Outside equity, innovative entrepreneurship and risky investments: Evidence from the German 'INVEST' program

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Abstract

In this paper, we propose a novel approach to test the causal link between financing and investment decisions. In particular, we focus on the link between outside equity and risky investments (R&D) in entrepreneurial firms. To account for the endogenous nature of financing in investment decisions, we take advantage of a major policy program for providers of early stage equity capital in Germany. The program partially reimburses private investors of equity capital (angel investors) when financing eligible companies. This results in exogenous variation in the cost of outside equity between eligible and non-eligible firms over time, and allows us to identify the causal link between equity capital and firms' risky investment decisions. We test our model on a representative sample of entrepreneurial companies. Consistent with theory, we find evidence of a causal effect of outside financing on risky investments. Equity financing doubles the propensity of firms to engage in innovation activities. We further estimate that a 10% increase in employed equity capital leads to a 10.32% increase in R&D expenditures and correspondigly to 5 additional R&D employees.

Key words: Equity Financing, Venture Capital, Angel Investors, Innovation, Entrepreneurship Policy

1 Introduction

Is early stage equity financing instrumental for high-growth innovative entrepreneurship, or is it a consequence thereof? Anecdotal evidence supports both views. Consider the stories behind two of the most valuable and innovation driven companies at present, Google and Microsoft. Google received their first investment from Sun Microsystems founder Andreas von Bechtolsheim before the company was incorporated. Von Bechtholsheim gave the founders twice the amount they asked for, knowing that they wold require more cash to build the company they envisioned. Microsoft on the other hand, was a profitable company when venture capitalist David Marquardt joined their board for a 5% equity stake in the company. According to Microsoft founder Bill Gates, Marquardt's money is still on Microsoft's accounts today, and the firm was mostly looking for 'some adult advice' from a senior investor.

The stories behind Google and Microsoft reflect a more fundamental economic question about the role of the financial sector for innovation and growth that dates back to at least Schumpeter (King & Levine, 1993), namely whether the financial sector is instrumental for innovation and growth. This is not only relevant for academics, but on a more applied level it is relevant for entrepreneurs and policy makers who are interested in understanding whether financing choices are consequential for firms' innovation strategies. In this context, the question arises to what extent access to certain types of financing has an impact on the companies' innovation activities, and whether public policy can and should promote specific financing sources that are conducive to innovative entrepreneurship.

Equity financing for young and innovative companies has gained considerable interest from academics and policymakers over the past two decades. Spurred by the R&D boom of the 1990s in the U.S. (Brown, Fazzari, & Petersen, 2009), the role of equity capital for high-tech companies has been studied extensively, both theoretically and empirically. Public equity markets have a strongly positive effect on R&D activity in publicly traded young high-tech companies. By allow firms to build buffer stock of liquidity to smooth R&D spending, equity financing shapes the innovation strategies of these firms (Brown et al., 2009; Brown, Martinsson, & Petersen, 2012). For the early stages of entrepreneurial firms, there remain a number of unanswered questions regarding the relation between equity financing and innovation strategies. While theory predicts that equity-linked securities allow firms to engage in high risk high return projects (Winton & Yerramilli, 2008; Ueda, 2004), empirical evidence on the direct link between equity capital and risky investment decisions in early stage firms remains scarce (Müller & Zimmermann, 2009; Da Rin & Penas, 2017).

Estimates for the U.S. suggest that venture capital - i.e. equity-linked capital provided to privately held entrepreneurial companies - has accounted for 8% of industrial innovations in the period from 1983-1992 (Kortum & Lerner, 2000), and 6% from 1992-2005 in Europe (Popov & Roosenboom, 2012). However, estimates on the effect of venture capital on industrial innovation in the decade 1992-2005 are not significant, neither for Europe nor the United States (Popov & Roosenboom, 2012). Looking at within firm variation in patenting activity, several authors have questioned the causal link between venture capital and innovation activity both in Europe (Engel & Keilbach, 2007; Caselli, Gatti, & Perrini, 2009; Peneder, 2010; Lahr & Mina, 2016) and the U.S. (Hirukawa & Ueda, 2011). Instead these authors have suggested that venture capital is driving the commercialization of innovation outcomes, which has been documented as another role that venture capitalists have been shown to play in entrepreneurial firms (Hellmann & Puri, 2000; Samila & Sorenson, 2010). The fact that venture capital funds seems to have shifted their industry focus away from traditional high-tech industries also speaks in favor of this hypothesis (Lerner & Nanda, 2020). Other types of venture capitalists, such as angel investors, governmental venture capital, and corporate venture capital funds, have also risen in stature, with different effects on innovation performance (Chemmanur, Loutskina, & Tian, 2014; Bertoni & Tykvová, 2015; Dutta & Folta, 2016).

In this paper, we reexamine the role of outside equity for innovation in entrepreneurial firms. In particular we focus on the link between outside equity, firms propensity to engage in innovation activity and make risky investments. Unlike previous research, we look at innovation inputs (i.e. R&D expenditures and R&D employees) instead of innovation outputs (patents). This allows us to examine the role of venture capital in shaping firms' innovation strategies (Da Rin & Penas, 2017). To account for the endogenous nature of venture capital financing decisions, we exploit the introduction of a major policy program for providers of early stage equity capital in Germany. The program partially reimburses private investors of equity capital (angel investors) when financing eligible companies. This results in exogenous variation in the cost of outside equity between eligible and non-eligible firms over time, and allows us to identify whether equity capital is instrumental for firms' risky investment decisions. Focusing on R&D is important since VCs may play a role in commercialization rather than the development of products and services through financing innovation, for example in brand building and advertising expenditures.

