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Going public with public money

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Abstract We analyze what we consider to be an unanticipated consequence of the SBIR program, namely, that firms, publicly funded through the SBIR program, are going public based on their new technology developed with support from the SBIR program. There is a conspicuous void with regard to publicly funded firms that do go public. Through the estimation of a qualitative choice model, we identify firm and project characteristics that are associated with an increased likelihood of a firm making (or planning to make) an initial public offering (IPO).

Keywords IPO · SBIR program · Technology · Program evaluation · Public sector

JEL classifications G11 · G32 · L26 · O31 · O38

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A billion here, a billion there, and pretty soon you're talking real money.
—US Senator Everett McKinley Dirksen

1 Introduction

The US Small Business Innovation Research (SBIR) program was established in 1982 as part of the Small Business Innovation Development Act of 1982, Public Law 97-219. The purposes of the 1982 Act are as follows:

(1) To stimulate technological innovation
(2) To use small business to meet Federal research and development needs
(3) To foster and encourage participation by minority and disadvantaged persons in technological innovation
(4) To increase private sector commercialization innovations derived from Federal research and development

The 1982 Act was promulgated in response to the productivity slowdown that started to impact the US economy in the early 1970s and then intensified in the late 1970s and early 1980s. The architects of the 1982 Act were focused on moving new technologies into the economy, and thus the SBIR program, among several other programs, was intended to push new technological innovations to the point of commercialization.[1]

[1] See Leyden and Link (2015) and Link and Link (2009) for a history of the SBIR program and for the empirical literature related to the commercialization of SBIR-funded technologies.

Commercialization was the intended goal of SBIR-funded projects, and, according to Leyden and Link (2015), it was the only explicitly legislated goal of the program.[2]

President Jimmy Carter charged the US Congress to formulate SBIR programs across agencies in his 1979 Domestic Policy Review (Domestic Policy Review 1979):

> Small innovative firms have historically played an important role in bringing new technologies into the marketplace. They are also an important source of new jobs. Although many of the initiatives in this Message will encourage such companies, I will also implement several initiatives focused particularly on small firms. First, I propose the enhancement by $10 million of the [experimental] Small Business Innovation Research Program of the National Science Foundation. Further, the National Science Foundation will assist other agencies in implementing similar programs, with total Federal support eventually reaching $150 million per year.

As background, an SBIR program funds Phase I and Phase II research projects. Phase I projects are proof of concept research that are generally designed and funded for a period of 6 months. Phase II projects are focused toward the development of a new technology poised to enter the market. Phase II projects are generally designed and funded for a period of 24 months.[3]

In this paper, we analyze what we consider to be an unanticipated consequence of the SBIR program,[4] namely, that firms, publicly funded through the SBIR program, are going public based on their new technology developed with support from the SBIR program. Hence, the paper contributes, first, to the academic and policy debate about public intervention to promote entrepreneurship by revealing how it is closely linked to the demand for financing and, therefore, to finance studies. For instance, there is mixed evidence concerning the crowding-in versus the crowding-out impact of public intervention in private equity markets, such as the establishment of government-based venture capital funds (Colombo et al. 2016). There are indeed concerns about government agencies' inability to select and nurture their portfolio of firms and about the risk of capital misallocation, leading to the crowding out of private investors and an inadvertent market disruption. Second, we contribute to the corporate finance literature by identifying empirically covariates that affect the likelihood of an (actual or planned) initial public offering (IPO). Indeed, although the literature about the decision to go public is well developed, there is little data-based evidence about the role of public research funding.

In Section II, we briefly review the relevant literature on the decision to go public through the issuance of an IPO. This review concludes that there is a conspicuous void with regard to *publicly* funded firms that do go public. In Section III, we describe the Phase II project data that we use in this paper. We posit a qualitative choice model and identify firm and project characteristics that are associated with an increased likelihood of a firm making (or planning to make) an IPO. In Section IV, we present and discuss our empirical findings. In Section V, we conclude the paper with summary remarks, an emphasis that our analysis begins to fill a void in the relevant literature on corporate and entrepreneurial finance, and suggestions for future research on this topic.

2 Literature review on IPOs

The financial economics literature has extensively studied IPOs. The IPO is indeed an extraordinary opportunity for firms to raise capital to finance their investments as well as to improve their liquidity and rebalance their financial structure. The main reason to list on a stock exchange is the access to new sources of financing to fund growth. When internally generated cash flow is insufficient, the stock markets offer the opportunity to tap into financial sources without the mediation of financial intermediaries such as banks or venture capital firms. This is the case, in particular, of technology-based entrepreneurial ventures, where the IPO is traditionally necessary to achieve company growth objectives otherwise limited by financial constraints (Pagano et al. 1998).

