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Working Paper 16-013

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Abstract

This paper studies the uncertainty associated with screening early-stage ventures. Using data on 652 ventures in high-growth industries, we examine whether experienced entrepreneurs, executives, and investors can predict the outcomes of early-stage ventures by reading succinct summaries of their business ideas without meeting the founding teams. We find that the predictability of venture outcomes varies with the intensity of research and development (R&D) in the sector. In R&D-intensive sectors, such as life sciences, the ideas that elicit more positive evaluations are significantly more likely to reach commercialization and/or to raise substantial funding; this pattern does not hold for ventures in non-R&D-intensive sectors such as enterprise software. Our results suggest that, despite the many uncertainties associated with innovating at the technological frontier, early-stage ventures in R&D-intensive sectors can be screened effectively using information on their non-human capital assets. In contrast, such information is not sufficient to screen ventures in non-R&D-intensive sectors.

JEL Codes: G32, L26, M13, O31

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1 Introduction

The uncertainty associated with early-stage ventures poses serious challenges for financial intermediaries (Hall and Lerner, 2010). Kaplan et al.'s (2009) finding that a venture's nonhuman capital assets coalesce early and remain relatively stable suggests that investing in ex-ante better ideas could generate considerable value—if investors could assess them effectively. A substantive literature focuses on the selection preferences of venture capitalists (VCs) and angel investors, i.e., on the criteria by which they invest (Quindlen, 2000; Gompers and Lerner, 2001; Bernstein et al., 2015); in contrast, systematic evidence on investors' ability to screen early-stage ideas is scant. This paper empirically examines whether early-stage venture ideas that receive more positive subjective evaluations from a large number of start-up experts, including experienced entrepreneurs and investors, are more likely to commercialize in the future. To the best of our knowledge, we provide the first direct empirical evidence on the conditions under which ex-ante assessment of an early-stage venture idea predicts its future outcome.

Empirically, it is difficult to examine the efficacy of evaluators' ex-ante assessments due to the identification challenges inherent in venture financing. Ventures that elicit positive evaluations from investors receive additional resources that positively influence their outcomes.[1] Entrepreneurs may also alter the amount of effort they expend on a venture in response to positive or negative evaluations, resulting in a self-fulfilling prophecy. Furthermore, investors' complex evaluation mechanisms make it challenging to distinguish the assessment of ideas from other factors.[2]

In the absence of well-identified empirical studies, existing evidence on the plausibility of screening venture ideas is inconclusive.[3] Even the most successful investors assert that screening early-stage venture ideas is a highly noisy process. Sam Altman of Y Combinator notes that "for all of the really good seed investments I've made, other investors I respected thought they were bad ideas" (Altman, 2014). Altman's

[1] A large body of literature describes various mechanisms whereby venture capitalists professionalize ventures and improve their outcomes, such as active mentorship, network access, and control rights (Gorman and Sahlman, 1989; Sahlman, 1990; Lerner, 1995; Hellmann and Puri, 2002; Hsu, 2004). See also Kerr et al. (2014a) and Lerner et al. (2015) on the impact of angel investors, and Lerner (1999) and Howell (2015) on the impact of government grants.

[2] For instance, Bernstein et al. (2015) show that angel investors are highly responsive to information about the founding team.

[3] In correlational analysis, Kerr et al. (2014a) and Kerr et al. (2014b) find a weak relationship between assessment of a venture by angel investors and venture capitalists at the time of financing and its subsequent performance conditional on receiving funding; however, funded ventures are a small subset of the full sample of ventures evaluated by investors, and thus do not shed light on investors' overall ability to differentiate among early-stage venture ideas. In contrast, Astebro and Elhedhli (2006) find a positive relationship between the expert evaluation of an invention and its likelihood of subsequent commercialization and financial returns. The authors note, however, that the evaluation itself may influence subsequent outcomes via signaling to entrepreneurs. In other contexts, Kornish and Ulrich (2014) find that the ex-ante evaluation of a new household consumer product by consumer panelists and expert evaluators positively predicts its future performance; Goetzmann et al. (2012) and Luo (2014) find that the price of a movie script predicts the commercial performance of the final product.

partner at Y Combinator, Paul Graham, one of the most prominent investors in Silicon Valley, explains that "if a good idea were obviously good, someone else would already have done it" (Graham, 2012). It is the novelty of a venture idea that creates the opportunity for entry; however, novelty—by defying existing norms or principles—is inherently linked to uncertainty. The degree of this uncertainty depends on such factors as the radicalness of the innovation, the lifecycle of existing products, and the industry in question (Kline and Rosenberg, 1986). For revolutionary early-stage innovations, Rosenberg (1996) argues that "decisionmakers do not have access to an even marginally informative probability distribution with respect to potential outcomes." Building on the insight that the idea quality of a venture may be ex-ante unobservable, the theoretical literature emphasizes the importance of experimentation and tolerance for early failure in venture financing (Bergemann and Hege, 1998; Manso, 2011).

In this study we find that succinct summaries of business ideas, even at an early stage, can be used to predict ventures' subsequent outcomes. Moreover, we show that the efficacy of screening ideas varies with the intensity of research and development (R&D) in the sector. To overcome the aforementioned empirical constraints, we leverage Massachusetts Institute of Technology's Venture Mentoring Service (VMS), a free educational service that helps aspiring MIT-affiliated entrepreneurs—alumni, post-docs, and students—to develop their nascent business ideas. We collect detailed data on the characteristics, assessment, and subsequent outcomes of 652 ventures that joined VMS between 2005 and 2012. The majority of these ventures are serious entrepreneurial endeavors and not recreational pursuits. In nearly half of the sample, the MIT-affiliated entrepreneurs pursued the venture full-time, forgoing traditional employment and attractive salaries.[4] These ventures have jointly raised over $700 million from venture financing and are fairly evenly distributed across several high-growth industry sectors. Following the National Science Foundation (2006), we define hardware,[5] energy, and life sciences and medical devices as R&D-intensive sectors. The non-R&D-intensive enterprises in our sample are primarily ventures in the consumer web / mobile, enterprise software, and consumer-products industries.

The mentors at VMS consist of a pool of over 100 experienced local practitioners with expertise in new-business formation and development across diverse industry sectors. When an entrepreneur enrolls at VMS, the mentors receive an objective, standardized summary of the proposed venture, composed by a VMS staff member; the summaries are consistent in form and tone. Each summary describes the venture idea—the

[4] Average starting salaries for MIT graduates are around $60,000 per year for those with bachelor's degrees and $70,000–$120,000 for those with graduate degrees (Hastings et al., 2010).

[5] That is, products that require large-scale manufacturing processes.

proposed business model and technology, target customers, and current challenges—but provides limited information about the entrepreneur and founding team. On the strength of the summary alone, without meeting the entrepreneurs, mentors express interest in ventures they would like to mentor.[6]

We find that venture ideas that elicit a high degree of initial mentor interest are more likely to ultimately reach commercialization, defined as having recurring revenue and expenses associated with the sale of products and/or services in keeping with the company's business objective. In our setting, aggregate mentor interest is unlikely to systematically influence either a venture's access to mentoring resources or the entrepreneurs' effort, because of several institutional factors discussed in Section 2: in brief, VMS provides entrepreneurs with equal access to its mentoring resources; only a semi-random subset of the mentors who initially express interest in a venture ultimately interact with it, and few if any become heavily involved. Furthermore, neither entrepreneurs nor mentors are aware of the magnitude of aggregate mentor interest. Our empirical analysis controls for venture/mentor interactions and also shows that our results are robust to (1) using alternative measures of mentor interest, (2) including only the subsample of ventures that interact minimally with VMS mentors, and (3) using specifications at the venture/mentor-pairing level that control for mentor-meeting fixed effects. In addition, we present several sets of evidence to demonstrate that mentors are recognizing high-quality ideas as opposed to excluding non-serious ideas.

Next, we explore the extent to which the predictive power of aggregate mentor interest varies by the R&D intensity of the industry sector. New business ideas in R&D-intensive sectors (e.g., pharmaceuticals) tend to innovate on the technological frontier and to face uncertainties beyond those related to the science itself, including adapting the technology for large-scale use, accessing complementary technologies, engaging emerging technological systems, and matching the technology to users' preferences (Arora and Gambardella, 1994; Rosenberg, 1996; Shane, 2000). But while innovating on the technological frontier introduces more technological uncertainties, it also creates barriers to entry, such as intellectual-property protection, that would reduce market uncertainty. These theories suggest that R&D-intensive and non-R&D-intensive ventures face distinct patterns of uncertainty. How these differences affect the predictability of evaluation of early-stage ideas across sectors remains an intriguing empirical question.

We find that initial mentor interest strongly and significantly predicts eventual commercialization for ventures in R&D-intensive sectors. Among ventures in such sectors, a one-standard-deviation increase in the proportion of mentors who express interest in a venture idea implies, on average, a 21-percent increase

[6]Mentors on average express interest in fewer than 5 percent of the ventures they review.

in the likelihood of commercialization (or a 6-percentage-point increase over the baseline probability of 28.5 percent). In contrast, the coefficient estimate on aggregate mentor interest is weak and insignificant among ventures in non-R&D-intensive sectors. These findings are robust to using angel and/or VC financing as an alternative outcome measure. We provide suggestive evidence that this heterogeneity across sectors can be explained by firms' formation around different critical resources even at very early stages: those in R&D-intensive sectors (e.g., life sciences) are more likely to form around specific intellectual assets than those in non-R&D-intensive sectors (e.g., enterprise software); the latter are more likely to form around the entrepreneurs' human capital. Consistent with this explanation, we find that, among ventures in R&D-intensive sectors, the predictive power of mentor interest is particularly strong and significant among ventures that possess documented intellectual capital—that is, ventures that are based on academic research or that have filed for intellectual-property protection by the time of evaluation. In contrast, mentor interest's lack of predictive power for ventures in non-R&D-intensive sectors does not vary by venture characteristics, including intellectual assets. This finding suggests that reading business summaries without meeting the entrepreneurs may limit the effectiveness of expert evaluation of ventures in non-R&D-intensive sectors. We present evidence refuting the alternative explanations that our results are driven by the differences in the stage or quality of ideas across industry sectors or by the specific expertise of our mentors.

