for the entrepreneur is knowledge generation" (p. 4). Entrepreneurs are advised to find out whether a market exists in which he or she can introduce a product and secondly, how to develop an organization to prof-

[3]Felin and Zenger cite the famous example of the observation by Isaac Newton of an apple falling from a tree causing him to question why it fell as it did and triggering the search for a theory.

itably deliver that product. Lean start–up advocates advise entrepreneurs to develop a (cognitive) theory of a potential business and then develop a "minimally viable product" to experientially test this theory (Felin, Gambardella, Stern, and Zenger 2020).

Entrepreneurs attempting to develop market applications from scientific breakthroughs often struggle to anticipate potential products or services that can be generated from a technology, or markets best suited for those applications (Afuah, 2002; Danneels, 2007; Dougherty, 1992).[4] Successfully transforming a scientific invention into a marketable innovation can be especially challenging for entrepreneurs who typically cannot simply import past routines from prior organizations (Cyert and March 1963, Nelson and Winter 1982) or rely solely on their knowledge and experience to provide a solution. In these highly uncertain situations cognitive evaluation of the environment is often insufficient, thus necessitating "hands–on" experiential search (Ganco and Hoetker 2009, Gavetti and Levinthal 2000).

In this study we are agnostic as to the sequence by which entrepreneurial firms may employ cognitive and experiential search. Rather, we follow Gavetti and Levinthal (2000) and Lopez-Vega, Tell, and Vanhaverbeke (2016) and assume that either type of search can and may be employed. The hypotheses we develop below instead pertain to the composition of the founding team and its effect on the likelihood that experiential search will be employed.

The breadth and diversity of entrepreneurs' technical knowledge can play an important guiding role in a technology–based venture's experiential search, as demonstrated by Gruber, Harhoff, and Hoisl (2013a), who found that the breadth of technological recombination in innovation was directly related to the breadth of education held by the inventor. Similarly, Dahlin, Weingart, and Hinds (2005) found that the range of information use was broader for teams with diverse educational backgrounds than for more homogeneous teams. At the organizational level, a founding team consisting of members from diverse scientific backgrounds would be more likely to approach an opportunity in an expansive light (Cohen and Levinthal 1990). In contrast, more specialized knowledge may lead to myopic problem–solving and limit exploration of product opportunities within a narrow area of expertise (Bercovitz and Feldman 2011, Fleming 2001, Fleming, Mingo, and Chen 2007).

[4]Even highly successful inventors have acknowledged an inability to predict which of their inventions would lead to a market breakthrough (Schwartz, 2004).

In the context of academic entrepreneurship, Fini, Perkmann, and Ross (2022) found that the act of founding a firm coincided with an expansion by the scientist beyond her local search space toward more exploration. For academic founding teams, Bercovitz and Feldman (2011) found that greater diversity in academic disciplines among teams commercializing new technology resulted in a higher likelihood of receiving a patent and licensing the invention. They interpret this finding as illustrating that more diverse teams in the commercialization of academic science pursue more wide–ranging search over a greater knowledge space than do teams consisting of members from the same academic department, resulting in more novel combinations and ultimately successful commercial outcomes. Such teams are more likely to engage in exploration than exploitation (Bercovitz and Feldman 2011, March 1991). Gavetti and Levinthal (2000) associate exploration with experimentation and experiential search in their development of a formal model of search. Building on Gavetti and Levinthal (2000) we apply their notion of experiential search to our setting of technology commercialization, thus leading us to our first hypothesis:

Hypothesis 1 *Greater diversity in disciplinary academic backgrounds within the founding team is associated with more experiential search in technology–based ventures.*

On the other hand, founding teams that include scientists with industrial rather than academic backgrounds may be less likely to pursue experiential search than teams consisting solely of academic scientists. Academic scientists are trained and incentivized to give priority to the production of scientific knowledge (Dasgupta and David 1994). Norms and values may lead these academic scientists–turned entrepreneurs to measure their ventures' progress in terms of knowledge gained (Gittelman and Kogut 2003), which can lead to a preference for novel, rather than market–driven, scientific knowledge (Dasgupta and David 1994, Fini, Lacetera, and Shane 2010). Academic scientists' drive for knowledge production should exceed that of their industrial counterparts, who, coming from an environment beholden to short–term milestones and financial results, are less likely to value knowledge purely for the sake of knowledge (Samsom and Gurdon 1993).[5]

[5] Herbert Boyer, University of California, San Francisco scientist and founder of Genentech, the first biotech firm formed to commercialize academic science, said: "Why is an entrepreneurial organization more likely to [produce knowledge]? Well, I think it's the nature of large, established companies, that the first objective of that company is to maintain market share. Much of the R&D spend of large companies is allocated to what we would call sustainable

Industry–experienced founders may have been exposed to a larger array of potential market applications than academic scientists, providing industry–experienced founders a greater ability to cognitively evaluate market opportunities than founders without such experience must evaluate experientially (Dew, Read, Sarasvathy, and Wiltbank 2009, Franklin, Wright, and Lockett 2001, Maitland and Sammartino 2015). Particularly in technology–based ventures, teams with prior industry experience have superior capabilities in sensing (Gruber, MacMillan, and Thompson 2013b) and seizing (Kor 2003) new growth opportunities. Such founders tend to focus their attention on exploiting market alternatives related to their prior knowledge and experience (Fern, Cardinal, and O'Neill 2012, Shane 2000), suggesting that founding teams that include scientists with industrial backgrounds would conduct less experiential search than teams without individuals possessing industrial experience.