Consistent with theory, we find evidence of a causal effect of outside financing on innovative entrepreneurship and firms' risky investment decisions. Our instrumented regressions suggest that equity financing doubles firms' propensity to engage in innovation activity (+95%). Looking at the sensitivity of R&D expenditures on venture capital, we find that a 10% increase in venture capital leads to a 10.32% increase in R&D expenditures, which corresponds to about 5 additional R&D employees. From there our results provide evidence that equity financing is instrumental for making risky investments and building innovation capacity in entrepreneurial firms.

The paper is organized as follows. We start by giving an overview of the literature on the relationship between equity financing and innovation, particularly addressing the role of financing constraints in entrepreneurial ventures. In section 2.3 we provide a theoretical framework to arrive at testable hypotheses. Section 3 gives an overview of the angel investor grant in Germany and how we exploit it for our identification strategy and estimation approach. Data sources and our sample are described in section 4. In section 5 we give an overview of our results. We conclude in section 6.

2 Literature and theoretical framework

2.1 Outside equity and growth opportunities

The finance literature holds conflicting views on the cost of outside equity, and how it relates to firms' investment decisions and ability to seize valuable growth opportunities. Based on Akerlof's "lemon argument," Leland and Pyle (1977) and Myers and Majluf (1984) point to the problem of information asymmetries between firms and investors. Information asymmetries may drive up the cost of capital and prevent efficient allocation of funds, keeping firms from seizing valuable growth opportunities. In entrepreneurial firms, where the entrepreneur's ability is crucial to the success of the venture but remains difficult to assess, information asymmetries may pose a fundamental problem to the efficient allocation of funds (Amit, Glosten, & Muller, 1990). This problem of adverse selection should be particularly problematic when signals about entrepreneurs' ability are difficult to assess. In the extreme case where "supply of poor projects is large relative to the supply of good projects, venture capital markets may fail to exist" (Leland & Pyle, 1977, p.57). It is important to note that the argument does not imply that there are no good projects in the market, only that investors and entrepreneurs fail to exchange information in a way that would allow them to base each others assessment on accurate information. The empirical distribution on the use of equity financing in various countries (including Germany, the U.K., and the U.S.) seems to support this pecking order hypothesis. Only a fraction of entrepreneurial firms use equity financing and the majority of small and medium sized businesses uses debt financing (Cosh, Cumming, & Hughes, 2009; Achleitner, Braun, & Kohn, 2011; Robb & Robinson, 2014).

The extend to which information asymmetries limit firms from seizing equity capital is currently subject to debate. For example Fulghieri, Garcia, and Hackbarth (2020) show that within the adverse selection framework, companies may prefer equity financing when there are high information asymmetries on assets in place, and growth opportunities are risky and take long to materialize. This suggests that there is not a general preference order of financing choices, but rather firm specific characteristics determine firms' financing choices. Along this line of thinking, and more important to the general debate on capital structure over the past two decades, have been arguments based on the theories of agency and incomplete contracts. These models have focused on the incentive effects of equity-based securities, linked to the fact that equity gives investors the right to participate in the upside potential of the firm, as well as extensive information, monitoring and control rights. Under this view, providers of equity capital are informed "insider investors" (such as angel investors and venture capital funds) allowing companies to make optimal investment decisions (Admati & Pfleiderer, 1994; Myers, 2000). An important difference is that in these models, equity financing emerges endogenously as the preferred financing choice of firms, conditional on firms' organizational setting. In other words, the underlying theories provide conditional (not general) predictions about the firms' optimal financing structure (Myers, 2003), given firms' idiosyncratic features related to strategic orientation and production technology (Hellwig, 2009). This literature predicts that firms prefer equity financing when there is little collateral, growth opportunities are large but risky, and payoffs are highly skewed (Ueda, 2004; Winton & Yerramilli, 2008). Also, equity-based securities are preferred when investors provide important assets to the firm that are complementary to those of the entrepreneur (Casamatta, 2003; De Bettignies & Brander, 2007; De Bettignies, 2008). These theories also predict, that ex-ante information issues are less relevant to financing decisions when existing assets of a company are less specific and can be replaced. When investors have control over assets in place, they can replace those assets and ensure efficient allocation of funds (Aghion & Bolton, 1992; Hellmann, 1998). Whether such contracts are feasible depends on founders willingness to engage and submit to such contracts and the investors ability to replace existing assets. The empirical observations on contract design (Kaplan Strömberg, Dland Studie), as well as the fact that equity financed firms grow faster, are more valuable and more often go public support this view.

2.2 Financing constraints and innovative entrepreneurship

Based on the argument made by Myers and Majluf (1984) on the role of information asymmetries in capital markets, a large literature has emerged on the role of financing constraints on corporate investment decisions (Fazzari & Athey, 1987; Fazzari, Hubbard, & Petersen, 1988; Himmelberg & Petersen, 1994; Carpenter & Petersen, 2002a, 2002b), as well as the role of liquidity constraints for entrepreneurship (Evans & Jovanovic, 1989; Holtz-Eakin, Joulfaian, & Rosen, 1994). The overarching goal of this literature is to answer whether capital market imperfections constrain firms' ability to exploit valuable growth opportunities. The main point in the seminal paper by Fazzari et al. (1988) is that there exists a middle group type of company whose financing needs exceed their internal funds, but are too small to raise (additional) capital from (public) equity markets. Within the literature on financing constraints, special attention has been given to the question whether financing constraints limit firms' ability to make investments in research and development activities (R&D) (Hall & Lerner, 2010; Czarnitzki & Hottenrott, 2010). The reasons for a focused consideration of these investments are on the one hand their outstanding importance for competitiveness and economic growth, and on the other hand the fact that R&D investments are predominantly investments in intangible goods, such as the knowledge stock of the firm. Intangible assets are poor collateral by comparison and thus exacerbate information problems with financiers, particularly those with inferior monitoring capabilities such as banks. But even if financiers like equity holders are able to monitor firms, this monitoring will be very costly. These higher costs will materialize in higher costs of equity for these firms and cause financing constraints, particularly for firms with more risky investment strategies (R&D). From there investments in R&D should be particularly affected by financing constraints.