By investigating the centrality of the initial idea in predicting entrepreneurial success, we build on the literature on critical resources and theories of the firm (Wernerfelt, 1984; Hart and Moore, 1990; Rajan and Zingales, 2001a,b). Our results are consistent with the prior evidence that ventures with specific intellectual assets tend to have stable identifiable lines of business (Kaplan et al., 2009), whereas ventures without specific intellectual assets are prone to substantial adaptation at early stages (Bhide, 2003; Livingston, 2007). Our focus on the earliest stage in a venture's lifecycle is valuable since young firms are increasingly attracting resources from early-stage financial intermediaries (Ewens et al., 2015; Cohen and Hochberg, 2015). In addition to screening venture ideas, early-stage investors may reduce uncertainty by basing their screening efforts on founding teams' human capital (Bernstein et al., 2015) and/or by adopting a "spray-and-pray" approach (Kerr et al., 2014b; Nanda and Rhodes-Kropf, 2015). Our results suggest that the R&D intensity of a given industry sector plays an important role in determining the effectiveness of screening early-stage venture ideas and has implications for how early-stage investors should choose among these alternative approaches.

2 MIT Venture Mentoring Service

Universities are instrumental in fostering high-impact entrepreneurship and stimulating local economic activity (U.S. Department of Commerce, 2013). MIT alumni have founded over 25,000 active companies that have collectively employed over 3 million people and generated annual worldwide sales of $2 trillion (Roberts and Eesley, 2009). Founded in 2000, MIT's Venture Mentoring Service is one of the university's longest-running programs designed to promote entrepreneurship and innovation via entrepreneurship education. Entrepreneurs from the larger MIT community—students, staff, alumni, and faculty—approach VMS with an idea, often in an early form, and receive customized advice from a team of elite volunteer mentors. VMS thus uses very early-stage ideas as the context for providing prospective entrepreneurs a hands-on, practical learning experience. The service is confidential and free of charge.

2.1 VMS Mentors

The volunteer mentors at VMS are experts in business formation and development who have typically acquired entrepreneurial experience in one of three ways: by founding and growing a new company, by leading a new business initiative at an established company, or by providing functional services (e.g. financial or legal) to startups. The majority of VMS mentors have either founded a company or joined a startup very early on. A fair number of these mentors are serial entrepreneurs; others have stayed put and become senior executives as a startup grew into a large company. Most of the remaining mentors have led new business initiatives (e.g., new product lines, new divisions, new markets) at established firms and encountered many of the same issues that entrepreneurs face. A few mentors specialize in particular functional areas, such as finance; they may lack direct startup experience, but they have interacted extensively with startups.

Considerable care is taken to ensure that the program remains focused on its educational aims and provides objective advice to entrepreneurs. Mentors are carefully screened by VMS staff; prospective mentors with other personal or business agendas are not accepted.[7] Every mentor must sign an agreement that specifies rigorous guidelines and a code of ethics that encourages transparency and limits conflicts of interest. VMS monitors mentor activity and promptly dismisses mentors who violate these principles.[8]

Mentors are not compensated for their time. VMS estimates that active mentors average over 100 hours

[7] For instance, while a fifth of mentors have investment experience, active venture capitalists are excluded from the program.

[8] On rare occasions, a venture will offer a member of its mentor team a more formal role, such as board director. If the mentor accepts such a role, he or she must resign from the mentor team for that venture.

of volunteer time annually. Mentors report that they do so for a variety of reasons. Among the most commonly articulated motivations are the intellectual appeal of the work, continuing engagement in the Greater Boston entrepreneurship community, and the satisfaction of promoting the development of new entrepreneurs. Mentors share a sense that, in the words of one mentor, "mentoring entrepreneurs is a way to give back for all the help that I received in my career." In addition to volunteer mentors, VMS consists of a small team of full-time staff members, including two mentors-in-residence.

2.2 Initial Screening of Venture Ideas

To be eligible for mentoring, an entrepreneur must be affiliated with MIT (e.g., alumni, post-docs, and students) and based in the Greater Boston area. Given the educational nature of the program, VMS imposes only minimal requirements on eligible entrepreneurs and their ideas: the only criteria are serious interest in learning about entrepreneurship and an idea that will provide a context and focus for practical entrepreneurship education. Entrepreneurs typically come to VMS very early. They may have conducted preliminary research on the feasibility of the idea, but they usually do not have a business plan, a strategy and revenue model, or a team. Few entrepreneurs are pursuing a venture idea full-time when they join VMS, and few of their ventures are incorporated or funded.

2.3 Matching Venture Ideas with Mentors

VMS follows a standardized routine to match new ventures to their initial mentor teams. Here we describe the matching procedures employed by VMS during our study period (2005–2012), which we also summarize in Figure A.1 in the Appendix.

To receive mentoring from VMS, entrepreneurs must first complete a short enrollment form. Drawing on the form and an initial consultation with the entrepreneur(s), a staff member distills the venture idea into a concise standardized summary for purposes of dissemination to mentors; the same staff member prepared almost all of these summaries throughout our sample period. Table A.1 in the Appendix provides sample anonymized written descriptions. The summary includes the following information:

- a straightforward description of what the venture intends to do, free of buzzwords and technical jargon
- information on potential customers and products

- the type of help the venture needs, and any relevant challenges, problems, and/or known issues (e.g., intellectual-property and legal problems)
- brief information on the founding entrepreneur(s), e.g., whether they are MIT alumni, staff, or students

VMS regularly emails venture summaries, in batches, to all active VMS mentors; the summaries are also delivered in printed form and orally at monthly meetings of mentors. Mentors then respond, indicating interest in working with a given venture. Because mentors do so via email or on paper, they evaluate ventures independently and only VMS is aware of the aggregate interest level.

An expression of interest indicates willingness to commit time to a venture, and mentors do not do so lightly. On average, mentors express interest in fewer than 5 percent of the ventures to which they are exposed. Interviews with mentors suggest that the appeal of the underlying technology and/or business idea is the primary driver of interest. For instance, one mentor reports basing interest on the "novelty of the idea and whether it offers some positive value to some group of people and/or the planet." Sometimes, mentors also consider the relevance of their experience and knowledge. But not all mentors look for ventures that hew closely to their own backgrounds. A mentor who reports being "most intrigued by the ventures that are the furthest from my own professional experiences" speaks for many mentors.

It is important to note that mentor interest is not used as a metric in program evaluation. VMS uses mentor-interest data only in the initial mentor venture pairing process and sets the initial mentor team size to two to four volunteer mentors (excluding the professional VMS staff members). Because more mentors typically express interest than can join the team, only a semi-random subset of mentors expressing interest in a venture interacts with the venture. VMS assembles the mentor team in light of a set of factors that include mutual scheduling constraints and load balancing. Entrepreneurs do not learn the aggregate mentor interest they attract, nor do they select their initial mentor team.

2.4 Mentoring at VMS

VMS ensures that access to mentoring resources does not differ systematically across entrepreneurs and ventures. After being paired with mentor teams, entrepreneurs largely determine the extent of mentoring they receive. Meetings are initiated by the entrepreneurs; VMS attempts to accommodate all requests, and checks in regularly with ventures to assure that its records on their status are up to date.

Generally speaking, a mentor who is initially paired with a venture is unlikely to become as heavily

involved as a typical investor or advisor. This is the case for two reasons. First, entrepreneurs request meetings based on their own needs and not on mentors' schedules. Given the *ad hoc* nature of these meetings, the entire mentor team may not attend. Second, the mentor team may change over time as different kinds of knowledge, skills, and experience become more useful. Later-stage mentors are not limited to those who initially expressed interest in the venture. In many cases, in fact, later mentor venture pairings are based on the specific skills of the mentor and/or facilitated by informal meetings at VMS events.

VMS measures the effectiveness of mentoring primarily via the feedback from entrepreneurs; internal evaluation of the program is largely qualitative. Objective metrics include the size of the program (the number of active mentors and entrepreneurs), its rate of growth, mentors' engagement (e.g., hours committed), and entrepreneurs' evaluations. In keeping with the focus on entrepreneurial education, VMS does not consider its ventures' rate of commercialization or successful exit a key performance metric. "We think it's a success if the prospective entrepreneur decides there isn't a viable business," remarked a VMS staff member, "or that they really don't want to be an entrepreneur now that they get what you really have to do [to be successful]."

Assessment of the VMS program is beyond the scope of this paper, but the program is highly regarded by the entrepreneurship community, individual entrepreneurs, and university educators alike. Over 40 institutions worldwide—including Harvard University, Yale University, Columbia University, and New York University—have established mentoring programs based on the VMS model. At MIT, VMS complements a rich array of other services, centers, programs, clubs, and initiatives, both academic and extracurricular, that support innovation and entrepreneurship.[9]

3 Data and Descriptive Statistics

3.1 Venture Sample

Our sample for analysis consists of all ventures that joined VMS between 2005 and 2012. We exclude the initial cohorts from VMS's first five years of operation because both ventures and mentors were few in number and may have been selected by virtue of connections with VMS's founders. By late 2004, however, VMS had grown substantially, increased awareness of its services in the larger MIT community, and intro-

[9]For example, the Martin Trust Center for Entrepreneurship is a hub for entrepreneurial courses and activities, and the Deshpande Center for Technological Innovation helps researchers take new discoveries from the lab bench to commercialization.

duced systematic electronic record-keeping. Figure 1 plots the number of new ventures that joined VMS during our sample period by starting year and month. We exclude seven ventures that had already been funded before joining VMS since they had progressed further than the typical venture that affiliates with VMS at the idea stage. Also, third-party validation by investors might have influenced the evaluations of VMS mentors. We also exclude ten ventures founded by MIT faculty, which may have special standing in the university ecosystem. Our resulting sample consists of 652 ventures.

Panel A of Table 1 presents summary statistics on the observed characteristics of ventures upon joining VMS across primary industry sectors. The most populous industry sectors are consumer web and mobile (27.9 percent), enterprise (or business-to-business) software (17.8 percent), and hardware/large-scale manufacturing (14.7 percent). Additional sectors include life sciences / medical devices (13.3 percent), consumer products (13.2 percent), and energy (5.8 percent). The remaining set (7.2 percent) includes non-profit ventures, lifestyle businesses, and a few ventures in consulting and finance. Around 23 percent already have filed for intellectual-property (IP) protection when they join VMS, but only 16.9 percent have established formal business entities; of the total, 15.5 percent are based on academic research.

Following the National Science Foundation (2006), we designate life sciences / medical devices, hardware, and energy—which jointly account for 221 venture ideas—as sectors with high research-and-development intensities. Unsurprisingly, a large proportion of these ideas draw on academic research or possess intellectual property when they join VMS. In contrast, ventures in non-R&D-intensive sectors, such as consumer web / mobile and enterprise software, are much less likely to draw on research or to have IP at entry.

Panel B of Table 1 shows that students and alumni respectively generate around 44.3 percent and 45.6 percent of venture ideas. The rest come from postdoctoral fellows, research associates, and staff. Around 7.7 percent of the venture ideas in our sample belong to entrepreneurs previously mentored by VMS on a different project.

