Leveraging Entrepreneurship through Private Investments: Does Gender Matter?

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Abstract

Using project data from a random sample of Phase II research awards from the National Institutes of Health SBIR program, we estimate the relative probability that woman-owned firms are able to attract private investments to fund the transition of the technology developed under the sponsorship of the SBIR program to an innovation to enter the market. We find that women-owned firms are as much as 16 percentage points less likely to attract private investment dollars compared to male-owned firms, factors excluding the size of the SBIR award held constant. Women-owned firms that received larger awards performed substantially better. Although the SBIR program has a legislated directive to increase the participation of woman-owned firms in the program, our findings suggest that it might not be sufficient to overcome market perceptions about the profitability of such investments actually bringing a developed technology to market.

Keywords: innovation, entrepreneurship, SBIR program, venture capital, gender discrimination
JEL codes: O31, L26, J16, G11

Leveraging Entrepreneurship through Private Investments: Does Gender Matter?

Half a league, half a league,
Half a league onward …
— Rudyard Kipling

I. Introduction

Most, if not all, technology-based entrepreneurial firms will enter the Valley of Death at some point during their growth.[1] After a new technology is created, often through public-sector support, the firm will find itself in need of financial capital to transform its creative ideas or inventions to innovations and ultimately to a commercializable product. When such capital is not available, the invention dies; when such capital is available to leverage the transition from invention to innovation, the entrepreneurial firm is positioned to enter a market and grow if successful.[2] This transitional funding generally comes from private investment sources, venture capital in particular.

Due to an underinvestment in the transitional research, not all firms bridge the Valley of Death. This underinvestment is due in part to an asymmetry of information between entrepreneurs and private investors. Some (e.g., Tassey 2010) have therefore argued that government has a role to help such firms bridge the valley because this asymmetry of information, and thus an inability of the private sector to accurately forecast expected returns, creates a barrier to the development of new technology. In fact, the Administration's recent report on reviving the U.S. manufacturing sector sets forth such a role to overcome this element of market failure, namely "to provide

[1] The term Valley of Death is generally attributed to Congressman Vernon Ehlers (1998, p. 40). Branscomb and Auerswald (2002) refer to the Valley of Death as the transition stage from science-based invention to commercial innovation during which venture capital is the primary alternative source of investment. According to Wessner (2007, p. 7): "The difficulty of attracting investors to support an imperfectly understood, as yet-to-be-developed innovation is especially daunting. Indeed, the term 'Valley of Death,' has come to describe this challenging transition when a developing technology is deemed promising, but too new to validate its commercial potential and thereby attract the capital necessary for its development."

[2] According to Schumpeter (1934, p. 78), the entrepreneur is the person who innovates, who makes new combinations in production: "everyone is an entrepreneur only when he actually 'carries out new combinations,' and loses that character as soon has he has built up his business, when he settles down to running it as other people run their business." Thus, bridging the Valley of Death is an entrepreneurial responsibility. See Hébert and Link (2006, 2009).

support to advance specific early-stage technologies that have transformative potential, but for which rational private actors will under-invest… ."(Executive Office of the President 2011, p. 18).

In this paper we focus on gender and alternative private investments in technology-based entrepreneurial firms. As such, we draw on two literatures to motivate the empirical focus of our analysis. The first body of literature relates to the role of gender in entrepreneurship and the second relates to gender and access to alternative private investments.

There is a rich literature on the role of gender in entrepreneurship. For example, previous research has shown that women are less likely to start a new business or to be self-employed than men (Blanchflower and Meyer 1994, Reynolds 1997, Blanchflower and Oswald 1998, Uusitalo 2001, and Link and Welsh 2001). Extending this literature, Fairlie and Marion (2010) show that affirmative action programs have led to an increase in women-owned firms in public procurement markets. Van der Zwan et al. (2001, p. 14) note that while women "are a valuable and untapped source of entrepreneurial diversity [who] can function as a role model for other females to engage in entrepreneurship," in some European countries females face barriers to starting new businesses.

There is also a rich literature on the role of gender on access to alternative private investments, especially to venture capital (VC) funds. Most of what is known about alternative private investments relates to the venture capital industry, its structure (e.g., National Venture Capital Association 2011) and its economic underpinnings (e.g., Gompers and Lerner 2004). In addition to industry-specific information, some stylized generalizations have been offered about the availability of venture capital to women in particular. One conclusion from the Diana Project is (Gatewood et al. 2009, p. 129):[3]

[3] The Diana Project, named after the Roman goddess of the hunt and thus symbolizing women's hunt for the rewards of entrepreneurial effort, was a multi-university research program to identify factors that support and enable high growth in women-led ventures. This project was funded by the Kauffman Foundation, the U.S. Small Business Administration, the National Women's Business Council, and the Swedish Institute for Small Business Research (Gatewood et al. 2009).

> Women's participation in the VC industry has not kept pace with industry growth, and women have exited the industry at a faster rate than men, thus creating a significant barrier for women entrepreneurs in that it is less likely that their networks will overlap with the financial supplier networks, despite any effort they many expend networking and seeking capital.

