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The Entrepreneur's Idea and Outside Finance: Theory and Evidence about Entrepreneurial Roles*

by

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ABSTRACT: We study the problem faced by the entrepreneur seeking outside support to turn an entrepreneurial idea into a successful innovation—specifically a successful technological innovation resulting from research and development. The paper develops and tests the hypothesis that as an entrepreneur's innovative idea becomes more complex, the entrepreneur will find it more difficult to obtain outside finance and then outside support more generally for the commercialization of the idea. Consequently, the entrepreneur will be more likely to take on additional roles beyond providing the essential idea. The evidence supports the hypothesis that, other things being the same, an entrepreneur with a more complex idea will have greater difficulty obtaining outside finance and will be more likely to take on the additional roles of development, production, marketing and distribution that are necessary for successful innovation.

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KEYWORDS: entrepreneur, outside finance, entrepreneurial roles, Small Business Innovation Research (SBIR) program, complexity

JEL CLASSIFICATIONS: O31; L26; O38; L24; O30; O32

I. Introduction.

Entrepreneurs play many roles. Reviewing the history of thought, Hébert and Link, (2009, pp. 100-101) list, among many other roles, the entrepreneur's roles as innovator, as organizer and coordinator of economic resources, as the person supplying financial capital, as the person assuming risk and uncertainty. Manne's (2014) perspective on the roles played by the entrepreneur is that the entrepreneur plays whatever roles are needed to get the entrepreneur's essential idea—the contribution of that idea being the initial and enterprise-launching role for the entrepreneur—into the marketplace as a commercial success. Typically it will be helpful for the entrepreneur to hand off to others some of the roles beyond having the essential idea.

Manne (2014) explains that the entrepreneur may need to play many roles beyond the provision of the essential entrepreneurial idea because it is difficult to convince others that the idea has commercial value. An important gateway to gaining outside support for the development of the essential entrepreneurial idea that promises a technical breakthrough is through obtaining outside finance for the research and development (R&D) leading to the commercialization of the idea. Among the various roles found in the economics literature for entrepreneurs, Hébert and Link (2009, p. 100) list the provision of financial capital prominently. The entrepreneur would—following Manne's (2014) insights—assume that role of the provider of financial capital because of the difficulty in explaining the value of the entrepreneurial idea to others. Moreover, research has shown that obtaining outside financial support for R&D to develop an entrepreneur's idea is an important determinant of the commercial success of an entrepreneur's R&D results (Link and Scott, 2009, 2013), and so the difficulty in obtaining outside finance can be an important barrier to successful innovation by an entrepreneur. Thus, obtaining outside finance—avoiding having to play the financier's role—is often important for successful commercialization of the innovation based on the entrepreneur's idea.

This paper uses data about the U.S. Small Business Innovation Research (SBIR) program to examine forces affecting an entrepreneur's ability to get early outside finance to support R&D efforts, and in particular the data are used to examine the impact of the complexity of the entrepreneur's idea. While there are many types of entrepreneurs, we restrict our attention to entrepreneurs who use R&D to create a new technology and then bring it to market, and we hypothesize that greater complexity of the entrepreneurs' ideas will make it more difficult for them to secure early outside finance for development of their ideas. Åstebro (2003) explains the problems that independent inventors face in attracting outside investors because of information asymmetries. Link and Scott (2012, p. 86) apply Åstebro's insights to small entrepreneurial firms. Following Åstebro's argument, for the entrepreneur to secure early outside finance for an R&D project, two hurdles must be cleared. First, the entrepreneurial firm must be selected from all of the firms that might be considered, and then second, the firm must be selected from all of those actually examined. In this paper, we explain why the complexity of the entrepreneur's idea will accentuate the information asymmetries that motivate Åstebro's argument and therefore make it less likely that the entrepreneur will obtain early outside finance.

Despite the long history of thought detailed by Hébert and Link (2009), studies of nascent entrepreneurship are a rapidly evolving area of research. Westhead and Wright (2013) provide an insightful, concise overview of the current state and future of entrepreneurship research.[1] Analyzing dozens of studies of panel data sets describing entrepreneurial dynamics, Davidsson (2006) makes suggestions for future research. For example, our approach in this paper addresses his concern that studies compare entrepreneurial efforts at the same stage in their development (Davidsson, 2006, p. 59) because we observe whether the entrepreneurial R&D projects obtained outside finance early, and as explained in Section III, at precisely the same point in the development of the entrepreneurial idea. We also address his concern that studies address the problem of attrition (Davidsson, 2006, p. 61) among the entrepreneurial efforts being compared because, again as explained in Section III, all of the entrepreneurial projects we examine began in the same year and none of them had been abandoned at the time they are observed in the data set.

Section II explains our hypothesis that the complexity of the entrepreneur's idea is a reason that many R&D-based entrepreneurs will find it difficult to secure early outside finance for the development of their ideas. Section III describes the sample, data, and variables that we use to test the hypothesis. Section IV presents the hypothesis test. Section V concludes.

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[1] The body of research has grown markedly, with Schumpeter (1934, 1942) stimulating a large literature about the disruptive, creative influence of entrepreneurs who introduce major innovations. Coase (1937) places the entrepreneur—deciding how to organize scarce economic resources—in the context of his classic discussion of the nature of the firm. Scherer (1970, p. 357) and Acs and Audretsch (1988) emphasized the importance of small firms for innovation. Baumol (2002, p. ix, p. 72) emphasized that the innovations of entrepreneurs are often critical, breakthrough innovations that significantly stimulate economic growth. Entrepreneurs have long been crucial for economic growth; Kohn (2014) places the entrepreneur at the heart of technological progress throughout the centuries of economic growth in preindustrial Europe.

II. The Complexity of an Innovative Idea and Early Outside Finance.

SBIR projects used in our study entail first a quick initial look in Phase I to establish feasibility of the idea. The R&D effort that follows in Phase II will, if all goes well, be followed by commercialization of the results from the R&D project. A SBIR R&D project can be quite complex in terms of the number of different broad technologies combined for the innovation. For example, one project in our sample combined electronics, mechanics, computer networking and software, and life sciences to create a telerobot to be used for surgery.[2] Other projects are much less complex in terms of the number of broad technologies combined. For example, one project developed a new gear to more accurately position and aim a weapon; just a single broad technology—mechanical performance of weapons, vehicles, and facilities—was involved.

For this paper, the presence or absence of early outside finance is observed between Phase I and Phase II of the SBIR project. Then, the hypothesis tested is that obtaining early outside finance is expected to be more difficult for more complex entrepreneurial ideas. With a more complex idea, communications costs result in less room for a mutually acceptable bargain between the entrepreneur and the outside investor. One way to think about the communications difficulties arises from the characteristics of the R&D sample space—the set of potential outcomes for an R&D project. An entrepreneur may have a complex idea in the sense that it is more challenging for R&D to get all of the components of the innovation to work well together—more challenging because of a larger number of ways each component can turn out along the dimensions that must be consistent with the other components.