3.2 Mentor Sample

The sample of mentors consists of 251 volunteer mentors who have ever been active between 2005 and 2012. We exclude full-time VMS staff members from the active mentor pool because they are aware of the aggregate mentor interest and interact with most ventures. The number of active mentors increases during our sample period from 68 in 2005 to 181 in 2012.

We collect detailed data on mentors' backgrounds and expertise by means of surveys and online searches.

Table 2 reports mentors' mean characteristics. Around 85 percent of mentors are male; 22.3 percent have a Ph.D. or M.D. Like the sample of ventures, mentors also come from diverse sectors. On average, each mentor has some experience in 2.5 sectors. We define a mentor's primary sector as the industry in which he or she has worked longest to date (as self-reported or extracted from online career histories). In this classification scheme, each mentor has a single primary sector. Mentors are fairly evenly split between having an R&D-intensive primary sector (129 mentors) and a non-R&D-intensive primary sector (122 mentors). The three most populous primary sectors are hardware (24.7 percent), life sciences and medical devices (21.5 percent), and enterprise software (21.1 percent).

3.3 Measuring Initial Mentor Interest

We use two variables to measure aggregate mentor interest: the percentage and the number of active mentors who express interest in a venture shortly after the venture joins VMS.[10] To accommodate delayed responses from mentors and delayed recording of their responses in VMS's electronic system, we include all indications of interest expressed within two months of a venture's eligibility for mentoring.[11] On average, a new venture interests around 4.5 percent of active mentors, or 6.3 mentors.[12] The median number of interested mentors is 6. Figure 2 shows the kernel density of aggregate mentor interest measured as a proportion, and a histogram of interest measured as a count.

3.4 Measuring Mentoring Intensity

As noted in Section 2, the educational structure of the program is designed to maximize entrepreneurs' access to mentoring resources regardless of the potential of their ideas. Thus, our identifying assumption is that the level of mentor interest expressed at the time of venture enrollment does not systematically cause the intensity of mentoring to differ. To test this assumption, we capture the degree of mentoring intensity at the extensive margin using two variables: the number of mentors who have met with the venture at least twice and the number of a venture's meetings at VMS, both measured at the time of data collection. The former measure controls for the relationships that entrepreneurs may have formed with VMS mentors.[13]

[10] The denominator in the percentage of mentors expressing interest is the number of mentors who were actively involved with VMS at the time, excluding mentors who had not yet joined VMS or who had already left the program.

[11] Our results are also robust to using a threshold of 1.5 months or three months.

[12] On average, a summary of a new venture is sent to 144 active mentors.

[13] This measure excludes mentors who meet with the venture only once, since a mentor who is not a member of a venture's team may be invited to meet with the entrepreneur to address specialized needs. For instance, a lawyer may meet with the entrepreneurs

The latter measure uses number of meetings instead of frequency of meetings to capture VMS's total impact on a venture.[14] Though we do not observe all channels whereby mentors and ventures could interact (such as email), we expect that, on average, ventures that have had more recorded interactions with their mentor teams have received more mentoring. We use additional robustness checks to investigate whether variations in the degree of mentoring at the intensive margin affect our key results.

The average venture in our sample meets with VMS mentors only around three times, and has repeated interactions with fewer than two mentors (see Table 1). Around 36 percent of ventures never meet with VMS mentors or do so only once; 40 percent never interact with any mentor more than once (see Table A.2). The correlations between initial mentor interest and venture mentor interactions are weakly positive (see Figure 3).

3.5 Measuring Venture Outcomes and Milestones

Our primary outcome of interest is whether or not a venture successfully reaches the stage of commercialization, characterized by recurring revenue and expenses associated with sales of the products and/or services that are the business objective of the company, and by a reasonable expectation of repeat business and new customers. We capture this outcome using public sources, including online product listings, news articles, and press releases, which we cross-checked against VMS archival data for robustness. Our definition of commercialization excludes revenue from one-off "consulting services" or "pilot-test fees," which are often employed as bootstrap financing vehicles but do not advance the business objective. In the rare cases of business models based on licensing, forging technology-licensing deal(s) is considered commercialization. Although commercialization is not necessarily the end-goal, it is an important milestone; commercialized ventures are those whose products and/or services have been validated by the market.

We also collect data on two additional entrepreneurial milestones to measure the progress of each venture. We consider a venture to be launched if at least one of its founding entrepreneurs has ever pursued it full-time. This definition excludes cases in which entrepreneurs pursue a venture part-time while attending school or holding a job. We also measure whether a venture has ever received funding from angel investors and/or venture capitalists. We exclude crowdfunding, government grants, and investments by friends and family from our definition since the criteria and purposes of such funding channels vary widely. Collec-

to discuss how to draft a founder's agreement.

[14] It is also difficult to measure frequency without errors, especially in the case of failed venture ideas since it is hard to pinpoint the precise timing of a failure.

tively, these measures portray the growth and impact of a venture idea. VMS tracks ventures' receipt of funding; we hand-collected the other data using VMS's archives and internet searches.

Because we aim to determine how far a venture has ever progressed to date, our outcome measures do not necessarily describe its current status. Instead, our outcomes are intended to capture a venture's potential economic impact. Some newer ventures were still pursuing intermediate milestones in summer 2014 when we collected outcome data. This censoring may cause our data to underestimate the likelihood that ventures in our sample eventually reach commercialization, biasing against finding a positive relationship between initial mentor interest and commercialization.

In our sample, 46.5 percent of ventures were pursued full-time, 18.6 percent raised funding from professional investors, and 22.4 percent ultimately commercialized (see Table 1). The ventures have raised over $621 million in venture-capital financing and $84.8 million from angel investors. Notably, of the 144 ventures that reached commercialization, 71 did so without funding from professional investors. Overall, these numbers suggest that the venture ideas observed in our data are generally serious endeavors and not recreational pursuits.

4 Initial Mentor Interest and Subsequent Venture Commercialization

4.1 Regression Specification

Figure 2 shows that, without any controls, venture ideas that are eventually commercialized are likely to elicit greater initial interest from mentors. To formally estimate the relationship, we use the following specification:

$$\begin{aligned} Pr(COMMERCIALIZATION_i) &= \alpha + \beta MENTOR\_INTEREST_i \\ &\quad + \gamma \left\{ D_i^{MENTOR\_RECUR}, D_i^{MEETINGS} \right\} \\ &\quad + \delta \left\{ D_i^{START\_YEAR}, D_i^{START\_MONTH}, Controls_i \right\} + \varepsilon_i \end{aligned} \tag{1}$$

where *i* denotes a venture and *MENTOR_INTEREST* is either the proportion or the count of active mentors who express initial interest in a venture idea as discussed in Sections 3.3.

The key coefficient of interest is β, which measures whether a venture idea that attracts more mentor interest in its initial form is more likely to be commercialized in the future. To control for the effects of

venture age and seasonality, we include dummies for the year and the month that a venture joins VMS. Some venture characteristics, such as industry sector or underlying technological intensity, could drive both mentor interest and commercial viability. We thus include a rich set of controls to determine whether mentors can accurately evaluate a venture's commercial viability beyond picking up on these characteristics. We control for variables that reflect the underlying business proposition by including whether the venture is based on academic research, whether it possesses intellectual property when it joins VMS, and dummies for its industry sector. We control for the venture's stage of development by including a dummy on whether it has a legal business entity (that is, whether it is incorporated) at the time of entry. We further control for the entrepreneur's characteristics by including whether he or she is an MIT student or alumnus and whether he or she has been previously mentored by VMS.[15] To capture the possible nonlinear effect of mentoring, we include dummies for the number of mentors who have met with the venture at least twice and for the number of meetings that a venture has had at VMS.[16]

4.2 Main Results

Table 3 presents the OLS estimates of Equation (1) with increasing levels of controls and robust standard errors clustered by venture sector and year of affiliation with VMS. Column (1) shows that, controlling only for the starting year and month, a venture that elicits more initial interest from mentors when it first joins VMS is more likely to subsequently commercialize. The magnitude of the coefficient estimate is economically important and statistically significant at the 1 percent level. A one-standard-deviation increase in the proportion of active mentors expressing interest, which is 2.68 percentage points, implies on average a 5.36-percentage-point increase in the probability of recurring revenue and expenses, or a 23.9 percent increase over the baseline probability of 22.4 percent.

Columns (1) through (3) show how the estimated relationship between mentor interest and commercialization changes with the inclusion of additional controls for observed venture and entrepreneur characteristics at the time of enrollment. Column (2) controls for characteristics of the venture observed when it joins VMS, including whether it is based on academic research, whether it possesses intellectual property, whether it is a legal business entity, and its industry sector. The coefficient estimate on mentor interest

[15] VMS does not systematically record further information about the entrepreneurs at the time of venture enrollment.

[16] See Table A.2 on the breakdown of the variable values. The base group for the former includes ventures that have not had repeated interactions with any mentors and the base group for the latter includes ventures that have met with VMS mentors at most once.

remains positive and significant, although the magnitude decreases from 0.020 to 0.015. Consistent with our field interviews, this decrease in the coefficient estimate shows that mentors do not express interest randomly. Their evaluations are based, at least in part, on observed venture characteristics that positively predict commercial viability. Adding controls for characteristics of the entrepreneur in column (3) only slightly decreases the magnitude of the coefficient estimate to 0.014, suggesting that mentors base their interest more heavily on the underlying business idea than on the entrepreneur's characteristics. This is inline with mentors observing only limited information about the entrepreneur.

Columns (4)-(6) include additional controls on venture mentor interactions. Columns (4) and (5) add the controls linearly; column (6) uses dummy variables to capture nonlinear effects. Because the number of mentors with whom a venture's entrepreneur(s) have met at least twice and the number of meetings they have had with VMS mentors have a high correlation of 0.76, columns (4) and (5) estimate their linear effects separately. Both variables have weak and insignificant relationships with the venture's likelihood of commercialization. Note that these results do not suggest that mentoring has no effect on a venture's development: entrepreneurs may be more likely to seek assistance both when the venture is struggling and when it is progressing rapidly. Importantly, consistent with our identifying assumption, including the venture/mentor interactions has negligible impact on our key coefficient estimate on aggregate mentor interest.

Our preferred specification is column (6). After controlling for venture and entrepreneur characteristics at entry and the degree of mentoring at the extensive margin, the proportion of active mentors expressing initial interest in a venture has an economically meaningful, positive, and statistically significant relationship with its likelihood of commercialization. All else equal, a venture that attracts a one-standard-deviation (or 2.68 percentage point) higher degree of interest is on average 3.75 percentage points (or 16.75 percent) more likely to reach commercialization. The coefficient estimate is statistically significant at the 5-percent level. Table A.3 in the Appendix shows that the marginal effects from estimating our preferred specification in Probit and Logit models are nearly identical to the OLS estimates.