2.3 Theoretical framework and hypotheses

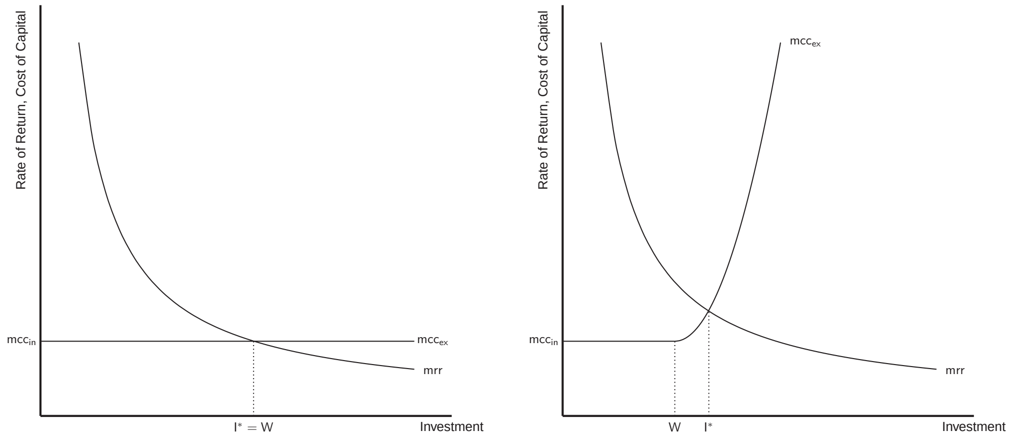
For our theoretical framework we have in mind a simple investment model like the one proposed by Kaplan and Zingales (1997), but adapted to the context of entrepreneurial firms and our particular research question. Our exposition is similar to Hottenrott and Richstein (2020) who adapt the framework developed by Howe and McFetridge (1976); David, Hall, and Toole (2000) and Hottenrott and Peters (2012) to the context of entrepreneurial firms. While the analysis by Hottenrott and Richstein (2020) is concerned with the effect of grants and subsidized loans on innovative entrepreneurial activity, we focus on the effect of shifts in a subsidy equity capital.

Demand for equity capital We have in mind a market, where entrepreneurial firms with innovative ideas are looking for funds. In each period, there is a number of entrepreneurs that start a company i based on an innovative idea. The value of each idea is reflected in an expected rate of return. To be realized, firms need to make investments I_i that are made from internal funds (W_i) as well as external resources (E_i). Ideas with a larger expected rate of return are realized first, such that the demand curve for external funds (D) - reflecting ideas' marginal rate of return (MRR_i) - is downward sloping. The location and curvature of the MRR_i depends on the level of investments I_i, as well as founder, firm and industry characteristics (X_i) and the technology that firms employ ($f(\cdot)$). The fact that D is downward sloping implies that to achieve the same MRR_i companies with higher innovative capacity require more external funds. Since these firms can employ the external capital productively, the surplus that they generate for a given rate of return is higher. We assume that firms with a higher innovative capacity spend (more of) their funds on research and development activities ($R\&D$) for example, to build absorptive capacity.

Supply of equity capital Since our focus is on the role of equity financing, we only consider this financing form, leaving aside other financing forms. To arrive at a testable hypothesis on the relation between equity financing and firms' risky investments, we need to have a notion of the marginal cost of equity. Our illustration of the cost of capital is based on Hyytinen and Toivanen (2005) who show in a simple model of firm level investment why capital market imperfections may lead to constraints in firm R&D and growth. Consider first the benchmark of a perfect capital market and the case of a perfectly informed 'inside investor' (see for example Admati and Pfleiderer (1994)). Such an investor has the same information as the entrepreneur; thus, there are no information asymmetries between the investor and the entrepreneur. Equity-like contracts emerge as a 'robust' security that allows firms to overcome agency issues. The benchmark investor disposes of sufficient liquidity to make investments at efficient scale and internalize potential externalities, such that no collective action frictions arise.[1]

The left hand Panel (a) in Figure 1 depicts a situation of fully informed 'inside investors'. The outcome with such an investor is efficient, in that equity financing ensures an optimal

[1] This is achieved, for example, through effective patent protection, and implies that funds are large enough to litigate against deep-pocket competitors for potential patent infringement.



(a) Perfect capital market.

(b) Capital market imperfections.

Figure 1: Market for outside equity financing.

Figure 1 depicts the market for equity financing. Panel (a) depicts the case of a perfect capital market where investors are fully informed about ventures. Panel (b) depicts an imperfect capital market, where either investors are partially uninformed or subject to constraints.

continuation and investment strategy. Outcomes are thus equal to a situation in which the entrepreneur could fully finance the project alone.