Contrasting "logics" held by academic and industrial scientists within the same team may also lead to less experiential search. An individual's institutional logic embodies one's taken–for–granted worldview and the concomitant goals and routines enacted in that worldview (Thornton, Ocasio, and Lounsbury 2012, Wry, Lounsbury, and Jennings 2014). Logics are particularly salient for professions such as academia, where professionals not only self–select into the given logic, but are incentivized and socialized to ascribe to the logic over time (Pache and Santos 2013, Roach and Sauermann 2010). Academic founders with a "research" logic not only have different goals, but they also enact diverging approaches to innovation than founders from industry (Gittelman and Kogut 2003, Sauermann and Stephan 2013).[6] Founders possessing a commercially focused "market" logic would engage in less experimentation than academic scientists ascribing to a research logic (Dubinskas 1985, Samsom and Gurdon 1993). Moreover, experimenting with multiple market applications involves both direct and indirect opportunity costs to ventures, diverting founder time (Miner, Gong, Bakeer, and O'Toole 2011), attention (Gifford 1992) and funds from other activities, which is contrary to a focused market logic. Divergent capabilities, logics, and norms of academic and industry scientists thus may lead to less experimentation than would homogeneity

engineering, or sustainable science. It's all science and improvement and endeavor to improve the existing products and to sustain them, because it's better to protect and reduce the cost of manufacture of existing products, and that's a rational thing to do." (Boyer 2001). Our informal interviews also reveal that founders with industry experience focus more on financially measurable goals and knowledge that advances their current products and technologies.

[6]There is evidence that these differences go deeper than social conditioning; graduating scientists preferring industrial employment show a weaker "taste for science," a greater concern for salary, and a stronger interest in downstream work compared to those who prefer an academic career (Roach and Sauermann 2010).

in academic startups. We therefore posit that diversity created by a mix of academic and industry scientific founders should lead to less experiential search:

Hypothesis 2 *Technology–based ventures led by a founding team with both academic and industry experienced scientists will engage in less experiential search than those led solely by academics.*

Prior *entrepreneurial* industrial experience may reduce the degree to which the firm undertakes experiential search due to an improved market perception that comes with a business background. While possessing scientific knowledge critical in developing technical advances, Vohora, Wright, and Lockett (2004) found that academic scientists lacking market knowledge found it difficult to frame a technological breakthrough in in terms of a market opportunity. They cite the example of an inventor of a technology related to the human genome who "realized her research efforts had produced a novel technology but faced 'pervasive uncertainty' over how best to realize the commercial value of the IP in the marketplace" (Vohora, Wright, and Lockett 2004; p.151). Such novice entrepreneurs would be expected to devote more effort to experiential search relative to those with prior exposure to market dynamics.

Gruber, Kim, and Brinckmann (2015) propose that entrepreneurial experience also narrows entrepreneurs' focus, making them more sensitive to questions regarding cash flow and the speed of revenue generation, both of which may be undervalued by the first–time entrepreneur lacking a business background. In contrast, repeat entrepreneurs often possess insights on what makes an opportunity attractive, suggesting that they will more readily recognize a good market application (Baron and Ensley 2006). Founding teams that include an experienced entrepreneur may therefore experiment less with market applications than purely "academic" teams as serial entrepreneurs possess superior capabilities to perceive successful market applications in uncertain environments (McGrath and Macmillan 2000).[7] This leads us to our third hypothesis:

[7]First–time academic scientists–turned-entrepreneurs also often remain deeply embedded in the research logic, retaining their tenured academic positions and carrying out academic research while founding a firm (Jain, George, and Maltarich 2009). As discussed previously, this logic defines success as knowledge production (O'Gorman, Byrne, and Pandya 2008), which leads to higher–than–normal search behaviors for academic entrepreneurs. The strength of this mechanism is enhanced due to the nature of technology development in science–based entrepreneurship; university inventions typically consist of early stage technologies with highly uncertain prospects that require significant experimentation to bring to market (Jensen and Thursby 2001). The initial stages of a firm's technological development process, therefore, are very similar to university research that the academic experiences difficulty leaving behind research logic routines (Gittelman and Kogut 2003, Miner, Gong, Bakeer, and O'Toole 2011, Stern 2004).

Hypothesis 3 *Technology–based ventures led by a founding team that includes an experienced entrepreneur will engage in less experiential search than ventures not including such an entrepreneur.*

Finally, varying levels of domain expertise by technical founders may also affect the degree of experiential search by academic technology–based entrepreneurial ventures. Scientists early in their careers (including their time as doctoral students) rely heavily on a broad knowledge set to guide their search efforts (Fleming and Sorensen 2001), even into distant technological areas (Gambardella 1995). In other words, novice scientists not having yet developed focused expertise tend to rely on a "knowledge of knowledge" mindset (Gibbons and Johnston 1974, Woolnough 1994), or a capability which enables them to seek out desired information within a complex and uncertain landscape. This breadth of knowledge encourages experiential search, as discussed above.[8]

As scientists advance in their careers from student to junior faculty member to more senior standing, however, attention becomes increasingly focused within a particular specialty (due to incentives to specialize within academia) over the professional life–cycle (Levin and Stephan 1991), resulting in knowledge "corridors" (Ronstadt 1989, Shepherd and DeTienne 2005). Thus a broad knowledge base initially acquired by scientific inventors can become narrowly focused over time—making the combining of technological knowledge across domains increasingly difficult (Fleming and Sorenson 2004, Gruber, Harhoff, and Hoisl 2013a). This difficulty may be compounded when crossing the domain from technological to business opportunities, as deep knowledge can breed over–reliance on one's own experience and routines (Teece 2007), especially in uncertain and demanding situations (Hambrick, Finkelstein, and Mooney 2005). Thus, while the knowledge set of highly experienced scientists can be considerable, these forces suggest that one implication of deep knowledge may be to limit search efforts in the development of market applications.