To show that the outliers eliciting extremely high or low mentor interest are not driving our results, column (7) excludes the venture ideas that attracted the top or bottom 5 percent in aggregate mentor interest; and the coefficient estimate on aggregate mentor interest becomes even stronger. Column (8) uses the number of mentors expressing interest, instead of the proportion measure used previously, and yields the same finding qualitatively and quantitatively as column (6). A one-standard-deviation increase in the count of mentor interest implies on average a 3.83-percentage-point (or 17.10 percent) increase in the likelihood

of commercialization.

We next increase the flexibility of our main specification by using dummy variables for the quintile of mentor interest relative to other ventures in the same sector, which allows us to investigate whether mentors distinguish between ideas at the lower and higher ends of the quality distribution. Figure 4 plots the coefficient estimates. Compared to ventures in the lowest quintile, being in the next two quintiles (between the 20-percent and 60-percent percentiles) results in similar likelihoods of commercialization, even though mentor interest varies considerably. (The 60-percent percentile in a given sector interests between 4 to 7 percent of mentors, or 7 to 12 mentors by count). In contrast, the likelihood of commercialization increases markedly in the fourth quintile (the 60-80-percent percentiles) and even more in the top quintile. These patterns suggest that the predictability of outcomes is driven by ideas that elicit above-median mentor interest. (Ventures in the top quintile interest on average 8 percent of mentors, or 11.9 mentors by count).

4.3 Robustness Checks

In this section we provide several robustness checks on our main results. Table 4 uses three tests to show that systematic variations in mentor engagement are unlikely to drive the relationship between mentor interest and venture outcome. In columns (1) and (2), we measure aggregate mentor interest as the proportion or count of mentors who express initial interest but never meet with the venture. These mentors have thus not had a chance to directly influence the development of the venture. Using more restrictive measures of aggregate mentor interest yields coefficient estimates and standard errors almost identical to columns (6) and (8) in Table 3. Thus our key findings are not driven by mentors who express interest, meet with the venture, and may thus be particularly engaged with it.

In columns (3) and (4), we investigate the role of mentor-team recruitment. When an insufficient number of mentors expresses interest in working with a venture, VMS formally recruits another mentor and/or member of the staff to complete the mentor team. Though contrary to VMS principles, it is conceivable that recruited mentors are less engaged than those who expressed initial interest, and as a result discourage entrepreneurs from engaging with VMS and/or pursuing the venture. We show that this is not the case: the relationship between aggregate mentor interest and commercialization remains unchanged when we include only the ventures that elicited initial interest from more than four mentors—the maximum initial mentor team size—and therefore did not need recruited mentors.

Mentor engagement may vary for a variety of other reasons. Thus in columns (5) and (6) of Table 4

we restrict our empirical analysis to ventures that have had limited interactions with mentors—that is, those that have had two or fewer meetings with mentors and no repeated interactions with an individual mentor. Examining only these 259 ventures yields results similar to those generated by the full sample. Unreported regressions show that the results in columns (3)-(6) of Table 4 also hold if we use the more restrictive measures of aggregate mentor interest from columns (1) and (2)—that is, the proportion or count of mentors who express initial interest but never meet with the venture. Thus, our key results hold among ventures where variations in the degree and/or quality of mentoring are more likely to be limited.

Next, we control for the heterogeneous effects that mentors may have on ventures' development using data at the venture/mentor pairing level using the following specifications:

$$\begin{aligned} Pr(COMMERCIALIZATION_i) &= \alpha + \beta INTEREST_{i,m} + \xi M_{i,m} \\ &\quad + \delta\left\{D_i^{START\_YEAR}, D_i^{START\_MONTH}, Controls_i\right\} + \varepsilon_{i,m} \end{aligned} \tag{2}$$

where i denotes a venture, m denotes a mentor, and each observation is a pairing between the two. For each venture, we only include the pairings with mentors who were active at the time of venture entry. $INTEREST_{i,m}$ is 1 if mentor m expresses interest in venture i, and $M_{i,m}$ is a set of 251 (the number of mentors ever active during our sample period) dummies that equal 1 if mentor m has met with venture i. The mentor meeting dummies $M_{i,m}$ control for the heterogeneous effects that meeting with a mentor could have on a venture's probability of commercialization. We include controls for venture and entrepreneur characteristics and timing of entry to VMS as included in Equation (1) and defined previously. As in the case of the main specification, the key coefficient of interest is β, which measures whether a venture idea that attracts more initial mentor interest is more likely to be commercialized in the future.

Table 5 presents the OLS estimates of Equation (2) with different measures of mentor interest and various degrees of controls. The standard errors are robust and clustered at the venture level. In columns (1)-(3), the key independent variable is a dummy that equals 1 if an active mentor expresses initial interest in a venture, regardless of whether they meet later. Column (1) does not control for any venture mentor interactions; the specification is thus similar to column (3) in Table 3. Column (2) includes a dummy that equals 1 if the mentor has met with the venture. The meeting dummy thus captures the average effect of meeting with a mentor; the effect does not vary by mentor. Column (3) allows the mentors to have heterogeneous effects on ventures by including the 251 mentor-meeting dummies. In all three specifications, the coefficient estimate

on mentor interest is positive and statistically significant. The estimates on mentor interest in column (2) and (3) are identical, indicating that controlling for variations in mentor-meeting effects does not affect our main results. In columns (4)-(6) of Table 5, we repeat the exercise using the more restrictive measure of mentor interest, which is 1 if the mentor expresses interest in the venture and the pair never meet. The coefficient estimate on mentor interest remains positive and statistically significant. Thus, our results are not driven by systematic matching of ventures that elicit more interest with higher-quality mentors.

In summary, the main specification demonstrates, by controlling for venture/mentor interactions, that our results are not driven by variations in the degree of mentoring at the extensive margin. The robustness checks in this section further substantiate that the results are not driven by variations in mentor engagement or quality. A remaining concern is that a venture eliciting more mentor interest may be matched to a mentor team whose skills are particularly well aligned with the venture's needs, conditional on mentor quality. We cannot directly rule out this hypothesis since we do not have the statistical power to control for heterogeneous treatment effects at the venture/mentor level. However, it is counterintuitive to conclude that any remaining variations in venture/mentor fit drive our key results, given that the controls for venture/mentor interactions have a negligible effect on the relationship between mentor interest and subsequent commercialization. Furthermore, our results are robust to restricting the sample of analysis to ventures that had only few interactions with mentors and whose mentoring is thus likely to vary minimally in degree and/or quality (columns (5) and (6) of Table 4).

5 Heterogeneity across Venture Sectors

Thus far we have assumed that the predictive power of mentor interest is constant across ventures even though the nature of the underlying innovation process varies widely across sectors (Kline and Rosenberg, 1986). Early-stage ventures in R&D-intensive sectors are apt to face very different technological and market uncertainties than ventures in non-R&D-intensive sectors, differentially affecting the predictability of the outcomes. This section examines the predictive power of mentor interest separately for ventures in R&D-intensive and non-R&D-intensive sectors. Following the National Science Foundation (2006), the hardware, energy, and life sciences / medical devices industries are defined as R&D-intensive sectors; the non-R&D-intensive sectors in our sample are primarily consumer web / mobile, enterprise software, and consumer products. We report results using the proportion of active mentors who express interest; using mentor

counts yields identical interpretations.

In Table 6, columns (A1) and (B1) repeat our preferred specification from Table 3, column (6), on the subsamples of R&D-intensive and non-R&D-intensive ventures respectively. Initial mentor interest strongly and significantly predicts subsequent commercialization for ventures in R&D-intensive sectors. In contrast, for ventures in non-R&D-intensive sectors, the coefficient estimate for aggregate mentor interest is close to zero and insignificant. The remainder of Table 6 reports results using receipt of angel and/or VC financing as an alternative outcome measure, demonstrating that heterogeneity across venture sectors is not specific to the prediction of commercialization. Consistent with our prior findings, we find that aggregate mentor interest in ventures in R&D-intensive sectors positively predicts the probabilities of raising any venture financing, raising over $1million in angel/VC funding, and raising over $5 million in angel/VC funding; the coefficient estimates are statistically significant for the latter two outcomes. Among ventures in non-R&D-intensive sectors, aggregate mentor interest has small and insignificant predictive power for all three funding outcomes.

The results from Table 6 indicate that the initial business propositions of ventures in R&D-intensive sectors contain critical information that allows the venture's commercial viability to be differentiated. In contrast, the initial business propositions of ventures in non-R&D-intensive sectors contain no such information. A source of heterogeneity that may explain this finding is that ventures in R&D-intensive sectors are more likely to form around specific intellectual capital to target established unmet needs in well-defined markets (e.g., a new pharmaceutical drug for high blood pressure).[17] As the venture matures, decisions to alter the technology or shift its application are often constrained by these intellectual assets, resulting on average in far less significant shifts. Thus the core business idea—the underlying technology and its intended application—is relatively stable over time and plays an important role in determining the commercial success of the venture (Kaplan et al., 2009). This configuration may enable expert evaluators to assess the commercial viability of an early-stage venture based solely on a description of the initial business idea. We provide suggestive evidence supporting this explanation in Table 7: among ventures in R&D-intensive sectors, aggregate mentor interest strongly positively and significantly predicts commercialization for ventures that are based on academic research or that possess IP at entry. In other words, having documented intellectual capital drastically increases the predictive power of mentor interest in R&D-intensive sectors, where intellectual capital is central to entrepreneurial success.

[17] See Shane (2000) for in-depth case studies of commercializing new technologies.

An alternative explanation is that ventures in R&D-intensive sectors are simply more mature; Table 1 shows that they are more likely to have formed a legal business entity when they first join VMS. However, Table 7, column (3), shows that the predictability of outcomes for ventures in R&D-intensive sectors is driven by ventures *without* a legal business entity at VMS entry. Table 7 as a whole indicates that mentors can assess the commercial potential of a venture's intellectual capital in R&D-intensive sectors, and that intellectual capital does not simply function as a signal of a venture's maturity.

In contrast, ventures in non-R&D-intensive sectors such as consumer web / mobile are less reliant on intellectual assets and more prone to substantial adaptation.[18] Typically, therefore, the early-stage business proposition less closely matches the version that the entrepreneurs ultimately commit to; thus the early-stage evaluation of the initial idea less consistently reflects the outcome. Panel B of Table 7 shows that among ventures in non-R&D-intensive sectors, aggregate mentor interest has no predictive power regardless of venture characteristics; this finding suggests that having information on the underlying business idea alone, without meeting the entrepreneurs, is not sufficient for experts to predict the outcomes of ventures in non-R&D-intensive sectors. Furthermore, Table A.4 in the Appendix shows that, even among the subset of ventures that were ultimately pursued full-time by their founders, the contrast between R&D-intensive sectors and non-R&D-intensive sectors persists. Thus the heterogeneity that we find is not simply an artifact of the quality distribution of venture ideas across sectors.