Wright et al. (2006) and Colombo et al. (2011) have studied access to venture capital by technology-based firms, but these firms were not necessarily nascent entrepreneurial ventures. Nascent technology-based firms, at least those in the United States, have relatively less access to VC funding than to other investment funds.[4]

Surprising, however, especially in light of the current policy forum and in the aftermath of the excitement of the Diana project, there is a conspicuous absence of systematic empirical information about the allocation of alternative investment funds to women-owned technology-based entrepreneurial firms, arguably the fastest growing group of entrepreneurial firms in the United States.

This paper advances this literature on an empirical level in several important ways. First, our empirical analysis focuses on technology-based entrepreneurial activity within small firms. Second, that activity is quantified at the project level, rather than at the more aggregated firm level, which dominates the literature. And third, we focus on access to alternative private investments, which do include VC but VC is rarely available among such firms.

We find that female entrepreneurs are substantially less likely to receive private investment funding, compared to similar male entrepreneurs. The difference is less pronounced when more information, prior government funding in particular, is available to potential investors. We also show that conditional on receiving private investments, female firm owners are likely to obtain less funding.

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[4]As Wessner (2008) has shown with regard to entrepreneurial firms in the United States funded by Small Business Innovation Research awards, the focal data in this paper, venture capital is an infrequently available source of alternative private investments.

In Section II, we posit a model of private investment to technology-based entrepreneurial firms, and we hypothesize correlates with the probability that a particular technology will attract such funding. We also describe our database of technology projects. It contains information on projects funded by the National Institutes of Health through a Phase II Small Business Innovation Research (SBIR) award. In Section III, we present and discuss our empirical findings. The paper concludes in Section IV with summary remarks.

II. Quantitative Analysis

A. Supply of Private Investment Funds

Gompers and Lerner (2004) argue that there are four factors that limit an entrepreneur's access to venture capital, or that guide venture capital investments. These include, with reference to a technology-based entrepreneur: uncertainty, asymmetric information, the nature of the firm's assets, and market conditions.[5]These factors also likely apply to any private investment in an entrepreneurial venture.

Briefly, uncertainty refers to the fact that there is an array of possible innovative outcomes from an entrepreneur's technology, and this imposes an element of uncertainty on the investor's calculus about the expected return on an investment. In other words, the less certain the investor about the specific innovation(s) that are likely to result from the entrepreneur's technology the less attractive the investment opportunity. Information asymmetry makes it difficult for private investors to determine who the more efficient entrepreneur is. Objective signals that facilitate the investor's ability to scrutinize independently the innovation potential of the entrepreneur's technology make the investment opportunity more attractive. In the event that the research output of the entrepreneur falls short of its innovation potential, a private investor will prefer to have invested in a firm with collateral tangible assets compared to only intellectual assets. And finally, market conditions, meaning the expected size and competitive condition in the market for the innovation, will influence the investor's investment decision.

Thus, we posit a simple probability model of the supply of private investment to a technology-based entrepreneurial firm as:

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[5] Gompers and Lerner (2004) also review the literature related to each of these factors.

(1) *Private Investment*$_i$ = $I(\mathbf{X}_i + u_{1i} > 0)$

where *Private Investment* is a dichotomous variable, **X** is a vector of project and firm characteristics, *I* is the indicator function, and $u_1 \sim N(0,1)$.

B. Small Business Innovation Research Program and Database

Equation (1) is estimated using project data on Phase II awards funded by NIH's SBIR program. The SBIR program was created in 1982 under the U.S. Small Business Innovation Development Act of 1982 with the following stated objectives: to stimulate technological innovation, to use small business to meet Federal research and development needs, to foster and encourage participation by minority and disadvantaged persons in technological innovation, and to increase private sector commercialization of innovations derived from Federal research and development (R&D).[6] The 1992 reauthorization of the program broadened the above objectives to emphasize the participation of woman-owned and -controlled firms.

Each government agency with an extramural research budget is required to set aside a portion (currently equal to 2.5%) of that budget to award to small (500 or fewer employees) U.S. firms (at least 51 percent owned by U.S. citizens or lawfully admitted permanent resident aliens) in response to requests for proposals on defined topics.

The structure of the SBIR program is defined by three phases: Phase I awards assist firms as they assess the feasibility of an idea's scientific and commercial potential in response to the funding agency's objectives; currently these are six-month awards for up to $100,000. Phase II awards assist firms to further their research with an expectation that the resulting technology will be commercialized; currently these are two-year awards for up to $750,000.[7] There are no agency awards in Phase III; it is the period of time when the funded businesses are to move their

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[6] For a theoretical justification of the role of the SBIR, see Link and Scott (2010, 2011).
[7] Being considered under the current temporary reauthorization of the SBIR program (to November 18, 2011 under H.R. 2608) are caps on Phase I awards of $150,000 and $1,000,000 on Phase II awards. These caps are effective under a March 30, 2010 amended SBIR policy directive initiated by the U.S. Small Business Administration. These caps are expected to be made when the program is reauthorized.

technology from the laboratory into the market place. The firm is expected to find private-sector funding (e.g., from private investors) during this period.

Eleven agencies currently participate in the SBIR program, with the Department of Defense (DoD) accounting for nearly 58 percent of all awards, followed by Health and Human Services' NIH with about 19 percent, and DOE with about 6 percent (along with the National Aeronautics and Space administration and the National Science Foundation with similar percentages). Currently, about $2 billion is allocated per year to Phase I and Phase II awards with nearly 98 percent accounted for by these five agencies.