Complexity of the entrepreneur's idea in the sense we use it here is defined in Scott (1991, pp. 133-135):

> Innovations are new bundles of components that work together; the components have consistent attributes. The integration of an innovation's components achieves *component gestalt* – the necessary integration of components. . . . Let C denote the number of project components . . . . Let Z be the number of ways each component could turn out for the set of characteristics that must mesh across all components. That meshing or consistency is necessary for a successful innovation. . . . The absolute number of development outcomes with a high degree of component gestalt is typically large and increases with complexity (measured directly by Z). As a proportion of the total number of outcomes, however, the high component gestalt cases are rare – increasingly rare as project complexity increases. The small proportion of the sample space associated with high component gestalt shrinks as the complexity of the development task increases. [italics in original]

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[2] The sponsoring agency, the U.S. Department of Defense, wanted to develop the capabilities for medical personnel at remote locations to operate on the front lines of combat. Clearly the development has non-military applications.

Thus, the complexity in the sense used in this paper is the component-gestalt complexity introduced in Scott (1991) and not the "complexity" in the large and evolving literature about complexity in science and technology described in Antonelli (2011).[3] From the description of the R&D sample space, there are two reasons that an entrepreneur with a more complex idea will have a more difficult time explaining the idea to others and securing their investment in the idea. First, consistent solutions are large in absolute number, so the entrepreneur and the potential investor may have different views about what will work. Second, consistent solutions are a small proportion of possible outcomes, so the potential investor may focus on failure.

We provide a detailed description of the R&D sample space in Scott and Scott (2015) and use examples to illustrate the general description in Scott (1991). Here we use a simplified example to illustrate the general points. As detailed by McCullough (2015, pp. 77-81, 86-90) there were many integrated components to the Wright brothers' 1903 flying machine, and the attributes of those components needed to be consistent with one another along many dimensions. The machine's components included the body with its wings, the rudder, the engine, the fuel system, the propeller, and more. For our simple example, however, consider just $C = 2$ components—the body of the machine and the engine—and just a single dimension—weight—along which the components must be consistent. As explained by McCullough, the light-weight body was a frame and ribs covered with cloth and the light-weight engine was deliberately simple. Now suppose for example that the R&D project has but $Z = 2$ outcomes, along the dimensions that must be consistent, for each component—each could be consistent with either a light or a heavy machine. There are two ($Z = 2$) consistent solutions to the R&D problem, either a light body and a light engine, or instead a heavy body and a heavy engine (think of the airplanes that appeared subsequently). There are four (Z^C) possible outcomes in the sample space—light body and light engine, light body and heavy engine, heavy body and light engine, heavy body and heavy engine. The proportion of the sample space with consistent solutions is one half. Now, if instead the R&D outcomes for each of the two components could be consistent

[3] As described by Antonelli (2011, p. 3): "Complexity is emerging as a new unifying theory to understand endogenous change and transformation across a variety of disciplines, ranging from mathematics and physics to biology. Complexity thinking is primarily a systemic and dynamic approach according to which the outcome of the behavior of each agent and of the system into which each agent is embedded is intrinsically dynamic and can only be understood as the result of multiple interactions among heterogeneous agents embedded in evolving structures and between the micro and macro levels."

with light, medium, or heavy weight, $Z = 3$, and the proportion of the sample space with consistent solutions is one-third (Z/Z^C). From McCullough's account of the Wright brothers' R&D, clearly the range of possible outcomes on the dimension of weight was much larger; consider for example the engine that they received from a manufacturer of automobile engines—despite their request for an engine that was sufficiently light, it was too heavy, and they set about building their own (McCullough, pp. 86-88). Suppose on the dimension of weight, there were 10 possible outcomes from the lightest to the heaviest for each component; there would be 10 consistent solutions to the R&D problem, and the proportion of the R&D sample space with consistent solutions would be one-tenth. With the weight dimension having 100 outcomes, there would be 100 consistent solutions and the proportion of possible outcomes that would be consistent would be one one-hundredth (100/10000 = 0.01).

The actual problem is much more complex because there are more than two components and they must all be consistent along the weight dimension. For example, the fuel system for the 1903 flying machine was extraordinarily simple, featuring a one-gallon tank among other weight saving features (MuCullough, 2015, p. 87). The propellers (that alone presented an extraordinarily difficult R&D problem) were "three spruce laminations glued together and shaped by hand" (MuCullough, 2015, pp. 88-89). Moreover, there were more dimensions beyond weight that had to be consistent across the components, for example, size. With four components—for example, body, engine, fuel system, and propeller—and two dimensions along which components must be consistent—for example, weight and size—and with three outcomes for each dimension—for example, light or medium or heavy weight and small or medium or large size, the number of ways that each component could turn out along dimensions that must be consistent across components is nine (Z = 9 = 3x3), the number of consistent solutions is nine and the proportion of the sample space with consistent solutions is 1/729 ($Z/Z^C = 9/9^4$) or approximately 0.001372. For each component, the number of possible outcomes along each dimension is typically large, and there are many components to be integrated in the developed technology, and there are many dimensions that must be consistent across components (for example, strength and temperature in addition to weight and size); the absolute number of consistent solutions increases and the proportion of the sample space with consistent solutions becomes very small. The more complete general problem with complete description of the R&D

sample space is in Scott (1991), with further explanation and illustrations in Scott and Scott (2015).

Our hypothesis, with its two related parts, is that if an innovative idea is more complex, the entrepreneur who has the idea will first find it more difficult to find outside finance for the development of the idea and, consequently, second will be more likely to take on additional roles beyond providing the essential idea as the commercialization of the idea proceeds. The hypothesis follows from the belief that an entrepreneur with a more complicated idea in the sense of component gestalt complexity will have a more difficult time explaining the idea to others and securing their investment in the commercialization of the idea. Because the absolute number of consistent solutions will be greater, complexity of the entrepreneurial idea increases the probability that the entrepreneur and a potential investor will have in mind different views of the successful R&D solution, making more difficult a meeting-of-the-minds about the development to be financed. Also, because the proportion of the R&D outcomes that are successful becomes vanishingly small as the idea becomes more complex, it becomes more likely that the potential investor will focus on the large proportion of the potential outcomes for which the development project will fail to produce a result that can be commercialized, again making more difficult the successful negotiation of outside finance for the R&D project.

Given the difficulty in conveying the idea to others, outside investors would be expected to find a complex idea especially risky. Even when willing to make an investment, those outside investors would be expected to ask for such a large share of the entrepreneurial firm's earnings that the entrepreneur with the idea would decide to go it alone. As some of the entrepreneurs whose projects are in the sample used in the present paper put it (Scott, 2000b, pp. 129-130): "We would not agree to sell our souls to the venture capitalists or a large company." "We would not agree to an arrangement where we would lose control of our company and our intellectual property." "The outside investors wanted half of the right to profits in return for providing one-third of the financing." "We tried to find support from other companies and venture capitalists. The venture capitalists want too high a rate of return and want returns too quickly. Joint ventures don't work either. You need their money, so they want lots of rights."

The entrepreneur may be confident that the right part of the sample space can be found, or even believe that it has already been found and development can proceed quickly. Yet, although the entrepreneur may have the foregoing optimistic—and even realistic—belief, conveying that information will be difficult, in part because of the paradox of information but also because convincing an outside partner that an integrated whole can be made of the many parts of a complex idea will be in itself difficult.