Several models have been proposed to explain the benefits of going public. For instance, Chemmanur and Fulghieri (1999) analyze the choice of a firm between going public and remaining private in an asymmetrically informed market where outsiders can produce information about the firm. They argue that going public reduces information asymmetry

[2] Relatedly, see Link and Scott (2018).

[3] Again, see Leyden and Link (2015) and Link and Link (2009) for a more complete description of Phase I and Phase II projects. Also, see Audretsch et al. (2019) and Bednar et al. (2019).

[4] The concept of unexpected consequences traces to Bastiat (1848).

since the presence of a publicly observable share price that conveys information across investors reduces the aggregate cost that outsiders need to expend to produce information about the true value of the firm, thus increasing its market value.

It is challenging to convince a diverse set of external investors that a firm has long-term potential. The valuation of an IPO company is determined by many factors. Country-specific institutional characteristics, such as listing standards and the quality and enforcement of securities laws, affect the valuation of listing firms (for a review, see Cumming and Johan 2018). Firm-specific characteristics are also found to play a role, such as the listing firm's fundamentals (Kim and Ritter 1999). Coherently, the success of an IPO has been investigated from the perspective of the signaling theory. Prior research at the organization level has considered a wide variety of characteristics that can serve as informative signals in markets laden with uncertainty, in particular focusing on how specific signals can reduce uncertainty about a firm's quality and prospects in the eyes of key stakeholders. These studies include firm characteristics, such as the classic age and size (Ritter and Welch 2002) or the human capital of its top management team, as well as third-party endorsements such as the affiliation with prestigious venture capitalists (Megginson and Weiss 1991), underwriters (Carter and Manaster 1990; Migliorati and Vismara 2014), and, for technology-based firms, universities (Bonardo et al. 2011).

The seminal study by Ritter (1991) finds that IPOs underperform in the long run. Several economic and behavioral arguments have been brought forward to explain this anomaly. For instance, the windows-of-opportunities theory argues that firms can benefit from periods in which investors are optimistic about the future of an industry by timing their IPO and obtaining higher valuations (Loughran and Ritter 1995). This inevitably results in poor performance in the long run. Information asymmetry decreases, and the market corrects temporary inefficiencies by adjusting stock prices (Fama 1998). Recently, many practitioners, academics, policy-makers, and the financial press have been alarmed at the prolonged drop in IPO activity that has characterized in recent years. Both the US and European markets have suffered from a decline in the number of companies going public. Gao et al. (2013) and Ritter et al. (2013) have identified, in the scope of economic analysis, a possible explanation. Based on the evidence that the decline in IPOs has been most pronounced among small firms, these authors argue that the costs and benefits of growing as an independent firm versus selling out in a trade sale are important determinants of the decision to go public versus being acquired. As far as small firms are worth more as part of a larger organization that can realize economies of scale, their owners will find it value maximizing to sell out rather than to go public and remain independent. Hence, the increasing importance of receiving an incumbent's support is one of the main reasons for firms' increasing preference toward being acquired rather than growing independently.

The going public versus standing alone decision is a key aspect of the growth strategy of small- and medium-sized enterprises (SMEs). Despite SMEs often being considered a key source of innovation (Acs and Audretsch 1988, 1990), the presence of financing constraints means that there are significant numbers of SMEs that could use funds productively were they available. The level of information asymmetry between a firm and its external investors is typically higher for SMEs than for large companies. The costs of bankruptcy are greater and more burdensome for smaller firms, and intangible assets are difficult to use as collateral. These two factors also tend to dissuade external sources of financing. Thus, for many entrepreneurial ventures, an IPO enables management to pursue growth opportunities that would otherwise be impossible to fund. But the IPO can become a particularly important marketing tool for small, innovative firms in terms of developing customer loyalty and gaining knowledge of the market (Demers and Lewellen 2003).

Recognizing the importance of easing the possibilities to go public for young and small firms, a major focus of financial policymakers around the world has been the creation of new stock exchanges for this type of companies. Policymakers are interested in determining whether secondary markets achieve their goal of supporting young firms in going public and becoming successful. For instance (European Commission 2014, p. 10):

> [The] Commission hopes to strengthen the IPO market in Europe … The recent decline in the IPO activity has again pointed to … why the sluggish IPO market is particularly worrisome in Europe.

Coherently, a number of secondary markets have been established in both developed and emerging economies. Vismara et al. (2012) document that these markets list around three of four IPOs in Europe.