As part of the SBIR program's reauthorization in 2000, the U.S. Congress charged the National Research Council (NRC) within the National Academies to make recommendations for improvements in the program. Among those evaluatory activities that the NRC undertook was an extensive and balanced survey in 2005 based on a population of 11,214 projects completed from Phase II awards during the 1992 to 2001 time period.

Projects funded by NIH are the focus of this study for two important reasons, the first being institutional in nature and the second being statistical pragmatism. First, firms that are funded through the larger DoD program and are successful in completing Phase II have a captive audience for much of their resulting technology, namely DoD (Link and Scott 2009; Nelson 1982). In 2005, the year of the NRC survey, nearly 40 percent of the technology developed by businesses through DoD Phase II awards was sold to that agency. And second, among the five agencies, NIH-funded firms are the most active in attracting private research investments, thus affording our empirical analysis not only a large number of project observations but sufficient variability in those projects that have and have not attracted such investment funds. See Table 1 for the data reduction process used to create the NIH sample of 323 Phase II awards studied herein ($i = 1 – 323$ in the specification of equation (1)).

C. Description of the Variables

The dependent variable, *Private Investment*, in equation (1) is a dichotomous measure that equals 1 if the firm received private investment funds to further its Phase II research project, and 0 if it did not. The dependent variable equals 1 if at least one of the following sources of private investment was received: U.S. venture capital, foreign investments, private equity, or other sources from private firms.

The focal independent variable in equation (1) is the gender of the firm's owner. *Female* equals 1 if the firm is majority owned by a woman, and 0 if it is majority owned by a man. There are at least three reasons for emphasizing the gender of the firm's owner. As mentioned above, the 1992 reauthorization of the SBIR program broadened its focus to emphasize the participation of women-owned and -controlled firms: "to provide for enhanced outreach efforts to increase the participation of … small businesses that are 51 percent owned and controlled by women." One might speculate that this broadened *per se* focus could result in Phase I and then Phase II projects being funded with less commercial potential than otherwise would have been the case. If so, a signal to this effect, as related to this paper, could be the observation that female-owned firms have greater difficulty in attracting private investment funds in a competitive market than male-owned firms at the same stage of technology development.

A second reason for our emphasis on the female/male ownership difference stems from the literature on risk taking. As reviewed by Croson and Gneezy (2009), and recently confirmed for example by von Gaudecker et al. (2011), economic experiments show that women are more risk averse than men in both laboratory settings and in their investment decisions.[8] To the extent that this is true, it might be the case that female-owned firms are less likely to make the necessary strategy and/or investment decisions that could be necessary for the entrepreneurial firm to take its technology to commercialization.[9] As such, gender *per se* might send a precautionary signal to private investors.

And third, it has been suggested that there is a degree of discrimination against female entrepreneurs seeking financial investments (Marlow and Patton 2005). Relatedly, network

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[8] See also, Levin et al. 1988; Johnson and Powell 1994; Barsky et al. 1997; Jianakoplos and Bernasek 1998; Sundén and Surette 1998; and Borghans et al. (2009). Schubert et al. (2009) present findings that question the prevalence of such a gender-specific risk attitude. But, the research in the field of psychology shows that men and women are equal in terms of their innate creativity (Baer and Kaufman 2008).

[9] This lack of risk taking could be related to a lack of self-confidence, and Brana (2011) discusses the latter in the context of gender and entrepreneurial ventures.

theory suggests that individuals associate with others who are similar to themselves (Aldrich 1989; Ruef et al. 2003), and the venture capital industry, as one example, is male dominated and homogeneous.

We thus predict, in the context of equation (1), that female-owned firms will have a lower probability of attracting private investments than male-owned firms, *ceteris paribus*. However, a counter argument could be proffered following Gompers and Lerner (2004). If women take on less risk then the outcomes of their entrepreneurial venture are less uncertain and therefore, at the margin, more attractive to a private investor.

Also, held constant in equation (1) is the size of the Phase II award, *Award*. If receipt of a Phase II award sends a signal to the private investment market that the research has been screened at least twice (it cleared the Phase I and Phase II review hurdles)in terms of its commercial potential, then perhaps the larger the award the greater the likelihood of commercial success, *ceteris paribus*, and the more likely that the firm will be able to attract private investment support.[10] An interaction term, *Award·Female*, is also included to test for gender differences in the perceived potential success associated with having received a larger Phase II award.

Not all Phase II research projects were completed at the time of the NRC survey in 2005. *Complete Phase II* equals 1 if the project was completed, and 0 otherwise. As with *Female* and *Award*, this variable measures uncertainty; those projects that have been completed (i.e., are less uncertain) are more likely to attract private investment funds, *ceteris paribus*, because more is known about the portfolio of actual outcomes from the research.

Also mitigating a private investor's concern about leveraging a Phase II project's technology in Phase III is if the firm had previously been able to attract private investment funds for other projects related to the technology of the current project, *Prior Private Invest*. This variable

[10] This argument suggests that one should compare the probability of a research project being supported by private investment between projects funded and not funded by SBIR. While a matched pairs analysis would be interesting, such data are not available in the NRC database, and may not be available at all. Although Lerner (1999) has compared a large sample of SBIR awardees and matching firms, finding that the SBIR recipients have higher employment growth, Lerner and Kegler (2000, p. 321) explain that it is difficult with the matched pairs analysis "to disentangle whether the superior performance of the awardees is due to the selection of better firms or the positive impact of the awards."

equals 1 if such prior support came from a private investor, and 0 otherwise. *Ceteris paribus*, firms with prior success in attracting private investments in support of their research should have a greater likelihood of attracting additional funding.