The hypothesis—that early outside finance will be more difficult to obtain if the entrepreneur's idea is more complex—is grounded in the economics described by the entrepreneur's and the investor's participation constraints. As an entrepreneur's idea becomes more complex to develop, the complexity makes more restrictive the constraints on the agreement between the entrepreneur and the outside financier so that the region for which a mutually beneficial deal can be reached shrinks and disappears if complexity becomes great enough. Figure 1 illustrates the constraints on an agreement and the region for which a deal for outside finance is feasible and shows how that region shrinks as complexity increases. Figure 2 shows how the set of projects—described by their gross return and the probability of that return—with agreements for outside finance shrinks as complexity increases.

To explain our illustrations in Figures 1 and 2, we develop now the participation constraints for a deal between the entrepreneur and the outside investor. The entrepreneur must obtain outside funding in the amount I to go forward with the R&D project. Going forward will also require the entrepreneur to exert effort, which has a cost e. If the project goes forward, it will generate a gross return M with probability π; both M and π are the private information of the entrepreneur. If the project succeeds, the investor receives μ; otherwise, the investor gets nothing.

The investor is willing to provide the financing as long as $\pi\mu \geq I(1 + R(\pi))$, where $R(\pi)$ is the required rate of return which may be decreasing with respect to π. Rearranging, we have the investor's participation constraint: $\mu/I \geq (1 + R(\pi))/\pi$.

The entrepreneur will accept an agreement as long as $\pi(M - \mu) \geq e$. Rearranging, we have the entrepreneur's participation constraint: $(M - (e/\pi))/I \geq \mu/I$. Under complete information—that is, if both the entrepreneur and the outside investor knew the true value of π, say π_0—there would be common ground for an agreement as long as both investor's and entrepreneur's participation constraints could be satisfied at the same time: as long as $(M - (e/\pi_0))/I \geq (1 + R(\pi_0))/\pi_0$. This situation is depicted in Figure 1, where mutually agreeable values of μ can be found on the line segment SW; mutually agreeable terms would exist as long as π takes on a value greater than that at which the participation constraints intersect, at point T.[4]

Now suppose the investor initially begins with a prior belief that π is strictly less than its true value π_0, say π_i. Raising the investor's belief involves costly communication, essentially as described by Dewatripont and Tirole (2005) and Caillaud and Tirole (2007). As the entrepreneur offers evidence, the investor's belief about π increases, and so the investor's required return (the minimum acceptable μ/I) falls, but it falls more slowly than $(1 + R)\pi$ falls, instead, as illustrated in Figure 1, moving along the curve AB to change the investors initial belief π_i to the final belief π_f. The reason is that communication is costly for both the entrepreneur, who is sending evidence, and the investor, who is receiving evidence. The return must compensate the investor for the cost of listening; also, that investor now perceives a higher expected value than other potential investors would perceive. As a result, competition with other investors is less intense. The entrepreneur, rather than incurring the cost of starting over with another potential investor with a less favorable prior, would be more willing to settle with the outside investor who already perceives the higher probability of success. Because of costly communication in the context of incomplete information, the region where an agreement for outside finance is possible is narrowed from the area TSW to the area bounded by VUB in Figure 1.

FIGURE 1 ABOUT HERE

The participation constraints and the region in Figure 1 for which outside finance is feasible not only allow description, analytically and visually, of why complexity shrinks the region for a deal, they prompt further thought about the economics underlying the hypothesis about complexity and outside finance. In particular, the reduced form model here is an internally consistent one. Consider first, if the true π is π_0 and point A is below point S, one outcome would be for any investor to offer I in exchange for μ(A), meaning the μ that gives the investor zero expected profit if the probability of success is π_i. As a take-it-or-leave-it offer, this is acceptable to the entrepreneur. Why not settle for such an offer, rather than both parties wasting

[4] Note that the shape of the entrepreneur's participation constraint in Figure 1 results because the entrepreneur's expected return net of the return to the investor must exceed the cost of the entrepreneur's effort. Hence, given the gross return and the cost of effort, as the probability of achieving the gross return increases, the entrepreneur's expected net return increases and the constraint will be satisfied for higher levels of return to the investor.

energy in communicating to establish that π is really larger? Well, the investor's belief is π_i for a reason. The investor knows he might be facing an entrepreneur with a much lower probability of success, and the investor therefore may be very willing to expend a little effort to rule out some really low values for π and thus raise his belief about π before investing. Point B really is on a higher indifference curve for the investor than point A, and as long as this difference is enough to compensate the investor for the cost of listening (including the possibility of listening in vain, either to an entrepreneur with a bad idea or one with a good idea who will nonetheless fail to convey its virtues to the investor), then it is worthwhile to try listening. For the entrepreneur, motivation for costly communication comes from the chance to lower μ from $\mu(A)$ to $\mu(B)$. The second consideration is that the model is for a market-clearing μ that could potentially be determined in a sophisticated way with either favorable selection (higher μ drives away all but the highest-π entrepreneurs where M is about the same for all) or adverse selection (higher μ attracts entrepreneurs with lower π and higher M, but with lower πM). But what allows us to sidestep the possible effect of μ on the self-selection of entrepreneurs? Our assumption is that we have a large pool of potential investors, all pretty much identical and competitive with one another. But we still take each entrepreneur and idea as unique, rather than part of a large pool whose members see the prevailing μ and decide to accept I on those terms or not. Given the special characteristics of each entrepreneur, all the investors reach roughly the same prior: a distribution over values of π such that if they had to set μ they would set it at $\mu(A)$. Yet, any one of them would prefer not to do that but instead, if given the chance, to communicate with the entrepreneur to get a better idea of the true value of π before committing funds. One investor gets the chance with each productive idea, and if communication is sufficiently successful then the idea is funded. In this telling, the more complex (still productive) ideas will more often fail to attract funding because communication is more difficult and costly, and therefore is not tried as often and fails more often when it is tried.

The greater the complexity of the entrepreneur's idea, the farther apart the entrepreneur and the potential outside investor will be in their beliefs about π and the more costly it is to change the investor's belief. In terms of our description of the complexity of the entrepreneur's idea, on the one hand, the absolute number of solutions increases with complexity, and so there is a greater likelihood that the entrepreneur and the investor would be envisaging very different solutions to the R&D problem faced in bringing the idea to commercialization. On the other hand, the greater the complexity of the idea, the smaller the proportion of the sample space for R&D outcomes that have the necessary consistency among the components of the innovation embodying the idea. As a result, the likelihood is greater that the potential investor will be thinking about the very large proportion (approaching 1.0 as complexity increases) of the sample space where the development project fails, and convincing the investor that the probability of success is sufficiently large will be more difficult. The investor is more likely to envisage unsuccessful outcomes.

One way—and the way that we have emphasized—that an entrepreneur's idea can be more complex is when it brings together multiple technologies.[5] The typical investor might understand one technology fairly well, but communication becomes difficult when it gets into second, third, or fourth technology areas that are outside the investor's area of expertise. The communications problem here could be along the lines in Caillaud and Tirole (2007) where here the entrepreneur would face the task of first explaining the relevant facets of the technology with which the investor is most familiar, and then after receiving that information, the investor is willing to invest the effort to try and understand the second technology with which the investor is less familiar. After understanding the second technology, the investor may be willing to listen to information about a third technology that is even less familiar, and so forth.