Based on the differences in how novice and more experienced scientists would be expected to employ their knowledge sets in search, we expect that technology–based ventures led by expert–

[8]Graduating scientists appear to sort into different career trajectories based on a preference for basic or applied research (Agarwal and Ohyama 2013). Graduates interested in entrepreneurship rather than academic careers may be more oriented towards applied research and less embedded in the routines of their field of study (Roach and Sauermann 2010). An entrepreneurial motivation coupled with knowledge, cognitive skills and abilities that the graduating scientist possesses, can achieve creative outcomes through experiential search (Amabile 1996).

level (faculty) and novice–level (student founders) to engage in greater experiential search efforts than ventures led solely by faculty founders.[9]

Hypothesis 4 *Technology–based ventures led by a founding team consisting of faculty and student founders will engage in more experiential search than ventures composed solely of faculty.*

3 Data and Methodology

3.1 Data and Sample

Testing our hypotheses requires data on the experiential search activities for viable market applications in a highly–uncertain context, as well as detailed characteristics of the founding team. The context of academic entrepreneurship, where university scientists create firms to commercialize their scientific inventions, is well suited for this endeavor.[10] Market applications of these scientific inventions are often uncertain as academic founders seek to commercialize knowledge that pushes the scientific and technological boundaries. Technology–based ventures serve as fonts of product advances or new markets (Jensen and Thursby 2001, Shane 2004), but more particularly, ventures built to commercialize scientific breakthroughs have a great potential to advance societal innovation (Danneels 2007, Shane 2000). Inventions arising from university science often have several potential technological applications (Jensen and Thursby 2001, Shane 2000). Each typically requires costly exploration prior to resolving the related market and technological uncertainties (Gittelman and Kogut 2003, Jensen and Thursby 2001). The basic nature of university research, even when compared to non–university technology–based ventures (Ensley and Hmieleski 2005), reduces potential endogeneity concerns found in the neighboring literature on opportunity identification (Markman, Phan, Balkin, and Gianiodis 2005, Shane 2002, 2004). In uncertain situations

[9] Although many academic technology–based ventures led by faculty scientists have graduate student employees, here we consider student founders only.

[10] Academic startups tend to commercialize more basic, complex, and less "market–ready" technologies than are typically licensed by universities (Agarwal and Shah 2014). According to a Technology Transfer officer at the University of Illinois, "If the technology is a 'one–off solution,' our office prefers to license to a big company every time. Why risk not seeing a return? . . . Narrow patents are licensed because it is easier to make a match. Broad or early–stage patents never made anybody anything; you need to build a company around it." Our informal discussions with numerous technology transfer officers in the University of Illinois and University of California systems are consistent with evidence obtained by Markman, Phan, Balkin, and Gianiodis (2005) in interviews with 91 university technology transfer offices (UTTOs), suggesting that universities prefer to license inventions to established firms, as the idiosyncratic nature of new university technologies makes it difficult to identify promising licensees.

such as developing market applications from university science, we posit that trial–by–error experimentation is often necessary to determine the viability of a market application of the firm's technology (Gans, Scott, and Stern 2018).

Our data come from Kenney and Patton (2011) who identified 621 technology–based ventures established between 1983–2011 by university–affiliated founders at six U.S. Tier–1 research universities—the University of Illinois; University of Michigan; University Wisconsin; University of California, Berkeley; University of California, Santa Barbara; and University of California, Davis. We observe whether these firms receive Phase I SBIR grants (explained at length below) until the end of 2012. These universities have generated a diverse set of start–ups differing by size, geographic location, and technology area.

We sought to capture only high–growth opportunity entrepreneurial ventures, excluding life–style, retail, housing, consulting (Shane 2004), and internet website firms based on commerce. Thus, the venture could not be a spin–off from an existing firm, a subsidiary or a branch operation, and must be technology–oriented. In addition to being identified as a new venture commercializing university technology, the firm must have been founded by at least one individual affiliated with the university during or immediately prior to establishing the firm. For those that left the university (typically students), the period between the time the individual left the university and founded a spin–off was determined by the individual's biography. If this time period was one year or less, and there was no information indicating that the individual was employed elsewhere in the interim, then the founded firm was included.[11]

3.2 Dependent Variable

To test our hypotheses we sought a measure that would proxy for a technology–based venture's experiential search for market applications (Carpenter, Geletkanycz, and Sanders 2004). Awards of SBIR (Small Business Innovation Research) grants from the Small Business Administration are one such proxy. According to the agency's website, the purpose of these grants is to en-

[11]We examined each firm to ensure that it was an entrepreneurial venture formed to commercialize a university invention. We also performed extensive research on the founding teams using such sources including company websites, LinkedIn, CrunchBase, local press (LexisNexis), university technology transfer offices, "specialist" websites (i.e., `www.inknowvation.com`) and local business associations. This exercise identified 45 consulting firms of the original 621, which we excluded. There were 15 cases where the founder or founders of a firm could not be identified or there was insufficient information to determine the employment background of the founder—these firms were also excluded. The resulting sample used in our analysis contains 561 firms.

courage "... small businesses to engage in Federal Research/Research and Development (R/R&D) that has the potential for commercialization" (https://www.sbir.gov/about/about-sbir, accessed October 20, 2023).[12]