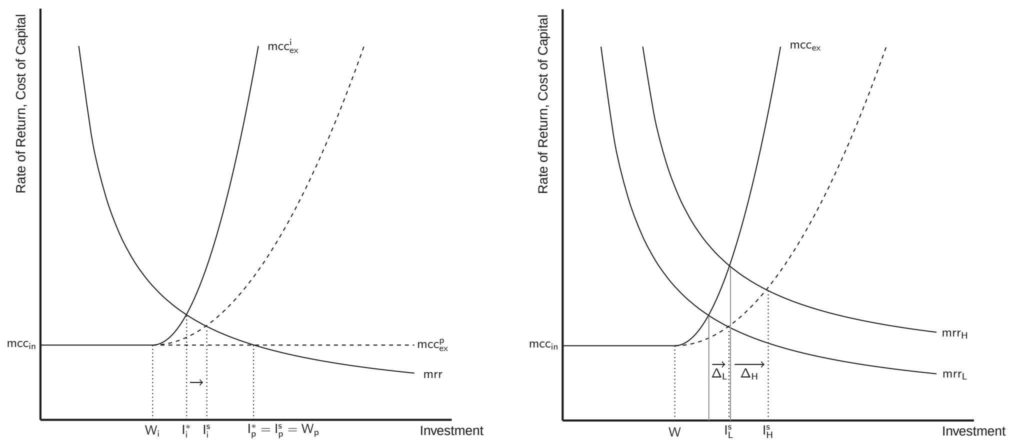
Next focus on the case of imperfect equity capital markets in Panel (b). In such markets, equity-like securities provided by informed investors may be the preferred or even the only *feasible* financing instrument, but still fail to result in an efficient allocation of funds. This could be the case because inside investors may be liquidity constrained themselves due to capital market regulations and other institutional characteristics of an economy. For example, Kortum and Lerner (2000) show that in the U.S., changes in the regulatory environment increased fundraising opportunities of venture capital funds and markedly shifted the supply curve of equity capital. In the case of private investors, liquidity constraints could be a result of their wealth being tied up in specific and inseparable assets, which are difficult to pledge as collateral.[2] If significant portions of wealth are tied up in such assets, private individuals may have limited investment capacity. Risk aversion may also be a limiting factor preventing private individuals to become inside investors and commit significant funds to entrepreneurial firms. Given that the minimum efficient scale of an investment in an entrepreneurial firm may be relatively large, achieving diversification requires significant funds that may exceed the amount of assets an individual is willing to commit to high risk investments. A final argument why firms may find it difficult to find sufficient equity capital for their venture is that investors in a specific institutional setting may have a preferred risk habitat that limits their attention to specific assets. [3].

[2] Think of the owner of a family business whose resources may be tied up in the firm. Unlike publicly traded stock these assets cannot be easily liquidated. As ownership of such an asset is concentrated and cannot be easily separated, it is unsuitable as collateral.

[3] Other arguments for inefficiencies in equity financing relationships but not discussed here in more detail are based on dynamic agency issues (Bergemann & Hege, 2005; Biais & Perotti, 2008, e.g.), and search frictions (Engineer, Schure, & Vo, 2019; Cipollone & Giordani, 2019)

With imperfect capital markets, either because of liquidity constrains, risk aversion or behavioral biases of investors, the marginal cost of equity capital is increasing in the amount of funds required. Note that this is different from the original literature on financing constraints, that was build on the notion of a pecking order in which equity financing in public markets is a last resort. It is however consistent with the assumptions in Brown et al. (2009) who postulate an increasing marginal cost of equity curve. However their analysis focuses on public equity markets in which they attribute increasing marginal cost of equity to increasing flotation costs. The right hand side Panel (b) in Figure 1 depicts an imperfect capital market in which private investors are liquidity constrained or risk averse.

Ad valorem subsidy and investment decisions In an imperfect capital market where investors are liquidity constrained, risk averse or subject to behavioral biases, subsidies on equity capital might alleviate sub-optimal investment decisions.



(a) Ad valorem subsidy.

(b) Heterogenous e□ects.

Figure 2: Subsidy on outside equity capital.

Figure 2 depicts the e ect of an ad valorem subsidy on outside equity capital. Panel (a) shows that the subsidy should have an e ect on the level of investment in imperfect capital markets, but not in perfect capital markets.

Figure 2 depicts the effects of an ad valorem subsidy on equity capital. Such a subsidy decreases the cost of capital for investors. Assuming that the market for equity financing is competitive, investors will pass the subsidy to firms, allowing them to raise more financial capital from investors. Having more funds available should allow firms to make more investments in risky and innovation related projects. Note that only in case of imperfect capital markets does the subsidy increase the level of investment (Panel a). In a perfect capital markets, firms already make optimal investment decisions. Also The effect should be more pronounced for firms with higher growth opportunities.

From there we arrive at the following two hypotheses:

Hypothesis 1: *A subsidy for angel investors should have a positive e ect on the supply of equity capital.*

Hypothesis 2: *An increase in equity finance should have a positive e ect on innovative entrepreneurial activity - like R&D expenditures and R&D employment.*

3 Empirical approach

3.1 The INVEST program for Angel investments

In May 2013, the German Federal Government introduced the program "INVEST - Grant for Venture Capital". The program intends to stimulate equity investments by private individuals (Angel investors) in young and innovative companies, by motivating existing investors to make additional investments, and attracting new people with an entrepreneurial (or managerial) background to become investors. For eligible investments, investors receive a tax-free grant amounting to 20% of the initial investment amount. Since 2017, the program also reimburses follow-up investments, but only if the initial investments received the grant. The revised guideline also includes a tax exemption on capital gains from existing investments that received the grant. As such the program constitutes a reduction in investment cost for eligible investments.

Between the start of the program and May 2019, 8,175 investments applied for the grant, which corresponds to 5,453 individual investors. In total, 6,441 applications of 4,399 individual investors in 1,656 different companies have been granted. To put this into perspective, Berger, Egeln, and Gottschalk (2020) estimate that about 5,120 firms in high-tech sectors and below the age of four, received an investment from a private individual in the years 2015 to 2018. Based on this estimates roughly a quarter to a third of all high-tech startups were funded by angel investors who received the grant. The average (median) subsidized investment amount per individual investor is 81,679 Euros (50.000 Euros), which corresponds to a subsidy of 16,334 Euros (10.000 Euros) per investment. About half of the investors that have participated in the program have received grants between 10.000 and 50.000 Euros, about a quarter of investors have received from 50.000 to 100.000 Euros in grants, and about 20% of investors received more than 100.000 Euros in grants. In 2019, the annual budget of the program was at 46 Mio. Euros, which is roughly equivalent to the previous years. Between 2013 and 2019, half of the earmarked funds in the federal budget were called up, which corresponds to an average call-up amount of around 21 Mio. Euros per year. In total, around 105 Mio. Euros in public funds went into the program in the corresponding period. Based on the funding quota, the program matched approx. 525 Mio. Euros of investments in young and innovative firms in Germany. This corresponds to about 13% of Early Stage Venture Capital that went into German startups in that time period, based on the numbers of *Invest Europe*, Europe's largest Private Equity association.