Lastly, Census-defined regional binary variables are included to control for regional differences in the availability of private investment funds, venture capital funds in particular (National Venture Capital Association 2011): *Northeast*, *Midwest*, and *South*.

The above variables are defined in Table 2 and descriptive statistics are presented in Table 3.

A potential empirical concern in the estimation of equation (1) is selection bias resulting from the relatively low response rate.[11] This possibility was considered by estimating equation (1) as a probit model with selection simultaneously with a probability of response model of the form:

(2) $Response_i = (Age_i \cdot \gamma_1 + Award_i \cdot \gamma_2 + u_{2i} > 0)$

where $u_2 \sim N(0,1)$ and $corr(u_1, u_2) = \rho$. *Age* measures the number of years since the Phase II award was received. Absent a theoretical argument for why some firms responded to the NRC survey for a particular project, we hypothesize that the older the Phase II award the less institutional knowledge that still exists about the project and thus the less likely the firm would be able to respond. Also held constant in equation (2) is the size of the Phase II award, *Award*. We hypothesize that the larger the award the more likely the firm will have responded to the survey perhaps as a *quid pro quo* for receiving a future Phase II award.

III. Empirical Findings

Table 4 presents the probit results for several specifications of equation (1) with controls for selection. The reported coefficients are average marginal effects from a maximum-likelihood

[11] There are 1677 projects in the full NIH random survey population, of which 495 (29.5%) respond to the survey and 323 (19.3%) are used to estimate equation (1) (see Table 1).

probit model with sample selection. The standard errors are clustered by the NIH agency that funded each project.[12]

The parsimonious specification in column (1) controls only for the gender of the owner, if the Phase II project has been completed, and regional dummies. The results suggest that female-owned firms are nearly 16 percentage points less likely to obtain private investment funding (significant at the 0.05 level) compared to male-owned firms. The magnitude of this estimate is large; the descriptive statistics in Table 3 show that only 19 percent of firms in the sample obtained private investment funding after the Phase II award. This result confirms our initial prediction above, the Gompers/Lerner caveat aside. Also as expected, the coefficient on *Complete Phase II* is positive and significant (0.10 level). Firms that completed their projects are 11 percentage points more likely to obtain private funding for Phase III, *ceteris paribus*.

Award and *Award·Female* are in the specification in column (2). Presumably, the way in which private investors use the information conveyed by the amount of the award is different depending on the gender of the firm's owner. The estimated marginal effect for *Award* is close to zero and not statistically significant, whereas the marginal effect of the interaction between *Award* and *Female* equals 0.3693, and it is significant (0.10 level). The coefficient on *Female* is higher in absolute value compared to the specification in column (2); the marginal effect in this specification is -0.4401. We interpret these results to suggest that firms with a female owner are considerably less likely to be the target of private investors. Although a one standard deviation increase in the amount of a Phase II award (σ = $232,000) is predicted to shrink the gap by 9 percentage points, the gap remains substantial. Stated differently, given two otherwise identical projects and firms, one with a male owner and the other one with a female owner, the latter's project would have to receive $1.2 million more in Phase II funding (assuming that the true coefficient of *Award* is 0) for the two projects to have an equal probability of receiving private investment funds to leverage the firm in Phase III. This amount is almost as large as the difference between the smallest and largest Phase II awards observed in the sample (see Table 3).

[12] There are 22 different agencies within the NIH that funded the 323 projects in the main estimation sample. The agencies that funded the most projects are the National Cancer Institute (53 projects) and the National Heart, Lung and Blood Institute (37 projects).

Controlling for the amount of Phase II award does not change much the coefficient on the *Complete Phase II* variable: its marginal effect is 0.1126 compared to 0.1085 in column (1).

The specification in column (3) controls for prior private investment support of research on a technology related to the Phase II award. The coefficient on *Prior Private Invest* is highly significant and the estimated marginal effect suggests that firms that received prior private investment research funding for the technology related to their Phase II project are 30 percent more likely to receive private investment funding for their current Phase II project.[13]

In column (3), the estimated gap between male and female owned firms shrinks slightly: the marginal effect is -0.3397 compared to -0.4401 in column (2).[14] Also, the results in column (3) suggest that firms located in the South Census region are less likely to receive Phase III funding. The estimated marginal effects are between -0.1429 and -0.1500, depending on the specification, and are significant at the five or ten percent level.

Table 4 also shows the results from the first stage selection model. As hypothesized, the age of the Phase II award is negatively correlated with the probability of selection. The estimated coefficient on *Award* is positive in all three specifications but not statistically significant in any. The correlation between the error terms in equations (1) and (2), rho, is negative, small in absolute value (between -0.18 and -0.21) and not significant. A test of the hypothesis that rho = 0 fails to reject the null with a probability value of over 0.6. Thus, we believe that selection bias is not an issue.

Absent any statistical evidence of selection bias, the specifications of equation (1) considered in Table 4 were re-estimated with year-of-funding fixed effects. Table 5 shows the results from the probit model in which we do not control for selection. The coefficients are almost identical to those reported in Table 4. The main difference is that the marginal effect of *Female* is slightly

[13]Since this variable conveys similar information to the Phase II award amount, it is not surprising that including it reduces slightly the absolute value of the coefficients on *Award* and *Award·Female*: to -0.0095 and 0.3393, respectively.