The SBIR Program is organized in three phases. According to the website the objective of Phase I is to "establish the technical merit, feasibility, and commercial potential of the proposed R/R&D efforts and to determine the quality of performance of the small business awardee organization prior to providing further Federal support in Phase II" (https://www.sbir.gov/about/about-sbir, accessed October 20, 2023).[13] We limit our analysis to Phase I awards, which assist science–based firms as they assess their intellectual property's scientific and commercial feasibility and potential. Entrepreneurs face a tradeoff when considering whether to apply for a Phase I SBIR grant. The application process is arduous and uncertain; proposals are peer–reviewed and must address the invention's potential for commercialization and detail how it ultimately leads to revenue generation. A firm is precluded from applying for SBIR grants if receives greater than 50% of its funding from venture capital. Finally, each Phase I application must be distinct from the last, moving laterally to explore a different direction for the invention, and the awards are not tied to having previously been awarded a grant. The relatively small amount of these awards, when compared to either research grants or venture capital, alleviates, to some degree, the worry that firms apply for these grants in a pure "money–grab" (Link and Ruhm 2009). Companies often use SBIR grants to fund alternative development strategies, exploring technological options in sequence or in parallel (Wessner 2007). In a study of start–ups applying for SBIR grants from the U.S. Department of Energy, Howell (2017) found that firms used initial grants to fund prototype development. Moreover, firms successfully receiving grants were more likely to receive follow–on venture capital (VC) funding for commercialization, suggesting that VC funding is a complement, not a substitute, for SBIR funding.[14]

[12]Enacted in 1982, the SBIR program is a public program that provides grants to fund private sector R&D projects. It aims to help fulfill the federal government's mission to enhance private sector R&D and to advance innovation in the basic sciences for ventures in very early stages of product development, a group generally ignored by private venture capital (Audretsch 2003).

[13]The objective of Phase II is to "continue the R/R&D efforts initiated in Phase I. Funding is based on the results achieved in Phase I and the scientific and technical merit and commercial potential of the project proposed in Phase II" (https://www.sbir.gov/about/about-sbir, accessed October 20, 2023). Finally, Phase III awards are intended to help the awardee to commercialize the technology resulting from the prior awards (this funding is not provided by the SBIR program, but rather by other federal agencies interested in funding follow–on commercialization).

[14]Experiential search for each additional market application, represented by Phase I grants, introduces a tradeoff for the new ventures, as effort spent vetting a market application may increase the likelihood that it will succeed, but can

Number of SBIR Grants: We consider the number of Phase I SBIR grants awarded to the firm as a metric for the level of experiential search. This variable proxies for the number of market applications searched for by the firm using the same underlying technology.[15] In finding appropriate measures of market opportunity development, the empirical measure must be both tied to the venture's underpinning resource base (Penrose 1959) and delineated from pure ideas (Short, Ketchen, Shook, and Ireland 2010). That is, the proxy should be subject to some evaluative process before it can be labeled as a market application of an opportunity (Dimov 2007). We do not presume that this measure covers an exhaustive "set" of exploration behaviors as only successful grant attempts are counted. However, unlike some measures of opportunity identification and search, grants are observable and avoid potential recall–bias (Davidsson 2015, Short, Ketchen, Shook, and Ireland 2010). Because SBIR grants serve as a means of probing the direction of a technology while not providing funding to reach market commercialization, we believe that this variable is consistent with exploration by the firm.

3.3 Independent Variables

Testing our hypotheses requires detailed, individual–level data on the early founders of the venture. While demographic measures do not covary perfectly with constructs such as knowledge, experience and expertise, they are important indicators of sources of cognition and behavior (Kaplan 2008). For this reason, studies of founding and top management teams suggest that these measures can serve as useful proxies for the latter (Taylor and Greve 2006, Wiersema and Bantel 1992), while offering the benefit of being assessed relatively objectively (Hambrick and Mason 1984). To achieve consistency, our consideration was restricted to founders of each venture rather

introduce non–trivial attentional, temporal, and financial costs for the firm (Murray and Tripsas 2004). One founder commented "We didn't want VC money initially because they want to see a prototype too soon, and the technology was still too fragile. If they don't see a product coming up soon in the process, VCs get worried and can put unreasonable pressures on the company."

[15]The federal government Small Business Administration prohibits awardees from receiving more than one SBIR Phase I grant for "essentially equivalent work." Essentially equivalent work is defined as "substantially the same research, which is proposed for funding in more than one contract proposal or grant application submitted to the same Federal Agency, or submitted to two or more different Federal Agencies for review and funding consideration; or work where a specific research objective and the research design for accomplishing the objective are the same . . . " (Administration 2023). This policy does not prohibit firms from receiving multiple grants for different applications of the same technology, as exhibited by an example of one awardee in our sample. This firm developed a lighting technology for which it received three SBIR grants, each covering a different application, (a) illumination in Hollywood productions, (b) lighting within refrigerated applications, and (c) lighting for automotive applications. Each effort had a different objective (e.g., assessing resilience in mobile/wet conditions, low temperature exposure, and crash impact exposure).

than the top management team, as rounds of venture capital funding often accompany obligatory changes in the leadership structure of the venture (Wasserman 2001).

Knowledge Diversity: Teams with diverse knowledge sets should not only have a greater ability to search for market applications, but should also have stronger incentives to evaluate potential applications experientially. Diverse knowledge sets should lead to increased dialogue as each founder will advocate for the market application closest to his or her discipline (Cyert and March 1963, Eisenhardt 1989). We develop a measure of team knowledge diversity analogous to the "generality" measure for patenting created by Henderson, Jaffe, and Trajtenberg (1998) to measure the breadth of technical fields covered by a patent.[16] We define knowledge diversity as

$$KNOWLEDGE\ DIVERSITY_{(i)} = 1 - \sum_{k=1}^{N_{(i)}} \left(\frac{N_{faculty_{(ik)}}}{N_{faculty_{(i)}}} \right)^2 \tag{1}$$

where $N_{(i)}$ is the number of different academic departments represented by the founding team and k is the academic department index. $N_{faculty_{(ik)}}$ is the number of faculty in department k and $N_{faculty_{(i)}}$ is the total number of faculty at the firm. The range is $0 \leq KNOWLEDGE\ DIVERSITY_{(i)} \leq 1$ with higher values represent less concentration and thus more diversity.