A major objective of the program is to keep approval times fast and administrative cost low. To this end, both the application process and eligibility criteria are kept simple. The application process is a two-step process. First, the company in which the investor seeks to invest in must have its eligibility certified. Then the investor submits his or her application for the grant. An exemption is provided for companies that are not yet incorporated. In this case, the investor can obtain approval before the company is founded. The company is then reviewed after it has been entered in the commercial register.

To be eligible, investments must be made directly by the individuals who invest into the company. Investments from individuals that have been affiliated with the company prior to applying for the grant are not eligible.[4] This requirement essentially excludes venture capital funds and corporate insiders from the program. The program covers only equity based investments, that result in an increase of the company's financial resources. This excludes secondary transactions of existing equity or subsequent conversion of existing credit lines or subordinated loans into equity. An exception are convertible loan contracts. These are covered by the program since the revision of the guidelines in 2017, and the grant is paid out once the loan has been converted into equity. The investment amounts covered by the program are capped at the top and bottom. The minimum investment amount per company is 10,000 Euros, and per year investors can claim a maximum of 500,000 Euros of their venture capital investments for the subsidy. The assessment basis for the subsidy is the share price of the issued equity, including a share premium, if this had to be paid.

Regarding companies, the following eligibility criteria apply. At the time of the application, companies must be privately held corporations, no older than seven years.[5] Their annual revenues and balance sheet totals must not exceed 10 million Euros, and they must not have more than 50 employees. The Head Office of the companies must be within the European Union and at least one branch or permanent establishment must be located in Germany.[6] Companies can claim a maximum of 3 million Euros in venture capital per year for the subsidy, which corresponds to a maximum funding amount of 600,000 Euro per company and year. Importantly for our research design, companies have to operate in specific industries to be eligible for the grant. These eligible industries are defined by a list of NACE industry codes that the government considers to be particularly prone to innovation activity.[7] The assignment to a specific industry is based on the company purpose, as specified in the official business register. When applying for the investor grant, firms have to provide this information in addition to the NACE-code of the main industry they operate in. The information is reviewed and validated by the Federal Office for Economic Affairs and Export Control (BAFA) - the administrative body responsible for the program administration of INVEST - using additional resources such as official busi-

[4] The grant has to be reimbursed if the investment relationship between the investor and the young company is terminated before the minimum holding period of three years. In addition, the subsidy must be repaid by the investor if the investor enters into a further relationship with the young company within these three years, e.g. increases the shareholding to over 25% or acquires more than 25% of the voting rights. An investment in a subsidiary of the subsidised company is also considered to be a link if this share exceeds 25%. The state subsidy for the completed investment in a young eligible company amounts to 20% of the issue price of the acquired Shares up to the amount of 250,000.

[5] Up until 2017 the maximum age threshold was set at ten years.

[6] Furthermore, according to the EU directive, the company must not be in difficulties, i.e. not be in a state of insolvency or even bankruptcy.

[7] There are possible exemptions to this rule, for example if startups have a valid patent or are have received funding through a public research funding program in the last two years prior to the application. However, this applies to only 2% of all eligible companies (Gottschalk et al., 2016), which in turn implies that for 98% of eligible companies the decision was based on the industry criterion.

ness register documents and firm-websites. According to a recent government statement, about ten FTE employees are responsible for administrating the program at BAFA. The government's definition for innovative industries is highly correlated with R&D-intensities at the sector level (see Figure 4). On average, firms that operate in eligible industries have higher R&D-intensities than firms in other, non-eligible industries.

In the following section we explain how the design of the program allows us to tackle the endogenous nature of the relationship between equity financing, innovative entrepreneurial activity and firms' risky investments.

3.2 Identification

Analyzing the relationship between funding choice in general (and specifically equity financing) on the one hand and firms' (risky) investment choices and innovation activities on the other hand is a difficult task because both are strategic choices of the firm. In that sense they inherently depend on the preferences of firm owners and the growth opportunities attached to their business opportunity. We have seen in the previous section that equity capital may be more suitable to finance risky investments (because of compatibility with investor incentives through superior monitoring abilities and participation with the investment's upside potential) and should therefore have a positive effect on firms' ability to pursue risky strategies. However, the choice to pursue risky strategies is strongly driven by the firms' growth opportunities which in turn will also affect their ability to raise external equity capital. Investor's may be willing to finance risky projects because they observe the growth opportunities attached to a firm that remain unobserved by the econometrician. In that scenario, it is not (only) equity that enables the firm to pursue risky strategies but also future growth prospects arising from the ability and preferences of the owners. Hence, the confounding (and unobserved) growth opportunities will bias estimates of the causal effect of equity on risky investments.

To identify the effect of access to equity financing on innovative entrepreneurship, and firms' ability to make risky investments, we need exogenous variation in the propensity to finance investments using equity. As outlined above, the INVEST program delivers us with exactly this kind of variation by constituting a cost shifter in the cost of external equity to a set of eligible industries irrespective of firm's individual growth opportunities and R&D strategies.

We use an approach that is similar to the one used by Duflo (2001) in the context of returns to education. Our approach uses firm level variation in eligibility criteria for the INVEST program. Investments in eligible firms experience a reduction in the cost of capital when applying for the program. This should increase the likelihood of firms that are eligible to the program to access outside equity, and exogenously increase the supply of outside equity in those industries.

In fact looking at Figure 3 provides visual evidence that firms in eligible industries experienced a clear increase in the equity financing after the program was introduced.