Bernstein et al. (2019) confirm the proliferation of these exchanges around the world, even in countries with high levels of venture capital activity, patenting, and financial market development. Still, there remains a void in the literature on IPOs among publicly funded small firms.

3 SBIR-funded firm data and a model of the probability of an IPO

The SBIR program has been reauthorized by the Congress several times. As part of the Small Business Reauthorization Act of 2000, Public Law 106-554, the Congress authorizes the National Research Council (NRC) within the National Academies[5] to perform an evaluation of the SBIR program in the five largest agencies (listed in order of SBIR program budgets) with programs: the Department of Defense (DoD), the National Institutes of Health (NIH), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and the National Science Foundation (NSF). As part of the Academies' evaluation, the NRC conducted a survey of Phase II projects in these agencies; the surveys were administered in 2011 and 2014. We assembled a random sample of firms that were awarded a Phase II project during the years 1998 through 2010 from these surveys.

The key survey question that motivates the empirics in this paper is whether or not, at the time of the survey, a firm had "made an initial public offering" or whether or not a firm was "planning to make an initial public offering in the next two years." From these survey questions, we constructed a binary variable (*IPO*) for an SBIR-funded firm. We set *IPO* equal to 1 if a firm made or was planning to make a public offering and 0 if not. In our empirical analysis, we use a binary choice model for *IPO*. Our goal is to identify covariates that affect the probability that the funded firm made or was planning to make an IPO in relation to its SBIR-funded and developed technology.

The focal independent variable that we consider in our model relates to a firm's SBIR-related patenting behavior. Our reasoning follows from the scholarship of Åstebro (2003) who argues that, in a context different than that of this paper, there are information asymmetries associated with any new invention between the knowledge base that the inventor has about his/her innovation and the knowledge base that is available to a potential investor. In our case, the owner/founder of the SBIR-funded firm has more information about the commercial potential of the SBIR-funded technology, and thus about the potential future profits of the firm, than a potential IPO investor in the firm. Thus, one hurdle that will reduce this asymmetry of information, or so we argue, is if patents have been awarded to a firm that are related to elements of the developed technology.

Both R&D investments and patents result in information-sensitive assets, making them distinct from other tangible assets. On the one hand, while R&D investments measure resource input to innovation, patents are measures of innovative output. Information asymmetries are typically large for firms with higher R&D investments, due to, among other aspects, the lack of disclosure. On the other hand, patents signal that the proprietary technology of the firms is developed and has defined a market niche. Coherently, Baum and Silverman (2004) find a positive association between patent applications and pre-IPO financing. Stuart et al. (1999) and Bonardo et al. (2010) document that biotech companies with a patent portfolio are more likely to have a successful IPO as well as a higher long-run performance. This is coherent with Rajan's (2012) predictions that while soft variables (e.g., human capital) successfully differentiate entrepreneurial ventures in early-stage financing, at later stage firms need standardization that will make the human capital embodied in the firm replaceable. Patents are central to this standardization process in technology firms as they provide external investors, such as IPO markets, with residual rights over the going-concern surplus. Confronting the effects of R&D investment and patents on IPO-firms, Vismara (2014) finds evidence that patents are an index of technological maturity for high-tech ventures, even more than age and size, that helps investors to individuate firms with a lower level of risk. Thus, our focus on patents is well grounded.

An IPO is more likely to be issued or planned when the firm expects the IPO to have market success, and an IPO is more likely to have market success if investors have reliable information about the commercial potential of the new technology; patents convey such information. Thus, our prior is that the number of patents related to a firm's SBIR-funded technology is positively related to the probability that a firm made or is planning to make an IPO.

[5] See https://www.nationalacademies.org/.

In alternative specifications of our qualitative choice model, we measure patenting activity either as a count of patents (*Patents*) or binary as an indicator for any patents (*PatentsDmy*). Comparatively, we are examining the relative association between the number of patents or having a patent per se and the likelihood of an (actual or planned) IPO.

A second independent variable is the experience base of the owner/founder of the SBIR-funded firm. The NRC surveys ask about the number of previous firms started by one or more of the founders (*FirmsFounded*). Our argument is that previous experience in starting a firm is also a hurdle that a potential investor will consider because it provides information about a firm's managerial experience and ability (Audretsch and Link 2019a). Thus, our prior is that the number of previously founded firms (i.e., the amount of accumulated managerial experience and ability) is positively related to the likelihood that a firm made or is planning to make an IPO.

We also construct a binary indicator for any previous firms started by one or more of the founders (*FirmsFoundedDmy*), and we use this measure whenever patents are measured dichotomously (*PatentsDmy*).