Hall (2005) shows that "dispersion" measures such as this are inherently biased—the greater number of academic founders in the team the more likely they will be spread out across a greater number of academic departments. Thus we employ the following bias correction from (Hall 2005) and use the bias–corrected value in our analysis:

$$KNOWLEDGE\ DIVERSITY_{(corrected)} = \left(\frac{N_{(i)}}{N_{(i)} - 1} \right) KNOWLEDGE\ DIVERSITY_{(i)} \tag{2}$$

Founders with Industry Experience: We coded each firm that included non–academic founders with prior industry experience as 1 and 0 otherwise. (The majority of these individuals had executive–level experience.)

Prior Founder: Following the practice of extant research (Beckman, Burton, and O'Reilly 2007, Gruber, Kim, and Brinckmann 2015), ventures were coded as 1 when at least one founder had previously founded a firm and 0 otherwise.

[16] Similar metrics have been constructed to cover diversity in other innovative settings, e.g., the "fragmentation" measure used by Ziedonis (2004) to measure diversity among third parties citing a focal firm's patents.

Faculty & Student Founders: "Mixed" teams are composed of both faculty and student founders. Ventures were coded as 1 when at least one founder was a student and 0 otherwise.

3.4 Control Variables

Number of Founders: Because founding team size is an important indicator of the human capital available in a new venture, we control for the number of founders.

Licensed Technology: Qualitative research suggests that ventures that in–license a technology from the university might have a advantage as the technology transfer office (TTO) can provide direction about potential market applications. This variable is coded as 1 if the venture licensed the core technology and 0 otherwise.

Technological Area: The resource requirements to develop new technologies and other factors vary across technological fields. We account for such variation by including indicator variables representing each technology area represented in the sample: IT and software (30% of the sample), biomedical (24%), wireless and communications (12%), engineering and measurement instruments (22%) and others (12%) including nanotechnology, semiconductors, etc. These categories are defined using the description of the company given by the university or by the company's website. "Other" is the left–out category in the regression models.

University: While scientists' proclivity to participate in university technology transfer is highly dependent upon individual attributes, those personal traits are conditioned by the local work environment (Bercovitz and Feldman 2008). University cultures vary in their attitude towards faculty and/or students participating in entrepreneurial ventures. We account for these differences through a university fixed effect.

3.5 Methodology

We regress our primary explanatory variables and control variables on our measure of experiential search. The dependent variable in model (3) is an integer "count," which suggests a Poisson–based model and estimation method. The expected number of SBIR Phase I grants is assumed to be an exponential function of the our primary explanatory variables of knowledge diversity, founder variables, and our control variables and indicators.

Because the firms in our sample were founded in different years they vary in the amount of time that we are able to observe whether they have received one or more Phase I SBIR grants, with firms being founded later being observed for a shorter time. To account for this "truncation–bias," we control for "exposure" or the time at–risk of receiving a grant in our regressions based on the age of the firm at the end of the sample period. Controlling for exposure converts our counts to rates, thus we report our results as incidence rate ratios (IRRs).

$$E\left[\textit{Number of SBIR Grants}|X\right] = exp\bigg(\beta_0 + \sum \beta_i \textit{(Primary Independent Variables)} + \sum \beta_j \textit{(Control Variables)} + \sum \beta_d \textit{(University and Year Indicators)} + Exposure + \epsilon\bigg) \tag{3}$$

where β_0 is the coefficient for the constant term, β_i are the coefficients for the primary independent variables, β_j are the coefficients for the control variables, β_d represents the coefficients for the university and founding year indicator variable terms, and ϵ is the error term. Exposure is reported as the natural log of age and its coefficient is constrained by the model to be 1.[17]

Our data exhibit "overdispersion," which violates the poisson regression assumption that the mean equals the variance. We therefore use a negative binomial specification that is robust to overdispersion.[18]

4 Results

Summary statistics for the primary and control variables are presented in Table 1. Thirty–seven percent of the firms in our sample applied for at least one SBIR Phase I grant. Firms explored an average of 1.78 market applications through the SBIR program. Our measure of knowledge diversity for the founding team ranged from zero to 0.75 with a mean of 0.06. Thirty percent of firms included a founder from industry, while 9% were founded by individuals with previous start–up experience. Also 9% of firms included student founders and 4% were founded solely by student founders. Forty–seven percent licensed in technology from the university. In terms of technol-

[17] Age is the time that the firm is "at-risk" of receiving a Phase I grant and is measured from the founding year until the end of the sample or time of exit for firms that failed or were acquired before the end of the sample period.

[18] We checked for overdispersion in a poisson regression of the baseline model (not reported). The Pearson "goodness of fit" test statistic is 2942.9 ($p < .01$), confirming that the variance is significantly greater than the mean.

ogy area, over half of the firms in the sample were founded to commercialize IT and software and biomedical technologies, with 31% in IT and software and 25% in biomedicine, respectively. Eleven percent were in wireless and communications and 12% were engineering and measurement firms. Twenty–one percent of the firms in the sample lay outside these five categories.

∗∗∗ Table 1 Here ∗∗∗

Table 2 presents correlations of the primary variables used in the analysis. Correlations among independent variables are all less than or equal to 0.228 (with firms with at least one founder with experience and firms with experienced founders generating the highest correlation), which alleviates concerns about possible collinearity. Variation inflation factors (VIF) were computed for all variables and returned small values (<3), also suggesting that multi–collinearity is not a concern.

∗∗∗ Table 2 Here ∗∗∗

Figure 1 shows that the distribution of the SBIR Phase I grants is in line with that of similar studies (see (Gruber, MacMillan, and Thompson 2013b)), but also that firms are not likely to assess multiple market opportunities initially (Schwenk 1984).