[14]The most likely reason is that, similar to private investment for Phase III research, pre-Phase II funding is also highly correlated with gender. Of the projects in the sample, 21 percent of male firm owners received private research funding prior to the Phase II award, compared to only 6 percent of female firm owners. This difference is statistically significant.

larger in absolute value, and so is the estimated marginal effect of *Award·Female* (-0.3745 and 0.3805 in the full model in column (3), respectively). These coefficients imply that private investors use even more of the information conveyed by the size of the Phase II award when deciding whether to fund a female-owned firm. None of the indicator variables for year of the award is significant individually, but they are significant as a group. Also, the estimated coefficients do not suggest that there is a time trend in the data. [15]

To test for the robustness of our conclusion that there are statistically significant differences in the supply of private investment between female- and male-owned technology-based entrepreneurial firms, as defined by our sample of Phase II research project firms, we considered the dollar amount of private funding that firms received to support their Phase II research, *Amount Private Invest*, as an alternative dependent variable. As shown in Table 3, the amount of private investment funding varies substantially in the sample of 323 projects: the mean of *Amount Private Invest* is \$0.9295 million, with a standard deviation of 6.8856.[16] This variability suggests that by only looking at whether or not a firm received private investment funding we might ignore information available in the data.

Thus, we estimate a tobit model, in which

$$(3) \qquad \textit{Amount Private Invest} = \begin{cases} 0 \text{ if } y^* \leq 0 \\ y^* \text{ if } y^* > 0 \end{cases} \text{ and } y_i^* = \delta \mathbf{X} + e_i.$$

The variables included in vector **X** are the same firm and project characteristics used to estimate equation (1).

The tobit estimates in Table 6 are from the full model with all controls.[17] The coefficients and standard errors in column (1) show the marginal effects on the latent variable y^*. Column (2) displays the conditional expected values: the marginal effect of each independent variable on the

[15] We also re-estimated the model with a polynomial in *Age* and did not find a relationship. These results are available from the authors upon request.
[16] The mean and standard deviation conditional on positive investment are 4.8425 and 15.1991, respectively.
[17] The results from the specifications in columns (1) and (2) in Table 5 are available on request from the authors.

observations with positive *Amount Private Invest*.[18] Clearly, the factors affecting the amount of private investment capital that firms receive are similar to the correlates of the probability of receiving any funding. Female owners tend to receive less private investment funding, but the gap is narrower among firms with larger Phase II awards. Completing the Phase II project sends a positive signal to investors, and so does having received private investment funding in the past. Firms in the South Census region tend to receive less capital from private investors.

IV. Summary Remarks

Based on a random sample of NIH funded Phase II research projects, our principal finding suggests that woman entrepreneurs are disadvantaged when it comes to attracting private investment funds to bridge the transition from invention to innovation. This conclusion does not challenge the legislated mandate to increase the participation of women-owned and -controlled firms in the SBIR program. Rather, it underscores that a legislated directive in itself might not be sufficient to overcome market perceptions about the profitability of requisite private investments to bring the developed technology to market.

We also find that private investors make use of available information to attempt to solve the asymmetric information problem. In particular, our results suggest that private investment funds are more likely to flow to a Phase II research project after it has been completed and if the firm conducting the Phase II research had previously been successful in soliciting private investment funds on related projects.

This paper is the first systematic investigation of the flow of private investments to technology-based entrepreneurial firms, women-owned firms in particular, and the first systematic investigation at the project level. However, future investigations will hopefully be able to overcome some of the data limitations that accompanied the NRC database upon which our empirical investigation is based. In particular, our analysis in this paper is on the supply of private investment funds, but certainly an important next step would be to quantify how the amount of those funds and when they were received affect the firm's ability to leverage its

[18]These coefficients show how the dependent variable changes when we change the **X** variables when *Private investment* equals 1, ignoring the changes in the probability of receiving Phase III funding associated with changes in the independent variables.

technology toward the market, the success of the related innovations in the market, and the subsequent life of the entrepreneurial venture.

Table 1

Data Reduction for the NIH Sample of Phase II Projects

Data Reduction	Number of Projects
Population of Phase II NIH projects	2497
Survey population	1680
Random survey population	1677
Respondents to the survey	496
Random sample of respondents	495
Random sample of respondents with complete data	446
Respondents with complete data and still in business at interview date	323

Table 2
Definition of Variables

Variable	Definition
Private Investment	=1 if the firm received Phase III funding of the Phase II project from a private investment source, 0 otherwise
Amount Private Invest	Amount of Phase III funding of the Phase II project from a private investment source ($M)
Female	=1 if firm is solely female owned, =0 if solely male owned
Award	Amount of the Phase II award ($M)
Award·Female	Interaction term between *Award* and *Female*
Complete Phase II	=1 if the Phase II project was completed at the time of the NRC survey; 0 otherwise
Prior Private Invest	=1 if the firm received prior private investment research funding for technology related to the Phase II project
Northeast	=1 if the firm is located in the Northeast; 0 otherwise
Midwest	=1 if the firm is located in the Midwest; 0 otherwise
South	=1 if the firm is located in the South; 0 otherwise
Response	=1 if the firm responded to the NRC survey about the Phase II project; 0 otherwise
Age	Age of the Phase II award measured as (2005 – year of the award)
Award Year XXXX	=1 if the Phase II project funded in year XXXX, 0 otherwise