Figure 2 illustrates the effect of the complexity of the entrepreneur's idea on the set of projects for which agreements about outside finance can be negotiated. As discussed above, there is common ground for agreement when $(M - (e/\pi))/I \geq (1 + R(\pi))/\pi$. Rearranging, agreement requires a project for which $\pi \geq (\mathrm{e} + I(1 + R(\pi))/M$. Thus, the set of projects—for which outside finance is feasible—is described by the area in the M-π plane that lies above the curve $(e + I(1 + R(\pi))/M$ and below the horizontal line for $\pi_0 = 1$. Greater complexity makes communication between the entrepreneur and investor more costly because the investor begins with a lower prior for π, relative to the true value π_0, which is the entrepreneur's private information. Because communication is more costly, the curve $(e + I(1 + R(\pi))/M$ shifts upward,

[5] The aspect of complexity that we have emphasized is focused on the complexity of the R&D problem itself—the problem for which the early outside finance is required—and multiple technologies will be a natural source of complexity. Yet even with a single technology, the resources necessary for development may come from multiple sources and thereby introduce complexity, although such complexity on the logistical side of development may not cause the communications problems we describe. More generally, complex entrepreneurial ideas will also entail complexity on the innovation side of the progression from R&D to commercialized technologies. For example, multiple commercial applications of the new technology might be envisaged, and such complexity might well make it more difficult to obtain outside financing even in the post-R&D period.

for example to the curve CD, and the area above the curve and below the horizontal line for π_0 = 1 shrinks.

FIGURE 2 ABOUT HERE

Our discussion of the difficulties faced by an entrepreneur seeking early outside finance is consistent with either risk or uncertainty in the sense of Knight (1921) as discussed in the context of the SBIR program by Link and Scott (2010, p. 190). Our discussion of the R&D sample space does not assign probabilities to the possible outcomes; our arguments about communications difficulties—because the absolute number of consistent outcomes is large and because the proportion of the sample space with consistent outcomes is small—depend only on the description of the sample space and not on associating each possible outcome with a specific probability. Our discussion of the expected returns for the entrepreneur and the outside investor do use expected values, and those expected outcomes of course associate probabilities with commercial values for possible outcomes for the R&D project. With risk, the probabilities are from either classical or empirical (frequency) perspectives of risk. With uncertainty, we must work with subjective probability—in the most extreme case, with completely diffuse priors (hence, uniform distributions for the set of possible outcomes).

III. The Sample, Data, and Variables.

For our sample and data, we use a special data set of SBIR projects that is especially well-suited to test the hypothesis about the complexity of the entrepreneur's idea and the use of outside finance. We use the sample and basic data in Scott (2000a), and for our hypothesis test, we will add a variable to measure the complexity of the entrepreneurial projects studied in that paper and show its effect on the findings in the earlier paper. The data set used in Scott (2000a) is a subset of the SBIR data gathered by the National Research Council (NRC) of the National Academies in 1999 for a study of the SBIR projects sponsored by the Department of Defense (DoD).[6] The data set is special in two ways that make it ideal for testing our complexity hypothesis.

The data provide information about the entrepreneurs supported by the SBIR program who had received early outside, third-party funding before their Phase II R&D. Such outside

[6] The NRC study and the master data set are described in Wessner (2000) and in Audretsch et al. (2002).

finance designated the firm as having “Fast Track” status in the DoD SBIR program; DoD gave Fast Track firms priority in funding their Phase II R&D. Such outside finance is arguably the key to subsequently getting others to assume the various entrepreneurial roles identified by Hébert and Link (2009, pp. 100-101)—not just the financier’s role, but the others as well. The 1999 NRC SBIR data set also provides information about the various technologies—up to six different ones—associated with each project, and that information is used to provide our new complexity measure that we add to the data set used by Scott (2000a) to explore the probability that a project would attract early outside third-party finance for the Phase II research to be supported additionally by the SBIR program.

The 76 DoD SBIR projects in the data set for this paper are the subset of the NRC study’s projects that were studied in Scott (2000a); these 76 projects are the DoD SBIR projects that are in the NRC study *and* that began in 1996 *and* that were continued into the substantial second stage of funding by DoD *and* not dropped by the performing firms and for which all of the variables used in Scott (2000a) were available. In Scott (2000a), the sample that is used in the present paper was used to study the circumstances in which substantial outside financing was obtained before the beginning of the Phase II R&D work to develop the entrepreneurial idea.[7] This paper begins with the empirical model specified in Scott (2000a) and adds one variable to that model—namely, a variable to measure the complexity of the development project to commercialize the entrepreneur’s idea.

The variable to measure the complexity of each entrepreneurial project is the number of *broad* technology areas associated with the project. For the 1999 NRC study of the SBIR program, each of the DoD’s SBIR projects were associated with up to six technologies by the Small Business Administration. These were chosen from several different technologies within each of seven broad technology areas: computer, information processing and analysis; electronics; materials; mechanical performance of vehicles, weapons, and facilities; energy

[7] Our DoD sample is certainly special, but appropriately so. It is well-suited to our hypothesis—namely a sample of R&D projects at small businesses engaged in an entrepreneurial effort to introduce R&D-based technological change. Further, although one can estimate well a model of response to the NRC SBIR survey, controlling for the response is not important for estimating the probit model of substantive interest with the DoD sample because the correlation of the errors in the response model and the model of substantive interest is not significantly different from zero. Results are essentially the same with or without control for selection into the sample. See, for example, Link and Scott (2009, p. 271, p. 274) and Gicheva and Link (2013, p. 207). For an explanation of the absence of selection bias when the error in the equation that determines the sample selection is uncorrelated with the error in the equation of primary interest, see Greene (2012, pp. 872-876).

conversion and use; environment and natural resources; and life sciences. Our measure of the complexity of the entrepreneur's idea is the number of different *broad* technology areas, including the project's primary broad technology area, associated with the entrepreneur's project. Thus, if a project is associated with five different technologies, but those five different technologies fall within just two of the seven broad technology areas, the measure of complexity is 2, while for a project that is associated with just three different technologies, but with all three in different broad technology areas, the measure of complexity is 3. The measure is especially good with the Caillaud and Tirole (2007) story about communications difficulties. Yet it also fits with the story about the R&D sample space and the consistency of the components of the new technology developed in the SBIR project. For example, environmental technology is primary for none of the projects in our sample, yet it is associated with 14.5% of those projects. Adding a technology adds dimensions along which each component must be consistent—for example, emissions dimensions for environmental technology.

In addition to the measure of complexity, the model controls for whether or not the company had previously won a Phase II SBIR award and hence would require more outside support to achieve Fast Track status. The government's matching requirements were more generous to the firms that were new to the SBIR program. For the new firms, less of the total R&D investment was required to come from the third-party investor. A lower probability of outside finance for projects at firms with previous awards is expected, other things being the same, because with less of the investment bill picked up by the government, the expected rate of return to the private investor is less. Other things being the same, a project at a firm with a previous award would require more private investment funds to reach the total amount invested. Yet it would have the same stream of future returns as an identical project at a firm that was new to the SBIR program and therefore needed less private investment dollars because the government would provide more of the total R&D investment. A lower probability of outside finance would also be expected if the firms with previous awards were engaged in research with less commercial potential than the new firms attracted to the SBIR Program by the Fast Track initiative. Knowledge of the previous awards may reduce the information asymmetry between the entrepreneur and the outside investor. Although better information might make outside finance more likely, if commercial potential is less, better information could serve to reduce the prospects for outside finance.