∗∗∗ Figure 1 Here ∗∗∗

Results of the negative binomial regressions analyzing the venture's experiential search for market applications are presented in Models 1–5 of Table 3. Incidence rate ratios (IRRs) are reported, which can facilitate the interpretation of negative binomial regressions when firms experience varying exposure.

In the negative binomial estimations reported in Models 1-5 of Table 3, a likelihood ratio test that the log–transformed over–dispersion parameter α equals zero is listed below the test of coefficients. The associated χ^2 in all five models strongly suggests that α is non–zero and the negative binomial model is more appropriate than the Poisson model for these regressions.

Turning first to the baseline Model 1 of Table 3 that includes only the control variables, firms that licensed technology from the university engage in greater experiential search at a rate of 1.6 times that of firms not licensing university technology (the IRR for licensed technology is 1.60

and statistically significant at the 0.05 level in Model 1 of Table 3). Firms commercializing IT or software, as well as those with only students founders, engage in experiential search at a lower rate than other firms (these IRRs are 0.16 and 0.29, respectively, although the rate for student–founded teams is weakly significant). Perhaps surprisingly, the number of founders does not have a statistically significant effect on experiential search (the IRR of 1.02 in Model 1 is not significant at the 10% level). The incidence rate ratios for the control variables and their significance remain similar across all Models 1–5.

∗∗∗ Table 3 Here ∗∗∗

Models 2–5 in Table 3 introduce the primary explanatory variables. As indicated by the results, patterns of experiential search are distinct and divergent between the combination types of founder experience and expertise. Consistent with Hypothesis 1, firms led by founders with heterogeneous knowledge bases appear to be engaged in experiential search for market applications at over twice to three times the rate of ventures led by experts of a single discipline, as the IRR for founding team knowledge diversity are positive and statistically significant at the 5% level in Models 3 (IRR=2.61, p<0.05) and 5 (IRR=3.46, p<0.05). (The IRRs for knowledge diversity in Models 2 and 4 are similar but only weakly significant at the 10% level.) On the other hand, we find that heterogeneity among individuals in background experiences and logics is associated with a lower rate of roughly half of experiential search. The IRR for teams with industry and academic experience is below 1 and statistically significant in Models 2-4 (IRR=0.56, p<0.05, IRR=0.53; p<0.05, respectively), supporting Hypothesis 2 (The IRR in Model 5 is not significant, however.) This finding suggests that while diverse teams may identify a greater number of (narrowly–focused) opportunities (Gruber, Harhoff, and Hoisl 2013a), the combination of individuals with distinct approaches to innovation, such as industry and academic scientists, can lead to reduced experiential search efforts. This result lends support to reasoning by other scholars on the utility of scientific knowledge in commercialization (Gittelman and Kogut 2003, Sauermann and Stephan 2013).

We also find support for our assertion that heterogeneity in the levels of scientific expertise is associated with greater levels of experiential search for technology–based ventures. The incidence rate ratio for the faculty and student founders variable is positive and significant in Model

4 (*IRR*=2.62, p<0.01), consistent with Hypothesis 4.

Interestingly, we fail to find support for Hypothesis 3, that teams including individuals with prior founding experience (*PRIOR FOUNDER*) would engage in higher rates of experiential search. The *IRR* for this variable is not significant from 1 in Model 4, and is weakly significant in Model 5, although in the opposite direction from our hypothesis (*IRR*=1.81, p<0.10). Past research finds that entrepreneurial experience leads to the identification of more opportunities prior to entry (Gruber, MacMillan, and Thompson 2008), suggesting that while this experience may improve the venture's ability to perceive opportunities, such experience on its own is not necessarily associated with increased levels of experiential search.

5 Discussion and Conclusion

Embryonic technologies often must go through a costly process of determining their market viability (Jensen and Thursby 2001). This study has focused on the propensity of entrepreneurs to engage in experiential search in order to gauge that viability. By weaving together insights from the prior literature on innovation and organizational search we participate in the effort of building an entrepreneurial theory of the firm (Alvarez and Barney 2007). We build on recent findings that the level of uncertainty has implications for the types of knowledge and experience required of technology–based entrepreneurs (Dencker and Gruber 2015). Finally, we contribute to recent research on the heuristics used by firms to conduct search (Gavetti and Levinthal 2000, Lopez-Vega, Tell, and Vanhaverbeke 2016, Pisano 1994) by exploring the relationship between founding team composition and degree of experiential search.

Based on an analysis of experiential search by founders of 561 technology–based firms commercializing university research we arrive at three main conclusions. First, our results confirm findings from prior studies that heterogeneous experience positively influences group search efforts (Bercovitz and Feldman 2011, Singh and Fleming 2010) and mirrors similar determinations regarding heterogeneous experience and the ability to recognize opportunities (Davidsson 2015, Gruber, MacMillan, and Thompson 2013b). An individual's ability to gather, process and recombine knowledge in different ways is constrained by his or her abilities and experiences (March and Simon 1958). Founding teams that draw from multiple perspectives in selecting a market application to pursue, however, should exhibit a broader cognitive map of the technological landscape (Gavetti and Levinthal 2000), and thus expend greater experiential search effort than do individuals (Singh and Fleming 2010) or teams with less varied backgrounds.

Second, although individuals possessing different types of functional expertise view organizational problems from distinct vantage points (Dougherty, 1992), we contribute to an understanding of how these differences apply to opportunity evaluation and search. Speaking to the role of deep subject knowledge on search (Dew, Read, Sarasvathy, and Wiltbank 2009), our findings suggest that the narrowing effect of deep subject knowledge could be mitigated through the addition of non–experts such as graduate students. Our results also add support to the notion that different mechanisms may drive experiential search (Gavetti and Levinthal 2000, Lopez-Vega, Tell, and Vanhaverbeke 2016).