6 Discussion

We find that it is possible to use succinct summaries of initial business ideas to predict the future commercial viability of ventures in R&D-intensive sectors (hardware, energy, and life sciences). This section discusses interpretations and alternative explanations of our key results.

What does aggregate mentor interest measure?

Aggregate mentor interest is an *imperfect* measure of idea quality at an early stage. We define "idea quality" to encompass all nonhuman aspects of the venture, i.e., the capital assets that embody the underlying business proposition, the potential market, and traction.[19] The brief venture summaries contain two types of information: a description of the idea and limited information on the founding team. Mentors could express interest in response to any or all of the information provided, which could affect our results in two ways.

[18] See Bhide (2003) and Livingston (2007) for anecdotal evidence.

[19] Bernstein et al. (2015) also view traction as signaling the quality of nonhuman assets.

The first possibility is that, despite the venture summaries' emphasis on nonhuman capital, mentor interest measures team quality more than idea quality. But because considerably more variation is evident in the information available to mentors about the ideas than about the teams, it is unlikely that variation in *observed* team quality drives the outcomes that we observe. Bernstein et al. (2015) show that investors respond positively to signals of team quality, such as being educated at a top university like MIT or working for a top company like Google. All of the entrepreneurs in our sample are MIT-educated, and the venture summaries contain no information about entrepreneurs' work experience. It would be difficult for mentors to infer characteristics pertinent to entrepreneurial success, such as perseverance, without meeting them. Nor is mentor interest likely to be driven by entrepreneurs' ability to pitch their ideas, since the venture summaries are all written by the same staff member and standardized in tone and format. Consistent with these arguments, our regression results show that aggregate mentor interest is far more strongly correlated with observed venture characteristics than with observed entrepreneur characteristics (Table 3).

The second possibility is that mentors express interest for reasons other than their subjective evaluations of idea quality and unrelated to the ventures' likelihood of success. This scenario would result in measurement errors in our explanatory variable, which would bias our estimates toward zero. We thus interpret our results as conservative estimates of mentors' ability to assess venture ideas' commercial potential at an early stage. Furthermore, we have no reason to believe that measurement errors differentially affect the evaluation of R&D-intensive and non-R&D-intensive ventures; none of the mentors in our field interviews mentioned applying distinctive criteria to different types of ventures.

Are mentors recognizing high-quality ideas or excluding non-serious ideas?

VMS imposes minimal screening on venture ideas. One concern is thus that our sample of ventures could consist largely of self-evidently non-serious ideas, and could exhibit more variance in quality than the business plans that angel investors and VCs typically evaluate, a scenario that would undermine the external validity of our findings. We present three sets of evidence to demonstrate that mentors are not simply differentiating between serious and non-serious ideas and that our key findings apply to serious entrepreneurial pursuits. First, Table 4, columns (3) and (4), shows that the predictive power of mentor interest is robust to excluding ventures that elicited low mentor interest; Figure 4 also shows meaningful variations among the venture ideas that received above-median interest. Second, Table A.4 in the Appendix shows that our key findings hold when we restrict our analysis to ventures of entrepreneurs who pursue their

venture full-time.[20] Given the high opportunity costs facing MIT graduates, entrepreneurs are unlikely to make this commitment lightly and have done so based on their own subjective evaluation of their venture's merits. Finally, Table A.5 in the Appendix shows that aggregate mentor interest also predicts successful exit (i.e., acquisition or an initial public offering) among ventures that will be funded by VCs. Because there are only 56 such ventures and 5 exits, this evidence is merely suggestive. Nevertheless, it complements the previous findings, which jointly indicate that mentors are recognizing high-quality ideas rather than simply excluding non-serious ideas.

Are mentors able to predict the commercial viability of early-stage R&D-intensive ventures because of their unique expertise?

Differences in the predictive power of mentor interest between R&D-intensive and non-R&D-intensive ventures could in theory be driven by the composition of the pool of VMS mentors and not by the nature of the ventures themselves. VMS mentors may be particularly well-suited to evaluate ventures in R&D-intensive sectors given that, as Table 2 shows, slightly over half of them (129 mentors) have spent the bulk of their careers in an R&D-intensive sector. Table A.6 in the Appendix, however, reports evidence refuting the hypothesis that these mentors' professional experience is driving our key results: we find that interest expressed only by the mentors with primary career experience in non-R&D-intensive sectors also strongly and significantly predicts commercialization among ventures in R&D-intensive sectors and does not predict commercialization among ventures in non-R&D-intensive sectors. Likewise, we find that our results are robust to using only mentors who lack a doctoral degree. These results confirm that neither expertise in an R&D-intensive sector nor advanced scientific training is a critical factor in mentors' collective ability to differentiate among venture ideas in R&D-intensive sectors or in the inability to do so in non-R&D-intensive sectors.

Are mentors intentionally predicting the preferences of professional investors in R&D-intensive sectors?

In unreported regressions, we find two sets of evidence that mentors are not simply predicting the preferences of professional investors in R&D-intensive sectors. First, we find that among ventures in R&D-intensive sectors, aggregate mentor interest positively and significantly predicts raising venture financing and achieving commercialization, but does not predict raising venture financing without achieving commercialization. Furthermore, we find that the predictive power of mentor interest on commercialization remains

[20] The entrepreneur's full-time commitment to the venture usually occurs after joining VMS.

strong and significant within the sub-sample of ventures that have never raised venture financing.[21] Both results confirm that our findings are not driven by mentors' prediction of investor preferences.

7 Conclusion

Early-stage business ideas are rudimentary in nature and reliant on many assumptions, but we find that they offer pertinent information on ventures' eventual commercial viability. In collaboration with MIT's Venture Mentoring Service, we collected and examined detailed data on 652 early-stage venture ideas in multiple industry sectors. The ideas that elicited more positive evaluations from mentors were significantly more likely to ultimately reach commercialization. The predictive power of mentors' subjective evaluations is strong for ventures in R&D-intensive sectors such as hardware, but weak for ventures in non-R&D-intensive industries such as consumer web / mobile and enterprise software.

Our results suggest that firms in different sectors coalesce around different critical resources and that this pattern has strategic implications for the nature of venture financing across industries. In the absence of methods to reliably screen venture ideas, early-stage investors in non-R&D-intensive sectors may base their screening efforts on founding teams' human capital (Bernstein et al., 2015) or adopt a "spray-and-pray" approach (Nanda and Rhodes-Kropf, 2015). In these sectors, small initial investments may enable investors to gain more valuable information on ventures' probability of success than is provided by early-stage evaluation of the venture idea. Here, careful pruning of early-stage venture ideas through venture evaluation appears less efficient than low-cost experimentation. In R&D-intensive sectors, by contrast, developing early-stage ideas that innovate on the technological frontier is typically associated with high fixed costs, which makes diligent screening of early-stage venture ideas more pragmatic than "spray-and-pray."

We acknowledge several limitations of our study. First, though our setting allows us to examine the effectiveness of experts' evaluation of underlying business ideas, we cannot test whether our experts can effectively evaluate entrepreneurs' human capital. Nor can we compare the effectiveness of different types of evaluations. We leave this to future work. Second, though our data provide a valuable context in which to isolate the predictability of venture ideas, we are constrained by the specificity of the MIT setting. While we have presented and discussed several sets of evidence suggesting that the institutional setting does not

[21] Of the funded ventures in R&D-intensive sectors, 40 percent have not commercialized.

drive our key findings, similar investigations in other institutional and regional contexts would be a valuable direction for future studies. Finally, our focus on the earliest stage in a venture's lifecycle aids in understanding the uncertainties faced by young ventures, but it may limit the generalizability of these findings to later-stage venture evaluation. Examining the evolution of uncertainty during a venture's lifecycle would be another useful direction for future work.

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Table 1: Descriptive Statistics of Ventures (N = 652)

This table reports summary statistics for the sample of ventures that joined VMS between 2005 and 2012, excluding seven ventures that were already funded at entry and ten ventures founded by MIT faculty. Panel A reports venture characteristics by its primary industry sector; each venture is assigned to a single primary sector. *Academic research* indicates whether the venture is based on academic research. *Intellectual property* indicates whether the venture has filed for intellectual property protection before joining VMS. *Business entity* indicates whether the venture has formed a legal entity (incorporated) before joining VMS. Ventures classified as *Other* include non-profit, lifestyle, consulting, and finance ventures. Panel B reports additional descriptive statistics at the venture level. The characteristics of the primary entrepreneurs include their MIT-affiliation status at entry and whether they had previously been mentored by VMS with a different venture. *Mentor interest (%)* and *Mentor interest (#)* are respectively the proportion and number of mentors expressing initial interest in a venture. *Mentor meetings* is the number of meetings a venture has had with VMS mentors by August 2014. *Mentors met at least twice* is the number of VMS mentors that a venture has met more than once by August 2014. Venture Outcomes capture a venture's progress against three measures as of August 2014. *Full-time entrepreneur* indicates whether at least one of the venture's founding entrepreneurs has pursued the venture full-time. *Angel/VC funding* indicates whether a venture has received funding from angel investors and/or VCs. *Commercialization* indicates whether a venture has generated recurring revenue and expenses associated with sales of the products and/or services that are the business objective of the company, including forging technology-licensing deals.