In addition to controlling for the complexity of the entrepreneur's idea and for whether or not the small business performing the SBIR R&D had received previous SBIR awards, the model controls for whether or not the firm's founders had a business background and for whether or not the firm was minority-owned. Apart from the effects associated with the complexity of the entrepreneurial idea, with previous Phase II awards, with founders having a business background, and with minority ownership of the small business, the model controls for the geographic areas of the entrepreneurial small businesses and also for the primary technology associated with the R&D project to develop the entrepreneur's idea.

Table 1 provides the descriptive statistics for the variables used to test the hypothesis about the complexity of the entrepreneur's idea.

TABLE 1 ABOUT HERE

IV. The Hypothesis Test.

To test our hypothesis that more complex innovative ideas will make it more difficult for an entrepreneur to secure early outside finance, we add our new complexity variable to those in the specification in Scott (2000a) and observe that more complex projects are less likely to secure outside finance at the early stages of developing the entrepreneur's idea. Table 2 shows the results of estimating the probit model.[8]

TABLE 2 ABOUT HERE

As complexity increases, the probability of obtaining outside finance falls as hypothesized, although the effect is not quite significant at conventional levels for the two-tailed tests. For one-tailed tests, the effect is significant at the 8% level in the first specification and at

[8] Gicheva and Link (2013) show that among the SBIR projects funded by the National Institutes of Health (NIH), whether or not a woman owns the firm receiving an SBIR award is another qualitative variable that is an important determinant of whether the firm can obtain outside finance to support the development of their SBIR-funded technology as it becomes an innovation. They find that women-owned firms are less likely to obtain such outside finance. They provide and explain (p. 202) two reasons that the importance of women-owned firms is more likely to be detected in the NIH sample than in the DoD sample of SBIR projects. Indeed, adding to our model the qualitative variable to indicate women-owned firms shows that the variable is insignificant for our sample of DoD SBIR projects, and the results (available as supplementary materials in Scott and Scott, 2015) that we find in Table 2 are essentially the same.

the 6% level for the second. To see the magnitude of the effect, consider first a high probability case and then a lower probability case.

Other things being the same, SBIR projects in computer technology and performed in the west for the Army have a high probability of securing outside third-party finance before the R&D work of Phase II begins. Consider the impact of the complexity of an entrepreneur's idea on that high probability. Using the first specification, the probit index for a project performed in the west for the Army with primary technology in computers and performed by a small business with no prior SBIR awards, no founders with business background, and not having minority ownership is given by 2.62 – 0.350(*Complexity*). The probit index equals 2.27 when *Complexity* takes its smallest observed value of 1; the index decreases to 0.870 when *Complexity* takes its largest observed value of 5. Thus, with F(z) denoting the cumulative normal probability for the standard normal variable z, the predicted probability that the entrepreneur secures early outside third-party finance to support the SBIR project is F(2.27) = 0.99 for an idea that is not complex, but that probability falls to F(0.870) = 0.81 for a very complex idea. If instead the second specification that finds a larger penalty for complexity as complexity increases is used, the probit index for the project illustrated would be $2.23 - 0.0588(\textit{Complexity})^2$. Thus, with this specification, the probit index equals 2.17 when *Complexity* takes its smallest observed value. When *Complexity* takes its largest observed value, the index is 0.76. The second specification then predicts that in going from the projects with the least complex entrepreneurial ideas to those with the most complex ideas, the probability of early outside third-party finance for the projects falls from F(2.17) = 0.985 to F(0.76) = 0.776.

In contrast to projects performed in the west for the Army, SBIR projects performed in the northeast for DARPA, but otherwise having the same characteristics as described for the Army project just described, have a low probability of securing outside third-party finance before the R&D work of Phase II begins. Using the first specification, the probit index for a project performed in the northeast for DARPA with primary technology in computers and performed by a small business with no prior SBIR awards, no founders with business background, and not having minority ownership is given by 2.62 – 0.977 – 2.18 – 0.350(*Complexity*). The probit index equals – 0.887 when *Complexity* takes its smallest observed value of 1; the index decreases to – 2.29 when *Complexity* takes its largest observed value of 5. The predicted probability that the entrepreneur secures early outside third-party finance to support the SBIR project is

F(– 0.887) = 0.188 for an idea that is not complex, but that probability falls to F(– 2.29) = 0.0110 for a very complex idea. If instead the second specification that finds a larger penalty for complexity as complexity increases is used, the probit index for the project illustrated would be 2.23 – 1.00 – 2.21 – 0.0588(*Complexity*)^2. Thus, with this specification, the probit index equals – 1.04 when *Complexity* takes its smallest observed value. When *Complexity* takes its largest observed value, the index is – 2.45. The second specification then predicts that in going from the projects with the least complex entrepreneurial ideas to those with the most complex ideas, the probability of early outside third-party finance for the projects falls from F(– 1.04) = 0.149 to F(– 2.45) = 0.00714.

The estimated primary technology effects and the estimated agency effects may be in part because of complexity of the underlying projects' ideas, and that part of the impact of complexity may be distinct from what our variable for complexity captures. If so, the effect of complexity in the preceding predictions will underestimate the importance of the complexity of the entrepreneur's idea.

The impacts of the other control variables are qualitatively the same as found in Scott (2000a). The expected negative impact (discussed in the preceding section) of prior SBIR awards to the entrepreneurial firm is present. When the entrepreneurial firm has business founders, the probability of securing outside finance is greater, perhaps because of their previous experience their entrepreneurial firms appear less risky to outside financiers. The probability of securing outside, third-party finance is less for small businesses with minority ownership. These effects are discussed in Scott (2000a).

Thus, complexity of the entrepreneur's idea can reduce the probability of getting outside finance early in the development of the idea's commercial potential—in particular, at the end of a SBIR project's publicly-funded early Phase I trial to examine potential for the idea and before the R&D in Phase II begins. But then, after Phase II has developed the idea to the point where it is ready to become an innovation, some of the small entrepreneurial firms arrange to have other firms play many of the roles identified by Hébert and Link (2009, pp. 100-101) that have been associated with the entrepreneur.

For the probit model in Table 2, the 76 entrepreneurial projects are observed at the end of their Phase I trials and before the beginning of the R&D in Phase II, and at that time the projects that were able to obtain outside, third-party financing were identified. After Phase II has developed the entrepreneur's idea, the NRC data set allows another look at the projects, and some have by that time finalized agreements to hand off some of the roles to outside firms. But just some of the entrepreneurial projects have such agreements; many entrepreneurs are still playing all of the roles—wearing all of the entrepreneurial hats—associated with the further development, production, marketing and distribution of the innovation that results from the entrepreneur's idea. The NRC data set shows whether or not each of the 76 projects had finalized any agreements with other firms either for licensing the technology developed from the entrepreneur's idea, or for sale of the technology or the rights to it, or for joint ventures using the technology, or for manufacturing or marketing or distribution of the commercialized product resulting from the developed idea.