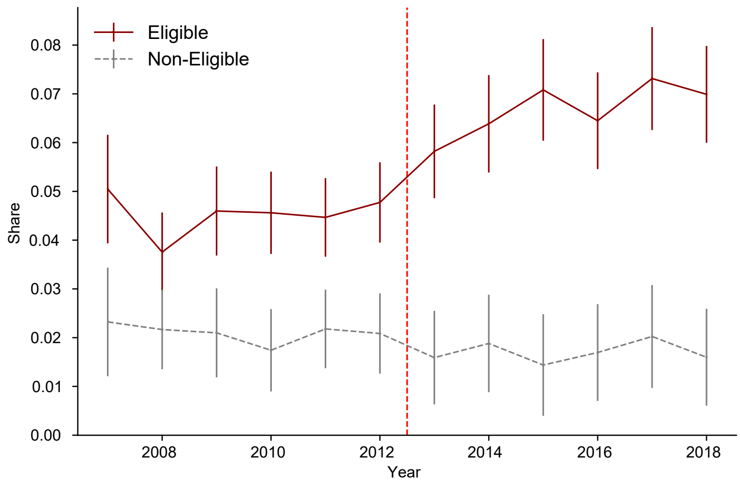


Figure 3: Share of Equity Financed Startups by Eligibility.

Figure 1 shows the share of startups receiving an equity investment in eligible (black) and non-eligible industries (gray) by reference year. The red line shows the point in time when the policy program was introduced. The error bands depict the 95%-confidence interval.

Also it does not seem to be the case that firms in eligible industries experienced a relative increase in equity financing prior to the introduction of the program. In this respect, we are confident that the program has been instrumental in increasing equity financing in eligible industries.

Our definition of eligible firms is based on the governments definition of innovative firm, which as it turns out is mostly based on the definition of innovative industries. According to the guidelines, companies that have already received project funding are also considered eligible. However, the evaluation of the funding data by Gottschalk et al. (2016) shows that this criterion only applies to 2% of the funded companies.[8] Also the program's top rejection criterion (after incompleteness of application) is that companies do not match the program's definition of innovativeness. In addition, other firm level eligibility criteria like the size and age thresholds defined by guidelines provide too much slack to serve as a meaningful cutoff point for a control group. According to the official program statistics, only 1% of the companies that have applied for eligibility have more than 40 employees. About two thirds of all applicant firms have less than 5 employees. The average age of the companies whose investors received the grant was 2 years at the time of approval. This is in line with the notion that angel investors invest in small and young companies. The local treatment effects that would be identified at the size and age threshold would not give meaningful result for the average investment. In the sample we use, we make sure to include firms that are comparable in size and age, such that these criteria should not be

[8] Since the revision of the guidelines in 2017, eligibility can also be certified via proof of innovation, which a□ects a total of 6% of all eligible companies. However, it is unclear how many of these companies were funded by an investor. Thus industry a□liation is the most important criterion for the assessment of innovativeness.

material for our analysis.

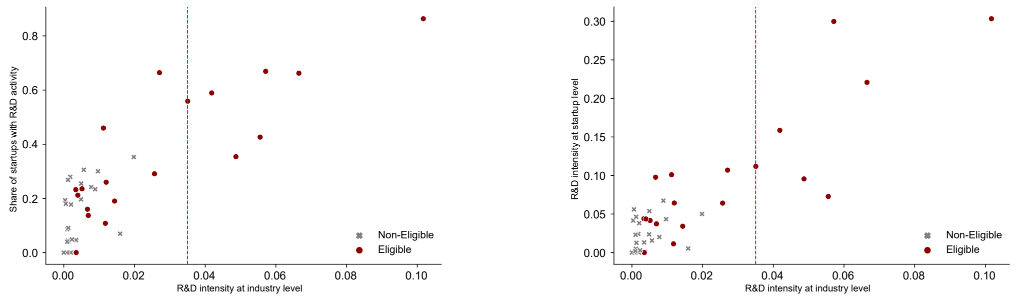
Investments in eligible industries experience a reduction in the cost of outside equity, irrespective of the actual R&D activity within those firms. In other words, the use of funds from the grant is entirely up to the investor and is not attached to any specific purpose. Firms in eligible industries should find it easier to access outside equity and experience an increase in supply of outside equity since the program has been introduced.

One concern with using eligibility based on the governments definition of innovativeness is that there is not enough variation in innovation related outcomes. In that case, the guidelines by the government would (almost) perfectly discriminate firms innovation potential and R&D strategies. In the following we will provide some evidence, that this is not the case, and that the definition used by the government still allows for variation in *realized* innovation performance, between eligible and non-eligible firms. An important aspect of our identification strategy is that firms in eligible industries were eligible irrespective of their realized R&D activity, and that the use of funds from the grant is entirely up to the investor and not attached to any specific purpose. As mentioned in Section 3.1, the definition of innovative industry is highly correlated with R&D-intensities at the industry level. Industries that spend more than 3.5% of their revenues on R&D are considered to be in the group of high-tech industries.

Figure 4 shows that industries that are above this threshold are all comprised in the programs definition of eligible industries. As Hughes (1988) argues, industry level R&D-intensities may be misleading when assessing innovation performance at the firm level, as intra-industry distributions of R&D-intensities - and therefore innovation performance - are fairly dispersed. Likewise, Catalini, Guzman, and Stern (2019) analyse founding choices of virtually all US businesses and find that firms realize growth opportunities irrespective of their funding choices. Firms can achieve high R&D-intensities both in any industry and with different choices of funding. Program eligibility therefore simply lowers the cost to access external funding to a subset of firms but should not be structurally related to their growth opportunities and potential R&D performance.

Panel (a) of Figure 4 provides some evidence regarding this point. It plots the share of startups with R&D activity in our sample against industry average R&D intensities in a particular industry.[9] Each point represents an eligible or non-eligible industry code. While clearly some eligible sectors do have the highest industry R&D intensity and activity, also many non-eligible sectors show significant startup R&D activity. As the program is based on *average* industry performance measures, there is variation in *realized* innovation performance. This variation goes in both directions. Within eligible industries there are firms that do not pursue risky R&D projects, and likewise firms in non-eligible industries may engage in innovation activities. Especially for non-hightech industries, the definition of innovative industries seems to be rather arbitrary and does not match with the data on realized innovation activity. This last point is supported by anecdotal evidence from

[9] Industry average R&D intensities come from o�cial statistics and not only include startups but all firms in an industry.