Table 3
Descriptive Statistics on the Variables (n=323)

Variable	Mean	Standard Deviation	Range
Private Investment[a]	0.1920	0.3944	0 / 1
*Amount Private Invest** ($M)	0.9295	6.8856	0-79.9
Female	0.1672	0.3737	0 / 1
Award ($M)[b]	0.6452	0.2320	0 .0148-1.6440
*Award*Female*	0.1197	0.2850	0-1.5712
Complete Phase II	0.9040	0.2950	0 / 1
Prior Private Invest	0.1858	0.3895	0 / 1
Northeast	0.2972	0.4577	0 / 1
Midwest	0.1641	0.3709	0 / 1
South	0.2632	0.4410	0 / 1
West	0.2755	0.4475	0 / 1
Response (n = 1677)	0.1926	0.3945	0 / 1
Age (years)	6.7864	2.5466	4-13
Award Year 1992	0.0372	0.1894	0 / 1
Award Year 1993	0.0433	0.2039	0 / 1
Award Year 1994	0.0372	0.1894	0 / 1
Award Year 1995	0.0526	0.2236	0 / 1
Award Year 1996	0.0433	0.2039	0 / 1
Award Year 1997	0.1022	0.3033	0 / 1
Award Year 1998	0.1176	0.3227	0 / 1
Award Year 1999	0.2012	0.4015	0 / 1
Award Year 2000	0.1486	0.3563	0 / 1
Award Year 2001	0.2167	0.4126	0 / 1

[a] Private investment funding in the NRC database includes U.S. venture capital, foreign investments, private equity, and other sources from private firms. Venture capital is the largest investment category. Of the 62 firms that received private investment funds in support of their Phase II project's technology, 11 received venture capital funds. In nominal terms, the mean level of private investment was $929.5 thousand; the mean level of venture capital was $389.7 thousand. Of the 62 firms that received private investments, the mean nominal amount of funding was $4,842.5 thousand and the mean level of venture capital was $11,444.1 thousand. Equation (1) was not estimated in specific terms of venture capital because no female-owned firms received such support.

[b] The smallest project in the sample was funded for $14,000. To account for any non-linearity in the impact of the award size on the propensity to receive private investment funds, *lnAward* was considered as an alternative regressor. There is no evidence of non-linearity and the other results reported in Tables 4, 5, and 6 are not substantially changed when this variable was considered. As well, when the $14,000 award datum was dropped from the sample, the results in those tables were not substantially changed. These results are available from the authors on request. Finally, as discussed in Link and Scott (2011), it is not uncommon for a Phase II award to exceed the $750,000 threshold. Simply, the funding agency has the discretion to "add on" to the existing award when the technology being developed is especially promising to the mission of the agency.

Table 4
Probit Results from Equation (1) with Selection

Variable	**(1)**	**(2)**	**(3)**
Female	-0.1564**	-0.4401***	-0.3397***
	(0.0736)	(0.1405)	(0.1266)
Award	--	-0.0333	-0.0095
		(0.0872)	(0.0831)
Award·Female	--	0.3693*	0.3393*
		(0.1970)	(0.1832)
Complete Phase II	0.1085*	0.1126*	0.0849*
	(0.0582)	(0.0582)	(0.0493)
Prior Private Invest	--	--	0.2966***
			(0.0404)
Northeast	-0.0819	-0.0829	-0.0629
	(0.0666)	(0.0682)	(0.0551)
Midwest	-0.0594	-0.0569	-0.0233
	(0.0661)	(0.0639)	(0.0587)
South	-0.1468*	-0.1429*	-0.1500**
	(0.0758)	(0.0760)	(0.0706)
Selection Model			
Age	-0.0822***	-0.0822***	-0.0822***
	(0.0121)	(0.0121)	(0.0118)
Award	0.1658	0.1653	0.1654
	(0.1446)	(0.1480)	(0.1494)
Constant	-0.3657*	-0.3653*	-0.3652*
	(0.2007)	(0.2012)	(0.2003)
Wald χ^2	18.09	51.32	183.12
(df)	(5)	(7)	(8)
Log pseudo-likelihood	-950.6283	-949.9612	-925.6649
Rho	-0.1766	-0.1765	-0.2082
	(0.3559)	(0.3632)	(0.4055)
Wald χ^2 (1) of independent equations (rho= 0)	0.23	0.22	0.24
Probability value of χ^2 (1) statistic	0.6294	0.6362	0.6212

Note: * p<0.10, ** p<0.05, *** p<0.01. Dependent variable: *Private Investment*. The reported probit coefficients are average marginal effects. The standard errors are clustered by funding agency. There are 1354 censored observations and 323 uncensored observations.