Third, our study acknowledges the role of the student in the journey from discovery–to–market application. Due to the vital role of new ventures in facilitating innovation and technology spillovers from universities into the economy, much research has increased our understanding of crucial actors in this process (Markman, Phan, Balkin, and Gianiodis 2005, Siegel, Waldman, Atwater, and Link 2004). A preponderance of this work has focused on faculty founders however (e.g., Fuller and Rothaermel (2012), Murray (2004), Thursby and Thursby (2004)). The unique role of student founders, who are less embedded in their academic domain, is less clear. Graduate students who choose to pursue entrepreneurship have a unique set of preferences and may serve as a catalyst in the firm's experiential search (Roach and Sauermann 2010).

Our findings raise questions regarding the role of prior entrepreneurial experience in experiential search, as we find little difference between scientists with prior firm founding experience and their entrepreneurially inexperienced colleagues in levels of experiential search, despite prior findings that experienced entrepreneurs identify more opportunities than their counterparts (Ucbasaran, Westhead, and Wright 2009). Prior work suggests that scientists with entrepreneurial experience may "leave their academic routines behind," thus lowering their propensity to engage in search. Instead, they may have acquired an improved "sensing" ability, which does not require the same level of exploration as would be expected by novice entrepreneurs (Dasgupta and David 1994). Because these explanations are not borne out in our data, more work on this question is needed.

Our study is not without limitations. For example, technological breakthroughs vary in their ability to generate market opportunities that could affect our results. While there is certainly heterogeneity in the teams and technologies in the study, we limit the sample to technology–based spin–offs from leading research universities, thus focusing on discoveries arising from "basic" research that could generate multiple potential market opportunities to pursue experientially. Our findings may not hold for other less embryonic technologies.

Second, we are unable to observe applications for SBIR grants that were not granted, thus we may be undercounting the extent to which applicants intend to conduct experiential search. This also raises the concern that that ventures of higher quality are able to receive more grants not because they engage in more intensive search but because they survive longer. The context partially relieves this concern, as academic start–ups are often founded by faculty or students with concurrent jobs at the university, so the same "up–or–out" pressures that apply to "typical" start-ups (Haltiwanger, Jarmin, and Miranda 2013) may be less important for these firms.

We are also unable to observe experiential search activities that may serve as a substitute for SBIR Phase I funding. Conducting experiential search through alternative means, however, would make it more difficult for us to find a significant effect for Phase I funding serving as a vehicle for experiential search.

Another concern is that ventures based on better technology will be awarded more SBIR grants. Our context partially alleviates this concern as well, as the university technologies in this sample are produced by tenure–track faculty in engineering and science fields in leading research–based institutions who have attained a certain level of grant–receiving ability. The numbers of grants awarded across states suggests that this assumption is plausible—across California, Illinois, Michigan and Wisconsin, the average grant application had between an 18.8% and a 24.9% chance of being awarded. This matches casual interviews with SBIR and NSF personnel, who estimate that roughly one–fifth to one–third of SBIR proposals are awarded, and that faculty applications tend to be awarded about one–third of the time. Due to the low dollar amount of SBIR Phase I grants, firms applying for these grants are typically in the bootstrapping phase of funding, where ventures do a significant amount of search but are likely in the pre–venture capital funding stage (Bhide 2000, Howell 2017). Two other sources of funding, large government grants used for research purposes and venture capital, are less likely to support experiential search, as government grants strive towards improving the underlying technology and venture capital promotes rapid market introduction (Murray and Tripsas 2004).

Future research could expand beyond the founding team to consider a broader set of resource providers (e.g., investors, early employees, and advisors). Little is known about how these resource providers may influence experiential search by the firm. Future studies could also exploit the evolving needs technology–based firms face during their life cycles and how these needs affect experiential search over time.

Technology–based entrepreneurial ventures are confronted with the decision of which market application to pursue while laboring under significant technological and market uncertainty (Kor et al., 2007). Although the likelihood of success should be improved if that decision is made after several potential market applications have been explored (Gruber, MacMillan, and Thompson 2013b), experiential search can be costly for the resource–constrained firm (Gavetti and Levinthal 2000, Gittelman and Kogut 2003, Jensen and Thursby 2001, Murray and Tripsas 2004). By examining the pursuit of grant funding to explore potential market applications for embryonic technologies developed by university–linked technology firms, this study explores the link between the nature of founders' knowledge, prior entrepreneurial experience, and the presence of industrial scientists and students on entrepreneurial firms' experiential search behavior prior to commercialization. Our results contribute to recent discussions on the discovery–to–market linking problem for entrepreneurial technology ventures, and in particular, for academic entrepreneurship. We look forward to continuing the conversation on experiential search and entrepreneurial opportunity.

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Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.	Obs.
At Least One SBIR Phase I Grant	0.37	0.48			561
Number of Phase I Grants	1.78	3.91			561
Primary					
Knowledge Diversity	0.06	0.17	0	0.75	561
Founders with Industry Experience	0.30	0.46	0	1	561
Prior Founder	0.09	0.29	0	1	561
Faculty and Student Founders	0.09	0.29	0	1	561
Control					
Licensed Technology	0.47	0.50	0	1	561
Number of Founders	2.21	1.13	1	7	561
Student–Only Founders	0.04	0.19	0	1	561
Technical Area					
IT and Software	0.31				561
Biomedical	0.25				561
Wireless and Communications	0.11				561
Engineering and Measurement	0.12				561
Other	0.21				561

Table 2: Correlations of Primary Variables

Variable	Knowledge Diversity	Founder with Ind. Exp.	Prior Founder	Faculty and Student Founders
Knowledge Diversity	1.000			
Founder with Ind. Exp.	0.013	1.000		
Prior Founder	0.156	0.228	1.000	
Faculty and Student Founders	-0.108	-0.207	-0.010	1.000