(a) Share of R&D conducting firms

(b) R&D intensity of startups in sample

Figure 4: Share of Equity Financed Startups by Eligibility.

Figure 2 shows the share of startups conducting R&D plotted against the R&D intensity at the industry level plotted against. The share of startups conducting R&D was calculated from our sample using population sampling weights. Sampling weights are available for firms not older than four years. The R&D intensity at the industry level is from taken from administrative statistics. Industries are aggregated at NACE 2 level. Industries with NACE codes 13, 25 and 32 were not considered because eligible and non-eligible industries are mixed. Industries with NACE codes 12 and 19 were not considered because of low number of firms in the sample. For better readability of the figure, NACE 72 (Scientific research and development) was also not considered. For NACE codes 41-43, 45, 47, 55-56, 68, 77, 85, 90-93, and 95-96 RD intensities at the industry level are unavailable.

talks to investors and startup founders in the course of a program evaluation, and was criticized as one of the shortcomings of the initial program design (Gottschalk et al., 2016).[10] In its revised form, starting in 2017, the program guidelines allow for a 'proof of innovativeness' to become eligible for the grant without operating in an innovative industry. The proof of innovation is provided in the form of a short expert report prepared by an external organization. However, according to a recent government evaluation the program guidelines now seem to be too vague for many firms and investors. Therefore the change in the guidelines did not really have a visible effect on non-eligible firms (see Figure 3).

One limitation of our data is that it does not differentiate between equity investments that were matched by the grant and those that were not. From there our measure captures both investments by angel investors that received the grant, and those that did not receive the grant, including investments from venture capital firms that are not eligible to the grant. While in principle, this could be an issue for our identification strategy, we believe that it is not material to it. First of all, investments by venture capital funds constitute a much smaller proportion of all equity investments. According to estimates by Berger et al. (2020), they constituted only a fifth of the investments made by Angel investors in young firms in the period 2015 to 2019. Second, the estimated increase in young hightech companies that were financed by Angel investors compared to the period 2009-2012, roughly

[10] The founder of Lyzca - a company engaging in innovative food products - said "*We had significant R&D expenditures, yet our company did not qualify for the INVEST program as a technology firm, because we operate in a non-eligible business sector. However, I think that digitization and technologies such as machine learning have an impact on all sectors of the economy, and therefore opens up innovation potential in all sectors of the economy. As policy makers cannot predict in which sector the next great innovations will appear, the classification of innovative sectors can be quite arbitrary.*"

matches the number of firms whose investors received a grant by INVEST program. The results by (Berger & Gottschalk, 2021) suggest that most of this additional deal flow has been generated by new investors entering the market. These investors seem to be quite important, as they constitute about 50% of applicants (Keil, Hinrich, Theunissen, & Hagedorn, 2019). From there we are fairly certain that the increase in deals is driven by the program, and therefore constitutes a valid instrument to estimate the causal impact of equity financing on innovative entrepreneurship and risky investments decisions.

3.3 Wald Difference-in-Differences Estimator.

We estimate our models using a Wald-Differences-in-Differences estimator (see for example Duflo (2001) for an application of the method to a school construction program in Indonesia). In the first stage, we use a differences-in-differences estimator to estimate how a reduction in the cost of outside equity (i.e. the introduction of the program) changes the propensity of startups' to use equity financing.

$$E_{it} = \alpha_1 + \beta_1 ELG_i \times POST_t + \gamma_1 X_{it} + \tau_i + \phi_i + u_{it}, \tag{1}$$

where ELG_i is an indicator for whether startup i is in an eligible sector, and $POST_t$ is an indicator when an observation is after 2013 (the year the policy was introduced). E_{it} is an an indicator whether startup i has issued equity in year t, X_{it} is a set of control variables, τ_i represents a year fixed effect, and ϕ_i a firm fixed effect.

Using the first stage predictions $\hat{E_{it}}$, we then use a two-stage-least-squares estimator to estimate how the reductions in the cost of outside equity affect R&D investments:

$$R_{it} = \alpha_2 + \beta_2 \hat{E_{it}} + \gamma_2 X_{it} + \tau_i + \phi_i + u_{it}, \tag{2}$$

where $R_{it} = \{R\&DActivity, R\&DExpenditures, R\&DEmployees\}$ are the main outcomes of interest.

4 Data.

4.1 Data sources and sample.

Our analysis is based on data from the IAB/ ZEW Startup Panel (SUP).[11] The SUP is a yearly survey among legally independent startups located in Germany and has been in existence since 2007. The sample is stratified and startups from high-tech industries are over-represented. When entering the survey startups must not be older than three years, and they remain in the survey up to their seventh year. We use the first eleven waves of the SUP ranging the founding cohorts 2005 to 2017. Since the second wave in 2009, between

[11] A full documentation on the the IAB/ZEW Startup Panel is provided in Fryges, Gottschalk, and Kohn (2009).

3,500 and 8,000 startups are newly entering the panel. In the first wave a larger sample of 23,000 startups entered the survey. In total between 6,000 and 8,000 startups participate in the survey each year. This gives us a sufficiently large sample to test our hypothesis.

For our main analysis we use the following information from the SUP: (1) startups' industry classification, (2) startups' patent stock, (3) startups' R&D decisions and (4) startups' financing decisions. For additional analyses we use information on founding team characteristics, as well as startups' incorporation year, location and legal form from the SUP. The information on industry classification and patent stock allow us to circumference startups that qualify as eligible investments.