Panel A: Venture Characteristics at Entry by Primary Sector

Primary Sector	N	Proportion (%)	Academic research (%)	Intellectual property (%)	Business entity (%)
All	652	100	15.5	23.2	16.9
Consumer web/mobile	182	27.9	4.4	4.9	9.9
Enterprise software	116	17.8	7.8	19.8	24.1
Hardware	96	14.7	31.3	52.1	30.2
Life sciences/medical devices	87	13.3	43.7	55.2	27.6
Consumer products	86	13.2	2.3	5.8	7.0
Energy	38	5.8	31.6	36.8	10.5
Other	47	7.2	4.3	4.3	2.1

Panel B: Additional Descriptive Statistics at Venture Level

	Mean	Std. Dev.	Min	Max
Year the venture joined VMS	2009.9	1.959	2005	2012
Month the venture joined VMS	6.469	3.400	1	12
Primary Entrepreneur Characteristics at Entry				
MIT student	0.443	0.497	0	1
MIT alumnus	0.456	0.498	0	1
MIT postdoc/staff	0.101	0.302	0	1
Previously mentored by VMS	0.077	0.266	0	1
VMS-Related Variables				
Mentor interest (%)	4.447	2.683	0	16.44
Mentor interest (#)	6.265	3.828	0	20
Mentor meetings (#)	3.212	3.100	0	21
Mentors met at least twice (#)	1.724	1.896	0	9
Venture Outcomes				
Full-time entrepreneur	0.465	0.499	0	1
Angel/VC funding	0.186	0.389	0	1
Commercialization	0.224	0.417	0	1

Table 2: Descriptive Statistics of Mentors (N = 251)

This table presents descriptive statistics about the pool of mentors active at VMS between 2005 and 2012. Panel A reports mentors' demographics including gender, possession of a Ph.D. or M.D. degree, and the number of industry sectors in which a mentor has acquired professional experience. Panel B reports the distribution of mentors across sectors. A mentor's primary sector is defined as the industry in which he or she has worked longest (as self-reported or extracted from online career histories): each mentor is assigned a single primary sector. *Other* includes finance, legal, and consulting.

Panel A: Demographics

Characteristic	Mean	Std. Dev.
Male	0.85	0.36
Doctoral degree	0.22	0.42
Sector experience (#)	2.47	1.13

Panel B: Distribution of Primary Sectors

	N	Proportion (%)
Consumer web/mobile	17	6.8
Enterprise software	53	21.1
Hardware	62	24.7
Life sciences/medical devices	54	21.5
Consumer products	6	2.4
Energy	13	5.2
Other	46	18.3

Table 3: Estimated Relationships between Aggregate Mentor Interest and Likelihood of Commercialization

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture. *Mentor interest (%)*, *Mentor interest (#), Mentors met at least twice*, *Mentor meetings*, *Academic research*, *Intellectual property at entry,* and *Business entity at entry* are defined in Table 1. *Mentors met at least twice FE* uses two indicator variables for the number of VMS mentors with whom a venture has had multiple meetings: 1-2, 3 or more. *Mentor meetings FE* uses two indicator variables for the number of meetings a venture has had with VMS mentors: 2-3, 4 or more. *Entrepreneur characteristics* include *MIT affiliation* and *Previously mentored by VMS*. *Sector FE* controls for industry sectors as explained in Panel B of Table 1. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample	Full	Full	Full	Full	Full	Full	Exclude top/bottom 5%	Full
Mentor interest (%)	0.020***	0.015**	0.014*	0.014**	0.013*	0.014**	0.020**	
	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	
Mentor interest (#)								0.010**
								(0.004)
Mentors met at least twice (#)				-0.003				
				(0.010)				
Mentor meetings (#)					0.003			
					(0.006)			
Academic research		0.114*	0.110*	0.112*	0.104	0.104	0.105	0.105*
		(0.060)	(0.062)	(0.064)	(0.064)	(0.063)	(0.069)	(0.062)
Intellectual property at entry		0.050	0.056	0.056	0.057	0.057	0.077	0.057
		(0.047)	(0.047)	(0.047)	(0.048)	(0.049)	(0.053)	(0.050)
Business entity at entry		0.324***	0.318***	0.320***	0.315***	0.317***	0.345***	0.317***
		(0.054)	(0.055)	(0.055)	(0.054)	(0.053)	(0.055)	(0.053)
Mentors met at least twice FE	No	No	No	No	No	Yes	Yes	Yes
Mentor meetings FE	No	No	No	No	No	Yes	Yes	Yes
Entrepreneur characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year joined VMS FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month joined VMS FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	652	652	652	652	652	652	590	652
R^2	0.12	0.24	0.25	0.25	0.25	0.26	0.25	0.25

Table 4: Robustness Checks on Estimated Relationships between Aggregate Mentor Interest and Likelihood of Commercialization

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture. *Mentor interest (%)* and *Mentor interest (#)* are defined in Table 1. Columns (1) and (2) use as a mentor-interest measure the proportion or count of mentors who express initial interest but never meet with the venture. In columns (3) and (4), the sample is restricted to ventures that elicited interest from more than four mentors, the maximum initial mentor team size. In columns (5) and (6), the sample consists of ventures that met with VMS mentors twice at most and had no repeat interactions with any mentors. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, mentors met at least twice, mentor meetings, entrepreneur characteristics, sector, year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Full		>4 mentors expressing interest		Limited interactions	
Mentor interest (%)			0.017*		0.018*	
			(0.009)		(0.010)	
Mentor interest (#)				0.012*		0.010*
				(0.006)		(0.006)
Mentor interest from those not interacting with the venture (%)	0.015*					
	(0.008)					
Mentor interest from those not interacting with the venture (#)		0.010**				
		(0.005)				
N	652	652	421	421	259	259
R^2	0.25	0.25	0.24	0.24	0.35	0.35

Table 5: Robustness Checks at the Venture/Mentor Level

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture paired with a mentor who was active at VMS when the venture joined. *Expression of initial interest* is an indicator variable on whether the mentor expressed initial interest in the venture. *At least one meeting* is an indicator variable on whether the mentor ever met with the venture and equals (1− *No meeting*). *Mentor meeting FE* is a set of 251 dummies, each dummy equals 1 if a specific mentor met with the venture. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, entrepreneur characteristics, sector, year and month of affiliation with VMS. Standard errors are robust and clustered by venture. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)
Expression of initial interest	0.018**	0.019*	0.020*			
	(0.008)	(0.012)	(0.012)			
Expression of initial interest & No meeting				0.024**	0.025**	0.025**
				(0.012)	(0.012)	(0.012)
At least one meeting		-0.003			0.012	
		(0.012)			(0.008)	
Mentor meeting FE	No	No	Yes	No	No	Yes
N	93,672	93,672	93,672	93,672	93,672	93,672
R^2	0.22	0.22	0.22	0.22	0.22	0.22

Table 6: Estimated Relationships between Aggregate Mentor Interest and Venture Outcomes by Venture Sector

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization, raised any Angel/VC funding, raised Angel/VC funding >$1 million, and raised Angel/VC funding >$5 million. The unit of observation is a venture. In Panel A, the sample consists of ventures in R&D-intensive sectors. In Panel B, the sample consists of ventures in non-R&D-intensive sectors. *R&D-intensive sectors* include hardware, energy, and life sciences and medical devices. *Non-R&D-intensive sectors* include consumer web/mobile, enterprise software, consumer products, and other. *Mentor interest (%)* is defined in Table 1. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, mentors met at least twice, mentor meetings, entrepreneur characteristics, sector, and year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Dependent Variable	Commercialization	Angel/VC funding	Angel/VC funding > $1 million	Angel/VC funding > $5 million
	Panel A: Ventures in R&D-intensive sectors (N=221)			
	(A1)	(A2)	(A3)	(A4)
Mentor interest (%)	0.0265***	0.0170	0.0171*	0.0179*
	(0.0093)	(0.0105)	(0.0090)	(0.0088)
	Panel B: Ventures in Non-R&D-intensive sectors (N=431)			
	(B1)	(B2)	(B3)	(B4)
Mentor interest (%)	0.0067	0.0021	-0.0006	-0.0050
	(0.0091)	(0.0089)	(0.0074)	(0.0047)

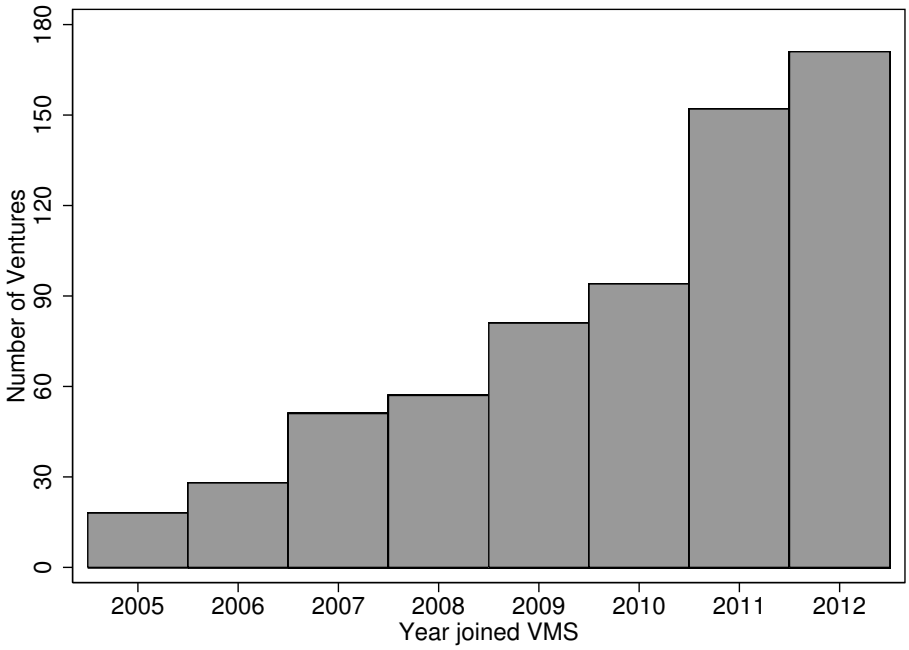
Table 7: Estimated Relationships between Aggregate Mentor Interest and Likelihood of Commercialization by Venture Characteristics

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture. The sample consists of ventures in R&D-intensive sectors. *R&D-intensive sectors* include hardware, energy, and life sciences and medical devices. *Mentor interest (%)*, *Academic research*, *Intellectual property,* and *Business entity* are defined in Table 1. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, mentors met at least twice, mentor meetings, entrepreneur characteristics, sector, and year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	In R&D-intensive sectors			In non-R&D-intensive sectors		
Mentor interest (%) * (Academic research = 1)	0.044***			-0.028		
	(0.011)			(0.026)		
Mentor interest (%) * (Academic research = 0)	0.016			0.009		
	(0.016)			(0.009)		
Mentor interest (%) * (Intellectual property = 1)		0.036***			-0.018	
		(0.009)			(0.028)	
Mentor interest (%) * (Intellectual property = 0)		0.015			0.011	
		(0.018)			(0.009)	
Mentor interest (%) * (Business entity = 1)			0.012			0.003
			(0.017)			(0.025)
Mentor interest (%) * (Business entity = 0)			0.033***			0.007
			(0.011)			(0.010)
N	221	221	221	431	431	431
R^2	0.27	0.26	0.26	0.34	0.34	0.33

Figure 1: Number of Ventures by Year and Month of Affiliation with VMS

This figure plots the number of ventures by year or month of initial affiliation with VMS. The sample consists of all ventures that joined VMS between 2005 and 2012, excluding seven ventures that were already funded at entry and ten ventures founded by MIT faculty.