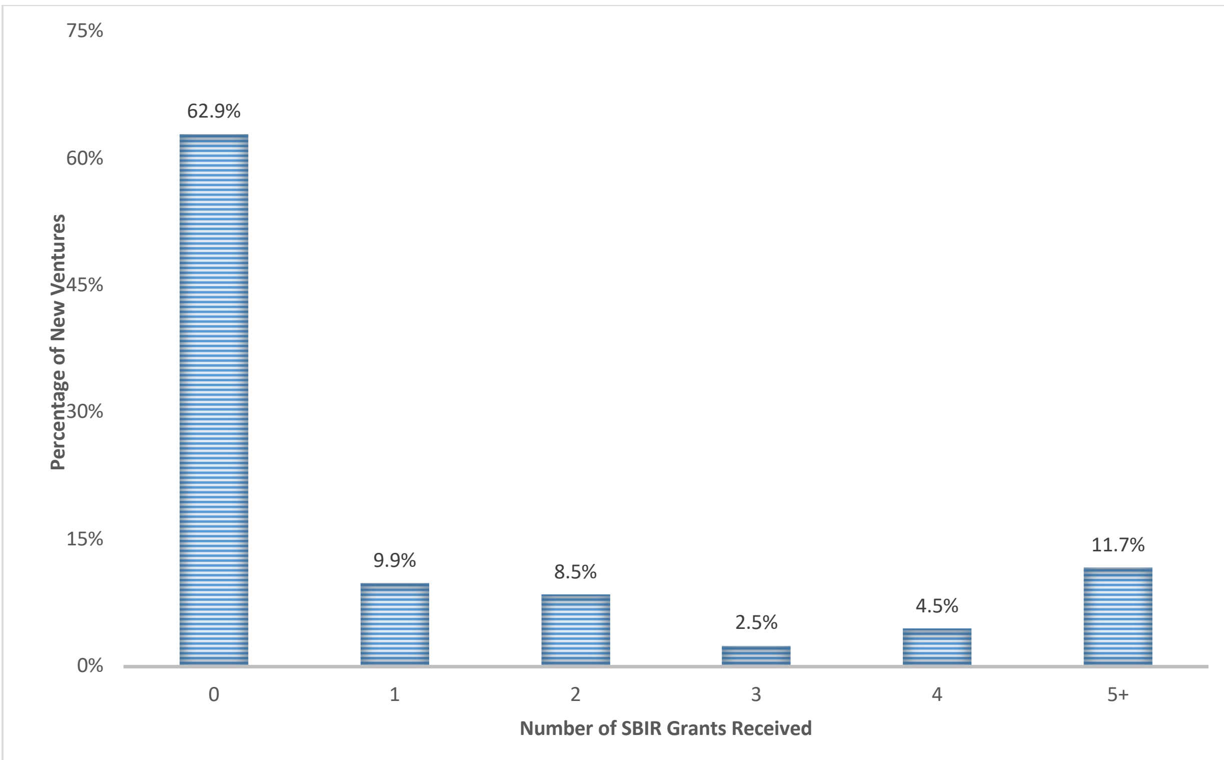
75%
62.9%
60%
Percentage of New Ventures
45%
30%
15%
9.9%
8.5%
2.5%
4.5%
11.7%
0%
0
1
2
3
4
5+
Number of SBIR Grants Received

Table 3: Venture Experiential Search for Market Applications

	Baseline Controls	Add Knowledge Diversity	Add with Industry Experience	Add Prior Founder	Add Faculty and Student Founders
	(1)	(2)	(3)	(4)	(5)
Knowledge		2.40*	2.61**	2.60*	3.46**
Diversity		(1.268)	(1.38))	(1.38)	(1.82)
Founder with			0.56**	0.53***	0.68
Industry Experience			(0.14)	(0.17)	(0.17)
Prior				1.67	1.81*
Founder				(0.57)	(0.61)
Faculty and					2.62***
Student Founders					(0.85)
Licensed	1.60**	1.61**	1.61**	1.61**	1.72***
Technology	(0.34)	(0.33)	(0.34)	(0.34)	(0.36)
Number of	1.02	0.99	1.07	1.04	0.92
Founders	(0.09)	(0.09)	(0.10)	(0.10)	(0.10)
Student–Only	0.29*	0.27*	0.26*	0.25*	0.28*
Founders	(0.21)	(0.20)	(0.19)	(0.18)	(0.20)
IT and	0.16***	0.17***	0.16***	0.16***	0.16***
Software	(0.05)	(0.06)	(0.06)	(0.05)	(0.05)
Biomedical	0.89	0.99	0.92	0.90	0.86
	(0.29)	(0.33)	(0.30)	(0.30)	(0.28)
Wireless and	0.68	0.71	0.65	0.68	0.58
Communications	(0.25)	(0.26)	(0.24)	(0.25)	(0.21)
Engineering	0.72	0.75	0.68	0.67	0.63
and Measurement	(0.25)	(0.26)	(0.22)	(0.23)	(0.21)
Indicator Variables					
University	Yes	Yes	Yes	Yes	Yes
Founding Year	Yes	Yes	Yes	Yes	Yes
Exposure					
ln(Age)	1	1	1	1	1
Constant	0.26	0.33	0.32	0.38	0.39
	(0.18)	(0.24)	(0.23)	(0.27)	(0.28)
LR Test of $\alpha = 0$	χ^2=1016	χ^2=1009	χ^2=1002	χ^2=1004	χ^2=960
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Pseudo R^2	0.072	0.074	0.078	0.079	0.084
Log Likelihood	-817.1	-815.11	-812.11	-810.9	-806.2
Number of Observations	561	561	561	561	561

Notes:
* p<0.10; ** p<0.05, *** p<0.01
Incidence rate ratios reported.
Standard errors in parentheses.