Table 5
Probit Results from Equation (1) without Selection

Variable	(1)	(2)	(3)
Female	-0.1573**	-0.4618***	-0.3745***
	(0.0752)	(0.1431)	(0.1081)
Award	--	-0.0581	-0.0889
		(0.1055)	(0.1008)
Award·Female	--	0.3978**	0.3805**
		(0.1931)	(0.1575)
Complete Phase II	0.1021*	0.1075**	0.0750*
	(0.0559)	(0.0548)	(0.0446)
Prior Private Invest	--	--	0.2994***
			(0.0431)
Northeast	-0.0869	-0.0883	-0.0619
	(0.0646)	(0.0659)	(0.0526)
Midwest	-0.0614	-0.0606	-0.0279
	(0.0674)	(0.0652)	(0.0555)
South	-0.1499**	-0.1463**	-0.1471**
	(0.0731)	(0.0729)	(0.0664)
Award Year 1993	0.0110	0.0142	0.0413
	(0.1449)	(0.1445)	(0.1339)
Award Year 1994	-0.1810	-0.1798	-0.1229
	(0.1628)	(0.1640)	(0.1515)
Award Year 1995	-0.0388	-0.0265	0.0717
	(0.1445)	(0.1542)	(0.1541)
Award Year 1996	-0.0074	-0.0061	0.1058
	(0.0771)	(0.0747)	(0.0987)
Award Year 1997	0.0247	0.0385	0.0796
	(0.0993)	(0.1004)	(0.1159)
Award Year 1998	-0.0250	-0.0109	0.0470
	(0.1278)	(0.1291)	(0.1285)
Award Year 1999	-0.0531	-0.0421	0.0362
	(0.0890)	(0.0987)	(0.0939)
Award Year 2000	0.0503	0.0607	0.1320
	(0.1254)	(0.1244)	(0.1400)
Award Year 2001	-0.0171	-0.0145	0.0147
	(0.0990)	(0.0998)	(0.0944)
Wald χ^2	173.61	859.40	1863.99
(df)	(14)	(16)	(17)
Pseudo R^2	0.0602	0.0648	0.2226
Log pseudo-likelihood	-148.45295	-147.72028	-122.80163

Note: * p<0.10, ** p<0.05, *** p<0.01. Dependent variable: *Private Investment*. The reported coefficients are average marginal effects from probit models. The standard errors are clustered by funding agency. n = 323.

Table 6
Tobit Results from Equation (3)

Variable	***δ***	***dE(y | y > 0)/d*X**
Female	-28.3763***	-3.8089
	(10.2058)	
Award	-5.4217	-0.9611
	(9.3338)	
Award·Female	29.0211**	5.1444
	(14.6581)	
Complete Phase II	7.7557***	1.2361
	(2.6820)	
Prior Private Invest	19.2187***	4.3361
	(3.6702)	
Northeast	-3.7602	-0.6494
	(4.2838)	
Midwest	-3.0903	-0.5284
	(3.8104)	
South	-8.7869*	-1.4543
	(5.0775)	
Award Year 1993	11.9487	2.6022
	(11.0084)	
Award Year 1994	12.1266	2.6568
	(15.0670)	
Award Year 1995	6.3827	1.2565
	(10.3191)	
Award Year 1996	7.5577	1.5218
	(6.1509)	
Award Year 1997	4.7503	0.9021
	(7.2815)	
Award Year 1998	3.8989	0.7296
	(8.1846)	
Award Year 1999	2.8096	0.5134
	(6.6856)	
Award Year 2000	9.9929	2.0219
	(8.3116)	
Award Year 2001	3.7374	0.6886
	(6.3866)	
Constant	-26.7776***	
	(9.1287)	
Tobin's sigma	16.2247	
	(3.3061)	
Pseudo R^2	0.0829	
χ^2 (17)	58.54	
Log-likelihood	-323.60269	

Note: * p<0.10, ** p<0.05, *** p<0.01. Dependent variable: *Amount Private Invest*. The standard errors are clustered by funding agency. n = 323.

References

Aldrich, H.E. (1989). Networking among women entrepreneurs. In O. Hagen, C. Rivchum, & D. Sexton (Eds.) *Women-owned businesses* (pp. 103-132). New York: Praeger.

Baer, J., & Kaufman, J.C. (2008). Gender differences in creativity. *Journal of Creative Behavior*, 42, 75-106.

Barsky, R.B., Juster, F.T., Kimball, M.S., & Shapiro, M.D. (1977). Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement study. *Quarterly Journal of Economics*, 112: 537-579.

Blanchflower, D.G., & Meyer, D.B. (1994). A longitudinal analysis of the young self-employed in Australia and the United States. *Small Business Economics,* 6, 1-19.

Blanchflower, D.G., & Oswald, A.J. (1998). What makes an entrepreneur? *Journal of Labor Economics*, 16: 26-60.

Borghans, L., Heckman, J.J., Golsteyn, B.H.H., & H. Meijers. (2009). Gender differences in risk aversion and ambiguity aversion. *Journal of the European Economic Association*, 7: 649-658.

Brana, S. (2011). Microcredit: An answer to the gender problem in funding? *Small Business Economics*, DOI 10.1007/s11187-011-9346-3.

Branscomb, L.M., & Auerswald, P.E. (2002). *Between invention and innovation: An analysis of funding for early-stage technology development.* NIST GCR 02–841. Washington, DC: U.S. Department of Commerce.

Brush, C.G., Carter, N., Gatewood, E., Greene, P.G., & Hart, M.M. (2001). An investigation of women-fed firms and venture capital investment. Final Report submitted to the U.S. Small Business Administration, Office of Advocacy.