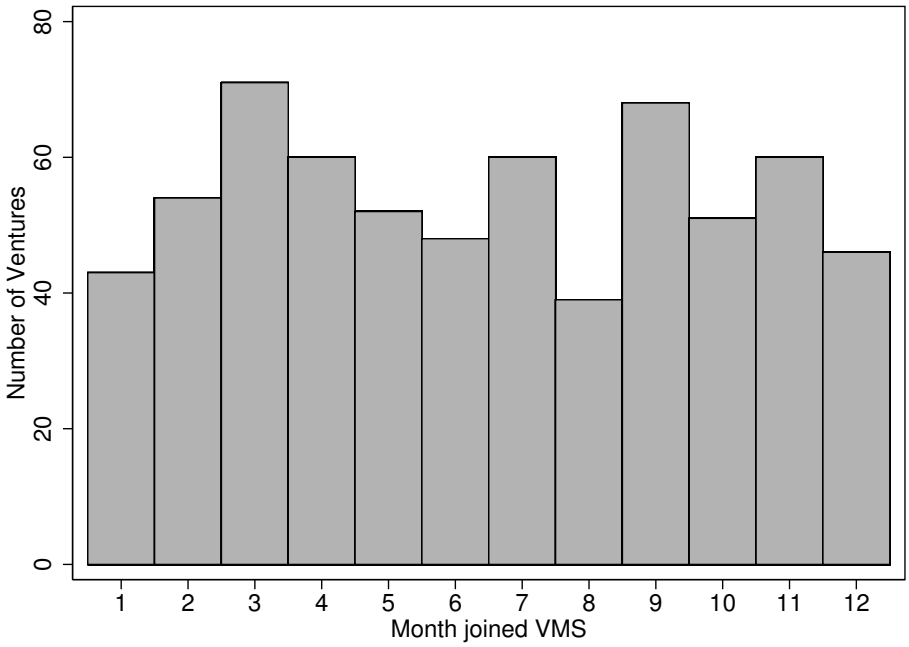
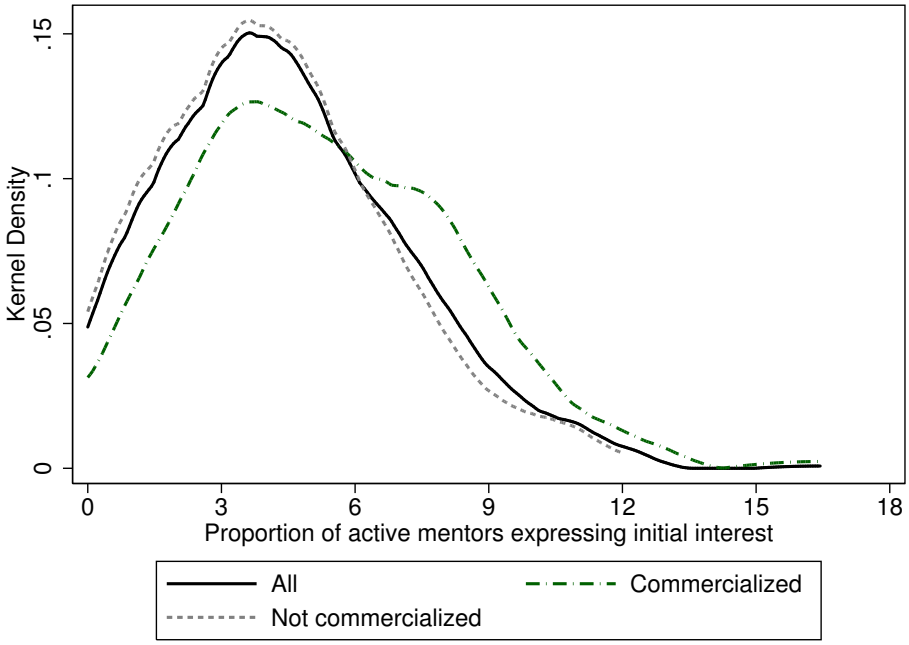


Figure 2: Distribution of Aggregate Mentor Interest

This figure plots the kernel density of the proportion of mentors who express initial interest in a venture and the histogram of the number of mentors who do so. A venture is *commercialized* if it has achieved recurring revenue and expenses associated with sales of the products and/or services that are the business objective of the company, including forging technology-licensing deals, by August 2014.



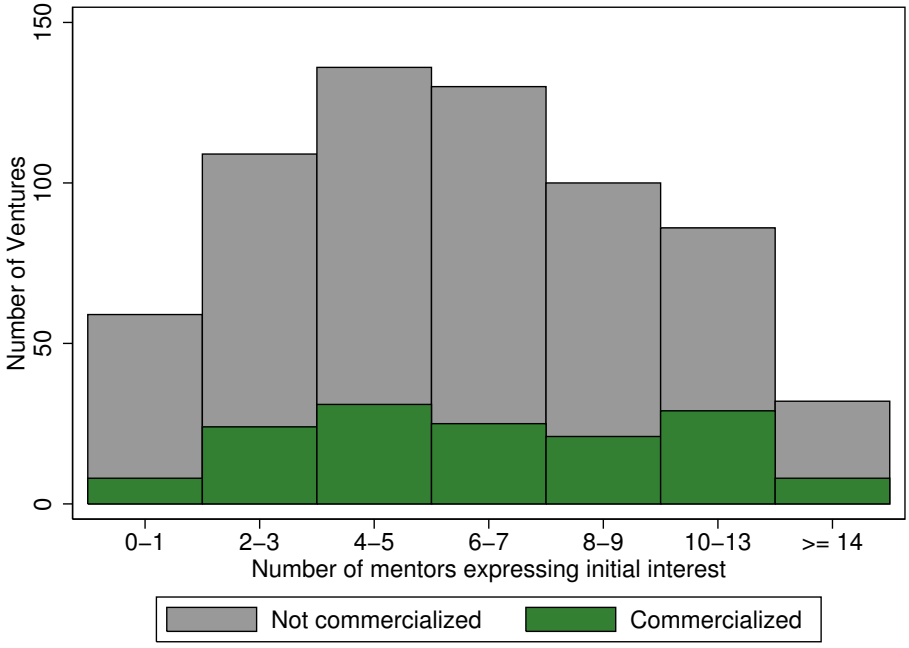


Figure 3: Raw Relationships between Venture/Mentor Interactions and Aggregate Mentor Interest

This figure presents scatter plots of the raw relationships between mentor interest and venture/mentor interactions for all ventures. All plots include a linear line of best fit.

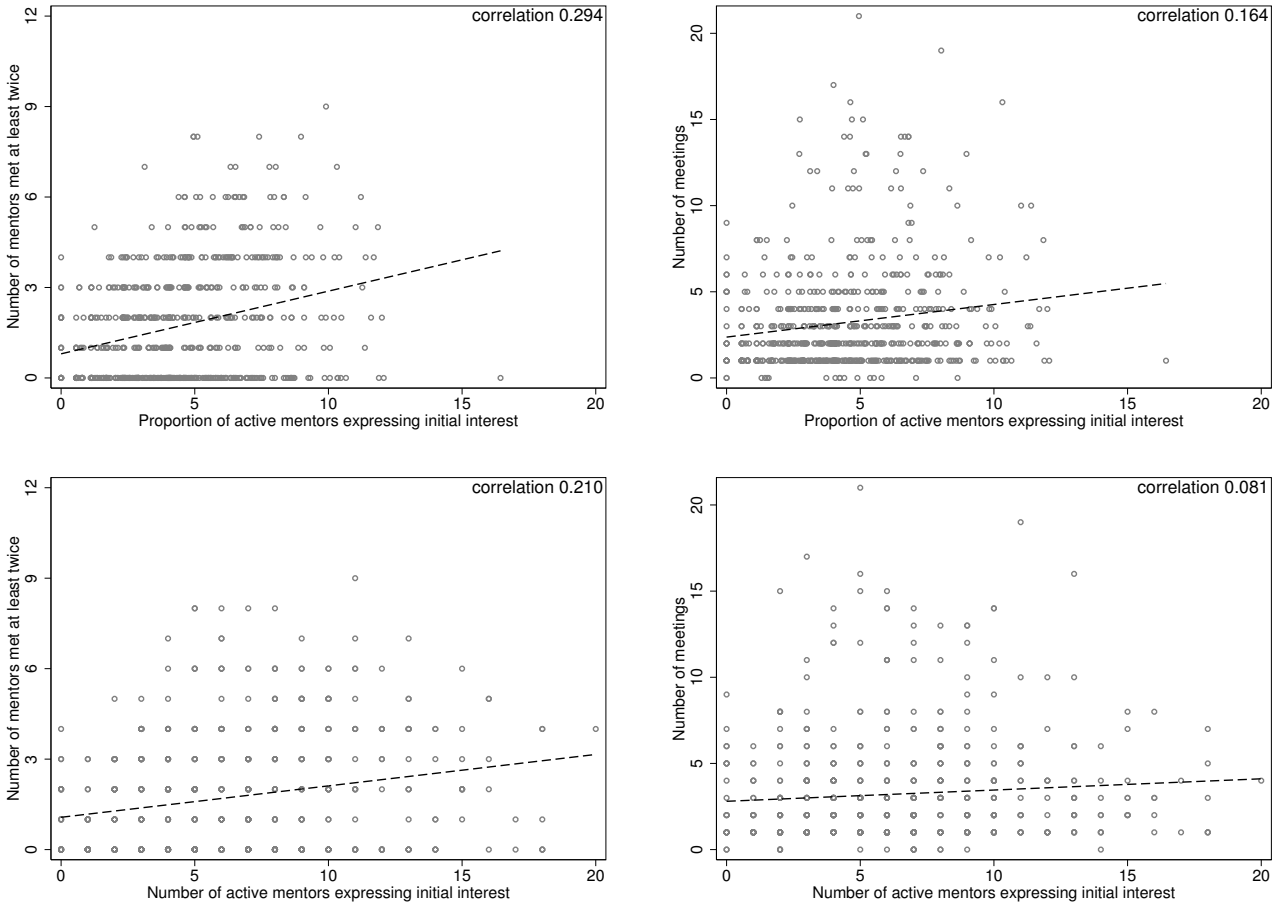
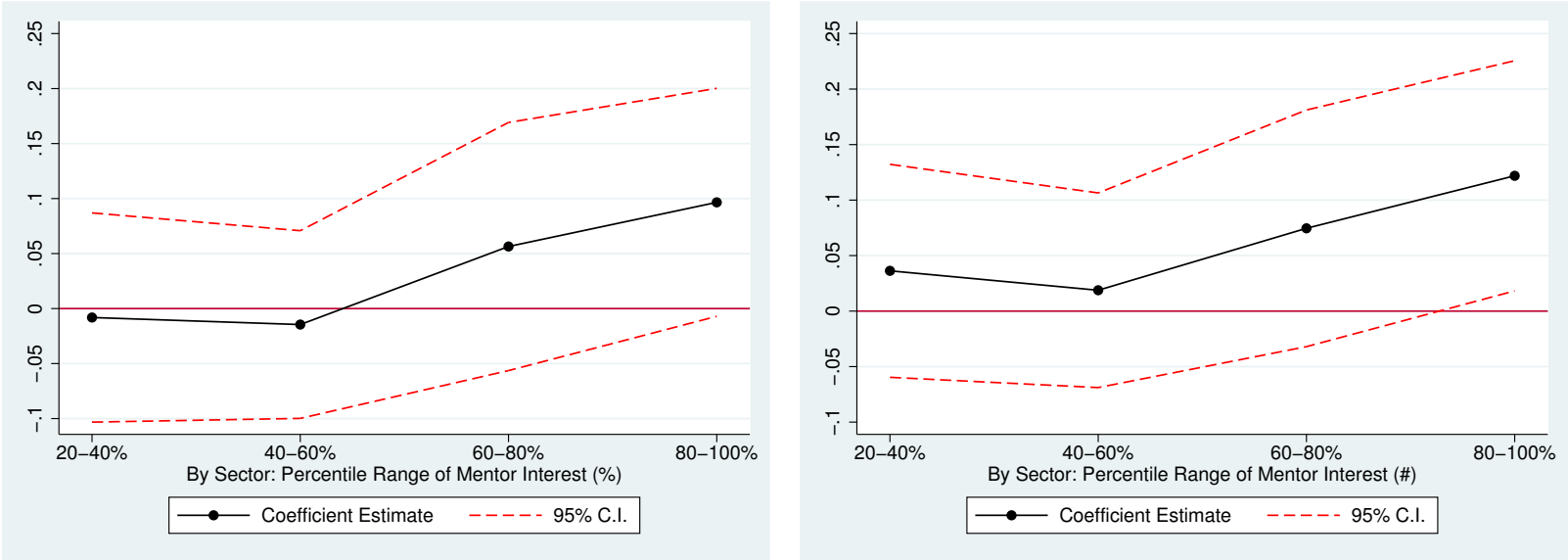