We have shown an effect of complexity on the probability of getting the critical outside finance at an early stage, and we suggested that getting that outside finance may be a key to securing other outside assistance in the various roles beyond providing the idea. All of the entrepreneurs for the 76 projects provide the idea for an innovation, and all play the role of performing the R&D, but after the Phase II development, some are able to pass off roles to other firms through agreements. Now does it turn out that not getting the outside finance early in the development of the entrepreneur's idea inhibits the entrepreneurial small business's ability to get other firms to take on these roles? Put differently, does getting early outside finance confer an advantage in securing additional help after the performance of the R&D in Phase II? The answer may be yes.

Consider the null hypothesis that whether a SBIR project had obtained outside, third-party finance before the beginning of its Phase II R&D project is unrelated to whether it has any agreements for post-Phase II development, production, marketing and distribution. There were 11 of the 76 projects that had such agreements; for 65 of the projects the entrepreneurs were still "wearing all the entrepreneurial hats." Table 3 provides the descriptive statistics for the qualitative variable *all hats* that takes the value 1 if the project has no finalized agreements with other firms for further development, production, marketing and distribution of the innovation resulting from the SBIR project, and takes the value 0 if the project does have one or more finalized agreements.

TABLE 3 ABOUT HERE

Table 4 reports the probit model of the probability that a project with early outside finance will be less likely to have no finalized agreements with other firms—i.e., to be one where the entrepreneur is wearing all the hats. The first specification estimates the probit model with *fast track* as the explanatory variable. For that specification, the null hypothesis is rejected at better than the 10 percent level of significance for a two-tailed test—even after their Phase II development, projects that received early outside financing are less likely than the other projects to have the entrepreneur wearing all the hats—i.e., more likely than the others to secure the help of other firms for the further development, production, marketing and distribution of the innovation resulting from the entrepreneur's idea. Of the 76 entrepreneurial projects, all begun in 1996, there were 65 of the projects that had not finalized agreements with other firms when the projects were observed in 1999 after Phase II development would have resolved the complexity of the entrepreneur's idea if the entrepreneur's belief that resolution would occur was accurate. For those projects, the entrepreneurs were still wearing all the hats—playing all the roles—for the additional development, and from the first specification of Table 4 it appears that even after the important Phase II R&D, early outside finance is associated with an advantage in the process of obtaining outside assistance with the various roles that must be played for a successful innovation.[9]

TABLE 4 ABOUT HERE

Our finding here complements and strengthens the finding of Link, Ruhm, and Siegel (2014). They find, using the sample of NIH projects used by Gicheva and Link (2013), that when SBIR firms have attracted private equity investments, they are more likely to have agreements with other firms to license or sell the rights to the technology developed with the SBIR project or to have collaborative R&D agreements with other firms. Because our earlier 1999 NRC DoD SBIR data set has the information about whether the SBIR firm obtained early outside finance for its project, we can ask if obtaining the early outside support before the Phase

[9] As Klein et al. (2014, p. 68) observe, ". . . in entrepreneurial ventures, suppliers of finance may also influence access to and the nature of human and social capital resources." That is important for success. As some of the entrepreneurs in the SBIR sample (that we have used in this paper) emphasized (Scott, 2000b, pp. 125-127), their success depended on obtaining outside help with the business aspects of innovation—marketing, finance, management, and business administration in general.

II R&D begins is associated with success in obtaining commercial agreements with other firms after the Phase II results are known. Thus, finding that early outside finance is associated with obtaining further outside help for commercializing the Phase II results complements the finding of Link, Ruhm, and Siegel (2014) that commercial agreements with other firms are more likely if the NIH SBIR firm has private-equity finance for the development of the technology developed in its Phase II R&D. Our finding strengthens theirs because it shows an effect for outside finance that was obtained before Phase II R&D began rather than outside investments that may have been obtained when the Phase II results show a good result. Entrepreneurs in our SBIR sample observed (Scott, 2000b, p. 128) that it is far easier to get outside investments once the Phase II research results are available. In our sample, the evidence supports the inference that failing to get outside finance *early* reduces the likelihood of getting other agreements even after the results of the Phase II research are observed.

However, while the fast-track status clearly indicates that early outside finance has been obtained, it may also be associated with other aspects of the project that we do not observe. For that reason, we present in Table 4 an additional specification that replaces the qualitative variable *fast track* with the prediction from Table 2's probit model of the probability of early outside finance.[10] With that very conservative specification, using just the prediction of the probability of early outside finance rather than the binary qualitative variable indicating the presence of such early outside finance, the sign of the relation is the same, but the relation is far from significant—for a one-tailed test it would be significant at just slightly better than the 20% level. Comparing the predictions of the two specifications, the first shows a probit index of 1.36 – 0.632(0) = 1.36 or a probability of 0.913 that for a project without early outside finance the entrepreneur will be wearing all the hats, as compared with the index for a project with early outside finance of 1.36 – 0.632(1) = 0.728 or a probability of 0.767 that the entrepreneur will be wearing all the hats. Using the second specification, the explanatory variable is the predicted probability of early outside finance. For the 76 observations, that variable had mean 0.394 and standard deviation 0.326 with a range from 0.00184 to 0.964. So, using the second specification, the predicted index function for a project with the lowest probability of early outside finance is 1.26 – 0.486(.00184) = 1.26, and the probability that the entrepreneur wears all the hats is 0.896.

[10] Table 2's first specification is used; the second specification gives essentially the same results. If the predicted probit index function is used in place of the predicted probability, the results are also essentially the same.

For a project with the highest probability of early outside finance, the index function is 1.26 – 0.486(0.964) = 0.791, and the probability that the entrepreneur wears all the hats is 0.786.

Using the binary qualitative variable and the first specification of Table 4, having early finance drops the probability that the entrepreneur wears all the hats from 0.91 to 0.77. Using the predicted probability of early outside finance, having the highest probability of early finance drops the probability of no finalized agreements from 0.90 for the project with the lowest probability of early outside finance to 0.79. Although all significance is lost when using the instrument, the difference in the probability is narrowed only slightly, so the result suggests that if there are factors that we cannot observe that influence both early and later investment, their effects are not explaining much of the observed change in the probability. Even when the effect of those factors are swept out, there remains an effect of early investment on later investment that can be explained by later potential investors seeing a positive signal in the early investment.

Our theory and empirical approach, in addition to explaining the pattern of early investment, suggests a strategy for identifying the pure signaling effect of early investment on later investment. If obtaining outside finance before performing R&D (SBIR Phase II) is correlated with obtaining post-R&D agreements, then an interesting question is why. Or, rather, there are both interesting and uninteresting aspects of why, and what is really interesting is to disentangle these. On the uninteresting side, it is very natural to think that there are attributes of projects (that we cannot observe but that are observed by, or at least influence the behavior of, parties to the agreements) that affect the probability of both pre-R&D outside finance and post-R&D commercialization (licensing, sale, joint ventures, etc.). What is interesting is the balance of the influence, the extent to which pre- and post-R&D agreements are still correlated after controlling for all the unobserved factors—interesting because it is evidence of a signaling value of early outside investment, which is evidence of asymmetric information having economically meaningful effects.

What is needed then is an instrument for the pure signaling value of the early outside financing. And here our theory of complexity becomes more than an intuitive story about why more complex ideas would have greater difficulty in securing funding. The value of our theory is that it is specific to the pre-R&D stage. After R&D has been performed, the difficulties specific to the complexity of the technology have been resolved; the remaining information asymmetries will be related to other aspects. Therefore, the complexity of the technology should affect the probability of *post*-R&D agreements *only* through its effect on *pre*-R&D agreements, making our broad-technology-area proxy of complexity a suitable instrument for the early agreement.