Colombo, M.G., Luukkonen, T., Mustar, P., & Wright, M. (2011). Venture capital in high-tech start-ups. *Venture Capital*, 12: 261-266.

Croson, R., & Gneezy, U. (2009). "Gender differences in preferences. *Journal of Economic Literature*, 47: 448-474.

Ehlers, V.J. (1998). *Unlocking our future: Toward a new national science policy*. Washington, DC: U.S. House of Representatives, Committee on Science.

Executive Office of the President. (2011). *Report to the President on ensuring American leadership in advanced manufacturing*. Washington, DC: President's Council of Advisors on Science and Technology (PCAST).

Fairlie, R., & Marion, J. (2010). Affirmative action programs and business ownership among minorities and women. *Small Business Economics*, DOI 10.1007/s11187-010-9305-4.

Gatewood, E.J., Brush, C.G., Carter, N.M., Greene, P.G., & Hart, M.H. (2009). Diana: A symbol of women entrepreneurs' hunt for knowledge, money, and the rewards of entrepreneurship. *Small Business Economics*, 32: 129-144.

Gompers, P., & Lerner, J. (2004). *The venture capital cycle*. Cambridge, MIT Press.

Hébert, R.F., & Link, A.N. (2006). The entrepreneur as innovator. *Journal of Technology Transfer*, 31: 589-597.

Hébert, R.F., & Link, A.N. (2009). *A history of entrepreneurship*. London: Routledge.

Jianakoplos, N.A., and Bernasek, A. (1998). Are women more risk averse? *Economic Inquiry*, 36: 620-630.

Johnson, J.E.V., & Powell. P.L. (1994). Decision making, risk and gender: Are managers different? *British Journal of Management*, 5: 123-138.

Lerner, J. (1999). The government as venture capitalist: The long-run impact of the SBIR program. *The Journal of Business,* 72: 285–318.

Lerner, J., & Kegler, C. (2000). Evaluating the Small Business Innovation Research program: A literature review. In C.W. Wessner (Ed.), *The Small Business Innovation Research program: An assessment of the Department of Defense Fast Track initiative* (pp. 307-324). Washington, DC: National Academy Press.

Levin, I.P., Snyder, M.A. & Chapman, D.P. (1988). The interaction of experiential and situational factors and gender in a simulated risky decision-making task. *Journal of Psychology*, 18: 173-181.

Link, A.N., & Scott, J.T. (2009). Private investor participation and commercialization rates for government-sponsored research and development: Would a prediction market improve the performance of the SBIR program? *Economica*, 76: 264-281.

Link, A.N., & Scott, J.T. (2010). Government as entrepreneur: Evaluating the commercialization success of SBIR projects. *Research Policy*, 39: 589-601.

Link, A.N., & Scott, J.T. (2011). *Employment growth from public support of innovation in small firms*. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

Link, A.N., & Welsh, D.B. (2011). From laboratory to market: On the propensity of young inventors to form a new business. *Small Business Economics*, DOI 10.1007/s11187-011-9345-4.

Marlow, S., & Patton, D. (2005). All credit to men? Entrepreneurship, finance, and gender. *Entrepreneurship Theory and Practice*, 29: 717-735.

National Venture Capital Association. (2011). *Yearbook 2011*. Arlington, VA: National Venture Capital Association (NVCA).

Nelson, R.R. Government stimulus of technological progress: Lessons from American history. In R.R. Nelson (Ed.), *Government and Technical Progress*, New York: Pergamon.

Reynolds, P.D. (1997). Who starts new firms? Preliminary explorations of firms in-gestation. *Small Business Economics*, 9: 449-462.

Ruef, M., Aldrich, H.E., & Carter, N.M. (2003). The structure of founding teams: Homophily, strong ties, and isolation among U.S. entrepreneurs. *American Sociological Review*, 68: 195-222.

Schubert, R., Brown, M., Gysler, M., & Brachinger, H.W. (1999). Financial decision-making: are women really more risk averse? *American Economic Review Papers and Proceedings*, 89: 381-385.

Schumpeter, J.A. (1934). *The Theory of Economic Development*. Cambridge: Harvard University Press.

Sundén, A.E., & Surette, B.J. (1998). "Gender Differences in the Allocation of Assets in Retirement Savings Plans," *American Economic Review Papers and Proceedings*, 18: 201-211.

Tassey, G. (2010). Rationales and mechanisms for revitalizing U.S. manufacturing R&D strategies. *Journal of Technology Transfer*, 35: 283-333.

Uusitalo, R. (2001). "Homo Entreprenaurus?" *Applied Economics*, 33: 1631-1638.

Van der Zwan, P., Ingrid Verheul, I., & Thurik, R.A. (2011). The entrepreneurial ladder, gender, and regional development. *Small Business Economics*, DOI 10.1007/s11187-011-9334-7.

Von Gaudecker, H.-M., van Soest, A., & Wengström, E. (2011). Heterogeneity in risky choice behavior in a broad population. *American Economic Review*, 101: 664-694.

Wessner, C.W. (2007). *SBIR and the Phase III challenge of commercialization: Report of a symposium*. Washington, DC: National Research Council.

Wessner, C.W. (2009). *An assessment of the SBIR program*. Washington, DC: National Research Council.

Wright, M., Lockett, A., Clarysse, B., & Binks, M. (2006). University spin-out companies and venture capital. *Research Policy*, 35: 481-501.