A third independent variable is the human capital resource base of the firm. The NRC surveys ask about the number of employees (*Employees*) at the time the firm submitted its most recent Phase II award application. Following Audretsch and Link (2019b), a greater number of employees is assumed to be related to a greater human capital resource base for the firm, and a greater human capital resource base is predictive of the overall success of the firm. When firms are perceived to be more successful, we argue that their IPO will also be more successful and thus more likely to be issued. Thus, our prior is that *Employees* is positively related to the likelihood that a firm made or is planning to make an IPO.[6]

The fourth and fifth independent variables are indicators of the SBIR-funded firm being owned by a woman (*WomanOwned*) and a minority (*MinorityOwned*). Gender and minority ownership of the SBIR-funded firm is asked about on the NRC surveys. Link and Morrison (2019) reviewed the literature on these ownership characteristics as they relate to innovative activity in general, and they report that the consensus of findings is mixed. We explore any potential influence that gender and minority ownership have on the probability that the firm made or is planning to make an IPO.

Finally, also held constant in the various specifications of our model are variables to distinguish the agency that supported a firm's SBIR-funded research. We are viewing these agency controls as a proxy for the scope of the technology being researched and potentially brought to market. No firms funded through NSF's SBIR program made or were planning to make an IPO. Thus, the final sample of firms only consists of DoD-, DOE-, NASA-, and NIH-funded firms.

Descriptive statistics for these variables are given in Table 1.

4 Empirical findings

The Probit regression results from alternative specifications of the probability that a SBIR-funded firm made or is planning to make an IPO are in Table 2. The specifications differ in how they model the association between *IPO* and two of the independent variables. In column (1), the number of patents awarded from SBIR-funded projects, *Patents*, is included linearly as a covariate. In column (2), the number of patents and its square are included. In column (3), instead of the count of patents, we include an indicator for a non-zero number of patents, *PatentsDmy*. Regarding the number of previously founded firms, *FirmsFounded*, we include the count linearly in columns (1) and (2), and we replace it with an indicator for a non-zero count in column (3).

The estimates from the three specifications presented in Table 2 tell a consistent story. The patenting history of a firm is positively and significantly correlated with the likelihood that a firm will make or plans to make an IPO.[7] From column (1), the calculated marginal effect is 0.0045. Thus, when the number of awarded patents increases by 10, the probability of an actual or planned IPO increased by 0.5 percentage points. As shown in column (2), the estimated Probit coefficient on $(Patents)^2$ is negative and significant, suggesting that the positive effect of patents on the probability that a firm will make an IPO eventually decreases, although the estimated Probit coefficient and calculated marginal effect are small. From column (3), the calculated

[6] A variable to proxy the financial resource base of the firm is not available from the NRC's surveys. The National Academies would not release to us the amount of the firm's recent SBIR award for confidentiality reasons, and the amount of the firm's previous SBIR awards was not asked on the surveys.

[7] We measure patent counts in 10s so that the Probit coefficient on the squared patent term in column (2) is of a reasonable magnitude.

Table 1 Descriptive statistics on the variables ($n = 1357$)

	Mean	Std. Dev	Min	Max
IPO (yes/no)	0.04	0.20	0	1
Patents	8.30	26.63	0	500
PatentsDmy (yes/no)	0.70	0.46	0	1
FirmsFounded	0.87	1.50	0	20
FirmsFoundedDmy (yes/no)	0.41	0.49	0	1
Employees	62.46	371.22	1	10,000
WomanOwned (yes/no)	0.09	0.28	0	1
MinorityOwned (yes/no)	0.09	0.28	0	1
DOE	0.13	0.33	0	1
DoD	0.46	0.50	0	1
NASA	0.10	0.30	0	1
NIH	0.31	0.46	0	1

marginal effect on *PatentsDmy* is 0.0377. Thus, the probability of an actual or planned IPO is about 3.8 percentage points higher for SBIR-funded firms that hold patents, compared to with firms without patents. Given that the average predicted probability of an IPO for SBIR-funded firms without patents is only 1.3%, holding at least one patent increases the probability by about 286%.

The estimated Probit coefficients and marginal effects of *FirmsFounded* and of *FirmsFoundedDmy* are positive, as predicted, but neither are significant at a conventional level.

The firm's human capital resource base, as measured by the natural logarithm of *Employees* to account for non-linearity, is a positive and significant covariate of the likelihood that a firm made or is planning to make an IPO. From column (1), the calculated marginal effect is 0.0163. This implies that a 10% increase in the number of employees is associated with an increase of 0.16 percentage point in the likelihood of an IPO.