To put it another way, the communication leading to the pre-R&D agreement, to be successful, must overcome the difficulties related to complexity *and* some other difficulties that are not related to complexity. When it comes to post-R&D agreements, outside potential parties (1) do not care any more about complexity because the outcomes of the R&D render that aspect of information asymmetry moot, (2) care about some things that we cannot see but that are immediately evident to those involved and relevant at both pre- and post- R&D stages (that is why we cannot just look at a correlation between getting early funding and striking a post-R&D agreement), and (3) care about things they cannot observe but which they know would have been relevant at the pre-R&D funding stage also, and so they take the very existence of a pre-R&D agreement as a good sign and so tend to favor projects that received early outside funding.

V. Conclusion.

Private-sector venture capitalists that specialize in funding high-technology R&D will have expertise for evaluating entrepreneurial ideas, but their expertise may be rather narrowly focused. To the extent that it is difficult for an entrepreneur to find in one potential investor both deep pockets and the knowledge of multiple technology areas, ideas that span multiple technology areas will have greater difficulty attracting outside funding in the private sector (compared with ideas of equal social value that are focused on a single technology area and therefore easier for the venture capitalist to evaluate), leading to an under-funding of technology-spanning ideas. In the context of publicly-subsidized support of entrepreneurial innovation research as in the SBIR program, a funding mechanism via public-private partnership may be able to improve efficiency by putting together panels of reviewers qualified to evaluate entrepreneurs' technology-spanning ideas. Our results suggest at least the possibility that recognizing a larger proportion of productive investments at the early stage in this way could have the additional positive impact of helping such investments to obtain subsequent support (through licensing, sale, joint venture, or other means) toward successful commercialization.

Additionally, our paper may serve to motivate discussion of strategies that entrepreneurial firms could use to help investors evaluate the commercial prospects for complex R&D projects—institutional steps that a firm could take to decrease the level of knowledge needed to make an investment decision and thereby decrease the importance of the investor's perception of the complexity of the R&D project. For example, one strategy that could have the desired effect, sending a reassuring signal as well as information to the investor, might be to have a university as a research partner. However, working with universities can introduce its own set of problems (Hall, Link, and Scott, 2001, 2003), and appropriate firm strategies may need to be augmented with technology-spanning panels of reviewers in public-private partnership. Yet, much remains to be done to establish conclusively whether or not the complexity of the entrepreneurs' ideas is important for investors' decisions about investments in developing the ideas. Future research can examine new samples and additional measures of complexity and additional control variables.[11]

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[11] For example, with larger samples, the Census regions could be replaced with more detailed geographic breakdowns that allow better control for effects of the economics of agglomeration, and complexity toward the innovation-end of the path from invention through R&D and then commercialization could be measured.

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Table 1. Descriptive statistics[a]

Variable	Mean	Standard deviation
Fast track	0.395	0.492
Complexity	3.54	0.840
Prior Phase II SBIR	0.579	0.497
Business founders	0.474	0.503
Minority ownership	0.145	0.354
Primary technology[b]		
Computers	0.276	0.450
Electronics	0.553	0.501
Materials	0.0132	0.115
Mechanical	0.0526	0.225
Energy	0.0921	0.291
Environment	0.0[e]	0.0
Life Sciences	0.0132	0.115
Agency[c]		
Air Force	0.263	0.443
Army	0.211	0.410
BMDO	0.289	0.457
DARPA	0.158	0.367
DSWA	0.0132	0.115
Navy	0.0658	0.250
Geographic area[d]		
West	0.408	0.495
Northeast	0.237	0.428
Midwest	0.0921	0.291
South	0.263	0.443

[a]The number of observations for each variable is 76. Except for the variable measuring complexity, all of the variables are binary (0-1) qualitative variables. The means for those variables, therefore, show the proportion of the sample with a given characteristic. Thus, 39.5 percent of the sample had Fast Track status because significant outside finance was obtained early in the research project; 14.5 percent of the projects were at minority-owned firms; 27.6 percent had computers as the primary technology, and so forth. Only one project had materials as its primary technology, and only one had life sciences as its primary technology. Only one project was assigned to the Defense Special Weapons Agency. The complexity variable, taken to be the number of different *broad* technology areas associated with the project, ranged from 1 to 5; there were up to 6 different technology areas to which a project could be assigned, and in our sample a given project was assigned to at most 5. Considering all of the technology areas associated with a project, 51.3% of the projects involved computer technology, 98.7% involved electronics technology, 96.1% involved materials technology (even though only one project had materials as its primary technology), 38.2% involved mechanical technology, 26.3% involved energy technology, 14.5% involved environment and natural resources technology (even though none of the projects had environment as its primary technology), and 28.9% involved life sciences (even though only one had life sciences as its primary technology). Note that these proportions of the projects that are associated with each particular broad technology are the means for the all-inclusive technology 0-1 variables that equal 1 whenever the particular technology (whether it is the primary technology or not) is associated with the project and equal zero otherwise. Those all-inclusive technology qualitative variables are used and summarized in Scott (2000a, p. 7). In contrast, this paper uses the technology qualitative variables

defined to equal 1 when the particular technology is the primary technology of a project. Further, observe that the sum for each project of the values taken by the all-inclusive technology qualitative variables is identically equal to our measure of complexity—namely, the number of broad technology areas associated with the project.
[b]Each project's primary technology is used to assign the project to a technology area. The technology areas are computer, information processing and analysis; electronics; materials; mechanical performance of vehicles, weapons, and facilities; energy conversion and use; environment and natural resources; and life sciences.
[c]The agencies are the Air Force, Army, Ballistic Missile Defense Office, Defense Advanced Research Project Agency, Defense Special Weapons Agency, and the Navy.
[d]The geographic areas are the U.S. Census Bureau Regions for the United States. The NRC data assigned each project to the U.S. state where it was located, and each state has been associated with its geographic region.
[e] No projects had their primary technology in environment and natural resources; however, 14.5 percent had that technology as one of the technologies associated with their development project.

Table 2. The probability of outside third-party finance early in the R&D: Probit model of Fast Track[a]

Variable	Coefficient (standard error) [p-value]	Coefficient (standard error) [p-value]
Complexity	– 0.350 (0.240) [0.144]	
(Complexity)^2		– 0.0588 (0.0371) [0.113]
Prior Phase II SBIR awards	– 0.621 (0.417) [0.137]	– 0.630 (0.422) [0.135]
Founders with business background	0.711 (0.390) [0.068]	0.665 (0.396) [0.093]
Minority ownership	– 1.25 (0.618) [0.042]	– 1.31 (0.629) [0.038]
Electronics	– 0.125 (0.478) [0.793]	– 0.155 (0.485) [0.750]
Mechanical	– 0.147 (1.06) [0.890]	– 0.184 (1.07) [0.863]
Energy	– 0.515 (0.941) [0.584]	– 0.570 (0.949) [0.548]
Air Force	– 1.66 (0.625) [0.008]	– 1.71 (0.635) [0.007]
BMDO	– 1.52 (0.580) [0.009]	– 1.54 (0.584) [0.008]
DARPA	– 2.18 (0.661) [0.001]	– 2.21 (0.669) [0.001]
Navy	– 1.31 (0.834) [0.116]	– 1.36 (0.834) [0.103]
Northeast	– 0.977 (0.553) [0.077]	– 1.00 (0.557) [0.072]
Midwest	0.313 (0.740) [0.672]	0.356 (0.745) [0.632]
South	0.0127 (0.563) [0.982]	0.0306 (0.571) [0.957]
Constant[b]	2.62 (1.11) [0.019]	2.23 (0.859) [0.009]
Number of observations	76	76
Chi-square (degrees of freedom)	38.8 (14)	39.3 (14)
Probability > chi-square	0.0004	0.0003
Log likelihood	– 31.6	– 31.4

[a]The estimates are for the coefficient of each variable in the probit index for estimating the probability of a project having Fast Track status—i.e., whether it obtains significant early outside finance.