Figure 4: Estimated Relationships between Commercialization and Mentor Interest, by Percentiles

This figure plots coefficient estimates and confidence intervals from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture. The regression plotted on the left consists of the quintile dummies of *Mentor Interest (%)* calculated within each industry sector. The regression plotted on the right consists of the quintile dummies of *Mentor Interest (#)* calculated within each industry sector. *Mentor interest (%)* and *Mentor interest (#)* are defined in Table 1. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, mentors met at least twice, mentor meetings, entrepreneur characteristics, sector, and year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS.



Appendix Tables and Figures

Table A.1: Anonymized Sample Venture Descriptions

Venture X — Student. The company is developing software that assesses [a certain medical condition] by capturing and analyzing [relevant characteristics]. This software provides the first objective measure of [the condition] based on analysis of physical characteristics rather than on a subjective evaluation. This will permit healthcare organizations and practitioners to diagnose and monitor [the condition] more effectively and at lower cost. The team is experienced in systems development and in medical research. So far they have developed and filed provisional patents on the core algorithms, and they have completed several studies in local hospitals demonstrating the feasibility of their approach. They are now in conversations with a potential client to develop the software for a pilot. They seek guidance from VMS on negotiations and also on organizational issues, IP portfolio strategy, marketing, and funding.

Venture Y — Students. The idea is to deliver [a certain content service] to subscribers, customizing the content delivered according to each subscriber's interests and tastes. The service will feature a proprietary behavioral system which monitors user behavior and solicits user tagging and feedback to teach the system. The venture also will offer tools for sharing interests among close friends to create an "addicting social network." Revenue will come from targeted advertising based on users' interests and demographics, and from partnerships with magazines and newspapers. Two student founders are doing the technical development. They have finalized the design and are currently building the prototype. They have come to VMS for practical advice on their business plan, getting to market, building a team, and obtaining funding.

Table A.2: Frequency of Venture/Mentor Interactions

This table shows the frequency of venture interactions with VMS mentors. *Mentors met at least twice* is the number of mentors with whom a venture met at least twice by August 2014. *Mentor meetings* is the number of meetings that a venture had with any VMS mentors by August 2014.

Mentors met at least twice (#)	Frequency	Percentage	Cumulative Percentage
0	263	40.34	40.34
1 ~ 2	191	29.29	69.63
3 or more	198	30.37	100
Mentor meetings (#)	**Frequency**	**Percentage**	**Cumulative Percentage**
0	17	2.61	2.61
1	219	33.59	36.20
2 ~ 3	210	32.21	68.40
4 or more	206	31.60	100

Table A.3: Estimated Relationships between Aggregate Mentor Interest and Likelihood of Commercialization Using Probit and Logit Regressions

This table reports coefficient estimates from OLS and marginal effects from Probit and Logit regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture. *Mentor interest (%)*, *Mentor interest (#), Academic research*, *Intellectual property,* and *Business entity* are defined in Table 1. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, mentors met at least twice, mentor meetings, entrepreneur characteristics, sector, year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Probit	Logit	OLS	Probit	Logit
Mentor interest (%)	0.014**	0.014**	0.015**			
	(0.007)	(0.006)	(0.006)			
Mentor interest (#)				0.010**	0.011***	0.011***
				(0.004)	(0.004)	(0.004)
Academic research	0.104	0.088*	0.086*	0.105*	0.089*	0.087*
	(0.063)	(0.051)	(0.051)	(0.062)	(0.050)	(0.050)
Intellectual property at entry	0.057	0.042	0.042	0.057	0.041	0.041
	(0.049)	(0.040)	(0.040)	(0.050)	(0.040)	(0.040)
Business entity at entry	0.317***	0.222***	0.209***	0.317***	0.222***	0.208***
	(0.053)	(0.031)	(0.031)	(0.053)	(0.032)	(0.031)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	652	652	652	652	652	652
Pseudo R^2	0.25	0.23	0.23	0.26	0.24	0.23

Table A.4: Estimated Relationships between Aggregate Mentor Interest and Likelihood of Commercialization Conditional on Full-Time Entrepreneurs

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture. In columns (1) and (2), the sample consists of ventures in which the entrepreneurs will commit full-time to the venture. In columns (3) and (4), the sample consists of ventures in R&D-intensive sectors and in which the entrepreneurs will commit full-time to the venture. In columns (5) and (6), the sample consists of ventures in non-R&D-intensive sectors and in which the entrepreneurs will commit full-time to the venture. *R&D-intensive sectors* include hardware, energy, and life sciences and medical devices. *Non-R&D-intensive sectors* include consumer web/mobile, enterprise software, consumer products, and other. *Mentor interest (%)* and *Mentor interest (#)* are defined in Table 1. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, mentors met at least twice, mentor meetings, entrepreneur characteristics, sector, and year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Entrepreneurs committing full-time					
Sector	All		R&D-Intensive		Non-R&D-Intensive	
Mentor interest (%)	0.030**		0.043***		0.016	
	(0.011)		(0.013)		(0.021)	
Mentor interest (#)		0.023**		0.034***		0.010
		(0.009)		(0.010)		(0.016)
N	303	303	131	131	172	172
R^2	0.19	0.20	0.30	0.30	0.30	0.30

Table A.5: Estimated Relationships between Aggregate Mentor Interest and Successful Exit Conditional on Receiving Venture Capital

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently was acquired or had an initial public offering. The unit of observation is a venture. The sample consists of ventures that will receive funding from venture capitalists. *Mentor interest (%)* is defined in Table 1. *Mentors met at least twice FE*, *Mentor meetings FE*, and *Entrepreneur characteristics* are defined in Table 3. *Venture characteristics* include *Academic research*, *Intellectual property at entry, Business entity at entry*, and *Sector FE, also* defined in Table 3. All regressions include fixed effects for year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Dependent Variable: Acquisition or IPO	(1)	(2)	(3)	(4)
Mentor interest (%)	0.032	0.043**	0.056**	0.0510**
	(0.019)	(0.018)	(0.0232)	(0.0253)
Mentors met at least twice FE	No	No	No	Yes
Mentor meetings FE	No	No	No	Yes
Entrepreneur characteristics	No	No	Yes	Yes
Venture characteristics	No	Yes	Yes	Yes
N	56	56	56	56

Table A.6: Estimated Relationships between Aggregate Mentor Interest and Likelihood of Commercialization within Subsets of Mentors

This table reports coefficient estimates from OLS regressions where the dependent variable is an indicator variable on whether the venture subsequently reached commercialization. The unit of observation is a venture. In column (1), the sample consists of the full sample of 652 ventures. In column (2), the sample consists of ventures in R&D-intensive sectors. In column (3), the sample consists of ventures in non-R&D-intensive sectors. *R&D-intensive sectors* include hardware, energy, and life sciences and medical devices. *Non-R&D-intensive sectors* include consumer web/mobile, enterprise software, consumer products, and other. In Panel A, *Refined Mentor Interest (%)* is the percent of mentors with primary experience in R&D-intensive sectors who express interest the venture. In Panel B, *Refined Mentor Interest (%)* is the percent of mentors with primary experience in non-R&D-intensive sectors who express interest the venture. In Panel C, *Refined Mentor Interest (%)* is the percent of mentors without a doctoral degree who express interest in a venture. Sector definitions are in Tables 1 and 2. All regressions include controls and fixed effects for academic research, intellectual property at entry, business entity at entry, mentors met at least twice, mentor meetings, entrepreneur characteristics, sector, and year and month of affiliation with VMS. Standard errors are robust and clustered by venture sector and year of affiliation with VMS. Significance: $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

	(1)	(2)	(3)
Sector	All	R&D-intensive	Non-R&D-intensive
	Panel A: Mentors in R&D-intensive sectors (129 mentors)		
Refined Mentor Interest (%)	0.010**	0.013*	0.008
	(0.005)	(0.007)	(0.009)
	Panel B: Mentors in non-R&D-intensive sectors (122 mentors)		
Refined Mentor Interest (%)	0.007	0.022**	0.001
	(0.005)	(0.01)	(0.005)
	Panel C: Mentors without a doctoral degree (195 mentors)		
Refined Mentor Interest (%)	0.013**	0.029***	0.005
	(0.006)	(0.01)	(0.008)

Figure A.1: Overview of the Initial Venture/Mentor Pairing Process