Finally, the Probit results in Table 2 do not show any significant relationship between either gender or minority ownership of a firm and the likelihood of an actual or planned IPO.

5 Concluding remarks

To the best of our knowledge, this is the first paper to investigate empirically covariates with the likelihood that a publicly funded research firm will go public with its

Table 2 Probit results and calculated marginal effects ($n = 1357$)

	(1)	(2)	(3)
Patents (in 10s)	0.0597***	0.1437***	--
	(0.0218)	(0.0341)	--
	[0.0045]	[0.0099]	--
(Patents)²	--	−0.0025***	--
	--	(0.0009)	--
PatentsDmy	--	--	0.6445***
	--	--	(0.2074)
	--	--	[0.0377]
FirmsFounded	0.0591	0.0548	--
	(0.0368)	(0.0381)	--
	[0.0045]	[0.0041]	--
FirmsFoundedDmy	--	--	0.1395
	--	--	(0.1375)
	--	--	[0.0111]
Employees	0.2159***	0.2057***	0.2273***
	(0.0451)	(0.0458)	(0.0441)
	[0.0163]	[0.0153]	[0.0179]
WomanOwned	−0.1949	−0.1992	−0.1253
	(0.2360)	(0.2472)	(0.2475)
	[−0.0130]	[−0.0131]	[−0.0091]
MinorityOwned	0.2131	0.2269	0.1219
	(0.2138)	(0.2149)	(0.2160)
	[0.0184]	[0.0195]	[0.0103]
DoD	0.6663*	0.7807*	0.7571*
	(0.3972)	(0.4354)	(0.3930)
	[0.0603]	[0.0721]	[0.0716]
NASA	0.9272**	0.9987**	0.9855**
	(0.4220)	(0.4571)	(0.4203)
	[0.1244]	[0.1369]	[0.1369]
NIH	1.1861***	1.2902***	1.2218***
	(0.4035)	(0.4434)	(0.3972)
	[0.1381]	[0.1538]	[0.1471]
Constant	−3.4114***	−3.5485***	−3.9465***
	(0.4419)	(0.4853)	(0.4699)
Pseudo log-likelihood	−198.4	−195.0	−204.4
Wald χ^2	50.43	71.70	54.55
p value	3.38e-08	7.05e-12	5.40e-09
Pseudo-R^2	0.161	0.175	0.136

*$p < 0.10$

**$p < 0.05$

***$p < 0.01$

Robust standard errors are in parentheses below each coefficient. Marginal effects are in square brackets. The Wald χ^2 is the statistic for the joint test that all coefficients are zero; its *p* value is given below the statistic. The pseudo-R^2 is McFadden's measure of model fit for binary choice models. The reference agency is DOE

developed technology. By documenting that the probability of an IPO is greater for SBIR-funded firms that hold patents, we provide evidence about the returns to public research funding that carries implications beyond the specific public funding program. As recently as March 2020, the European Union has defined a new package of initiatives designed to "unleashing the full potential of European SMEs."[8] This program is based on three pillars, namely, (1) sustainable and digital transitions; (2) intellectual property, with an action plan to uphold technological sovereignty and better fight intellectual property theft; and (3) better access to finance, including the establishment of an SME Initial Public Offerings Fund. Our study on the possibilities of "going public with public money" is therefore of great topicality.

However, our findings answer as many questions and issues as they potentially raise.

First, how well do our findings for SBIR-funded research firms compare to research firms funded through other sources (e.g., firms conducting contracted research by a state or federal agency)? Second, is the financial resource base of a firm correlated with the likelihood that it made or is planning to make an IPO? And third, if the answer to this second question is yes, is the financial research base of a firm positively or negatively related with the likelihood that a firm made or is planning to make an IPO?

There are other research questions that should be considered. Within the context of Åstebro's (2003) argument, does the experience of a research team ameliorate information asymmetries and thus is it positively related to whether or not a firm made or is planning to make an IPO? Also, how does the ex post financial success of a firm that issued an IPO based on its publicly funded research compare to the ex post financial success of a firm that issued an IPO based on internally funded research, holding technology research areas constant?

Finally, we are aware that the market for firms with a new technology is not homogeneous in the sense that the market demand for ownership in such firms is not constant across broad categories of new technologies. But our SBIR data only allow us to control for the funding agency and not for subtleties in the underlying technology. This fact necessitates that our findings be interpreted cautiously and it challenges future researchers to improve in the use of variables to control for such instances.

[8] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_416

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