[b]Left in the intercept are the geographic region West, the technology Computers, the agency Army, and the primary technology and agency qualitative variables that would predict perfectly because they had only a single observation with the characteristic. The qualitative variable indicating that the project's primary technology is environmental is omitted because none of the projects had the technology as a primary technology. The special-case variables with single observations (or none at all) for the qualitative characteristic are discussed in the notes to Table 1.

Table 3. The Proportion of the 76 Projects without Finalized Agreements—the Entrepreneurs Are Wearing All the Entrepreneurial Hats

Variable	Mean	Standard deviation
all hats	0.855	0.354

Table 4. The Probability that the Entrepreneur Wears All the Hats: Probit Model of *all hats*

Variable	Coefficient (standard error) [p-value]	Coefficient (standard error) [p-value]
Fast track	–0.632 (0.364) [0.083]	
predicted probability of early outside finance		– 0.486 (0.544) [0.372]
Constant	1.36 (0.262) [0.000]	1.26 (0.297) [0.000]
Number of observations	76	76
Chi-square (degrees of freedom)	3.07 (1)	0.80 (1)
Probability > chi-square	0.0797	0.371
Log likelihood	– 29.9	– 31.0

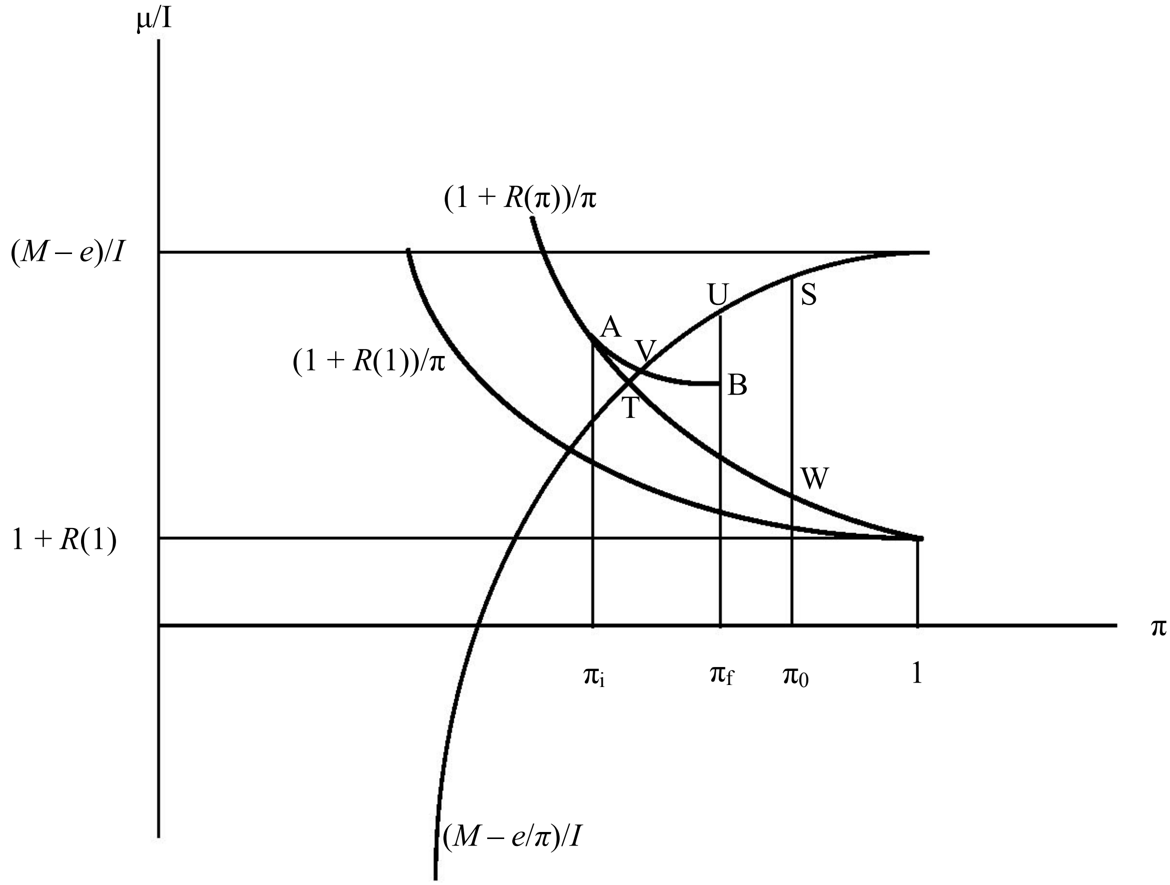

Figure 1. The entrepreneur's and the investor's participation constraints and the region for a successful deal for outside finance.

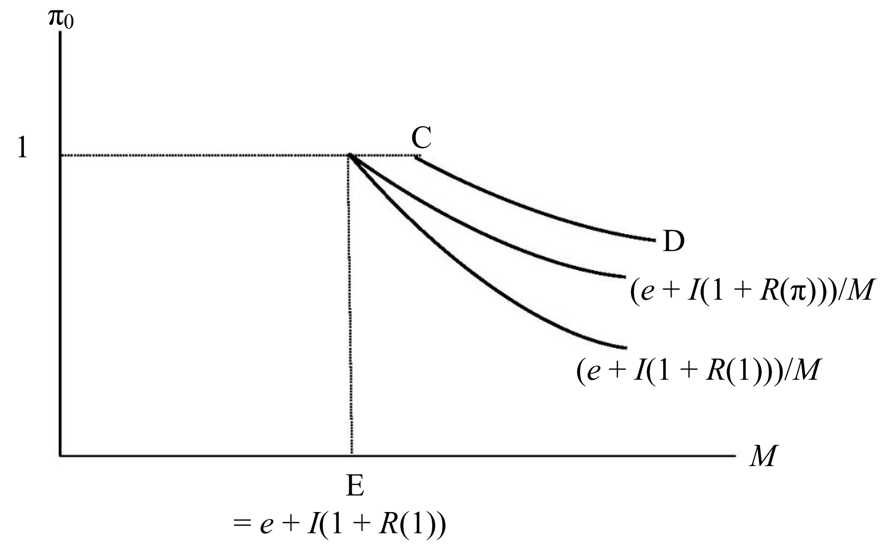

Figure 2. The effect of a more complicated idea on the set of projects (described by gross return and its probability) for which outside finance is feasible.