The funding agency considers investments to be eligible if the portfolio company fulfills the following criteria (1) it is at most ten years old (2) it has at most 50 employees and maximum yearly sales of 10 M Euros.[12] More than 99% of startups in of firms in the raw sample fulfill these criteria. Therefore we focus on the second set of criteria, that require that startups (3) operate in an 'innovative industry' (see table B.3 for the list of industries that qualify as innovative), (4) hold a patent that is related to its business objective or (5) has recently received an innovation grant.[13]

Our indicator for risky investment projects is based on the SUP's questions on R&D activity. Startups are asked about whether or not they have started R&D projects[14] in the reference year, either by conducting own R&D or awarding R&D contracts to third parties. Startups that indicate one of the latter to be true are then asked about the total R&D expenditures in the reference year, including both own and awarded R&D. Our indicator on equity investments is based the SUP's questions on financing decisions. The data distinguishes between the sources of equity capital. This allows us to identify startups that have used external equity capital, i.e. capital that is provided by investors rather than the founders, in the reference year.

4.2 Measuring the key variables

Equity financing:

We approximate the level of equity financing based on total cost accounting measures.

$$\tilde{E}_{it} = \left(I_{it}^{fix} \cdot \omega_{it}^{fix,ext} + \left(\sum_{k \in K} c_{it}^{k} \right) \cdot \omega_{it}^{oc,ext} \right) \cdot \omega_{it}^{equity}, \tag{3}$$

where I_{it}^{fix} are investments in fixed assets, $\omega_{it}^{fix,ext}$ is the share of fixed assets financed by

[12] This constitutes an SME accoridng to the definition of the European Commission (O□cial Journal of the EU L 124/36 of 20.05.2003)

[13] Note that requirements (4) and (5) are rarely used for the decision. Only for 2% of applicants is the decision based on those two criteria, which suggests that they are generally too costly for firms to make themselves eligible.

[14] In the survey R&D projects are defined as "systematic creative work to expand existing knowledge and use the acquired knowledge to develop new applications", and includes RD work commissioned by third parties.

Table 1: First stage results of program effects on equity financing

	Firm-Year Obs.	Mean	SE	Min.	Max.
Financing					
Equity (Y/N)	34,723	0.04	0.18	0	1
Equity (in tsd.)	1,150	254.52	748.86	0	14,800
Investment					
R&D activity	34,723	0.28	0.45	0	1
R&D expenditures (in tsd.)	9,863	87.59	179.34	0	2,000
R&D employment	6,911	2.59	3.78	1	100
	Firm Obs.	Mean	SE	Min.	Max.
Firm Characteristics					
Team	17,180	0.32	0.47	0	1
Founding exp.	17,180	0.41	0.49	0	1
Success. exit before	17,180	0.08	0.27	0	1
Industry exp. at start	17,180	14.04	9.89	0	60
Opportunity	17,180	0.36	0.48	0	1
Founder holds PhD	17,180	0.06	0.24	0	1
Academic	17,180	0.48	0.50	0	1
Female	17,180	0.10	0.30	0	1
Patent	17,180	0.03	0.18	0	1
Size at start	17,146	2.47	3.60	1	242
Limited	17,180	0.51	0.50	0	1
Region					
West	17,180	0.82	0.39	0	1
Berlin	17,180	0.04	0.21	0	1
East	17,180	0.14	0.34	0	1

Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

external funds, c_{it} are operating cost, where $K = \{wages, materials, other\}$, $\omega_{it}^{oc,ext}$ is the share of operating cost financed by external resources, and ω_{it}^{equity} is the share of external funds provided by external equity capital. Note that the difference between the estimated equity capital used and the equity capital provided are the cash reserves that the firm holds. Therefore our estimate tends to underestimate the amount of equity capital that firms receive. On the other hand, given that equity investors tend to keep financing tight and stage their investments into several rounds, the difference can be expected to be small.

Note that the data does only allow us to differentiate between different types of venture capital investors from 2015 on wards. From there we do not distinguish between different types of equity investors in our analysis. However we do see that about 2/3 of firms that use equity financing in the sample starting from 2015 onwards, receive capital from private investors. Also Berger and Gottschalk (2021) show that the share of firms receiving standalone investments form venture capital funds has remained relatively constant in the considered period.

Our outcome variables are taken from the following survey items that are asked in every wave of the SUP:

R&D activity:

> *"Did your company conduct its own research and development activities in the year ...? We define research and development as the systematic creative work to expand the existing knowledge and the use of the knowledge thus gained to develop new applications. Own research and development work also includes R&D work that the company has been commissioned with by third parties."*

R&D expenditures:

> *"How much did you spend on research and development in the year ..., including R&D contracts with third parties?"*

R&D employees:

> *"How many of the employees in your company, including the owners, spent at least half of their working time on their own research and development work last year?"*

Note that the way the survey items are constructed, firms may have R&D expenditures even if they are not conducting own R&D, because R&D expenditures include contracted R&D with third parties. One might think that handing out R&D contracts to third parties may be less risky than conducting own R&D. However, Mata and Woerter (2013) show that external R&D strategies are in fact riskier than internal R&D strategies, as profits for firms with external R&D strategies exhibit a higher spread. In robustness tests (not yet reported here), we will investigate whether our results are driven by this, and exclude companies that contract R&D activities to third parties.

4.3 Descriptive results

In this subsection we show some descriptive statistics for our sample. Table 2 shows the number of observations, means and mean differences for the firm-characteristics employed in our empirical analysis. The upper part of Table 2 summarizes all firms in our sample differentiating founding cohorts before and after the policy has been introduced in 2013. In the lower part of the table, the same descriptive statistics can be seen but only for firms that were eligible to the program according to the criteria outlined in section 3.1.

Looking at the upper part of Table 2 we see that firms of founding cohorts before and after the policy was introduced are fairly similar, with a few exceptions: Starting out with basic firm characteristics, 23% of founders of firms from founding cohorts after 2013 already had a successful exit before they started the business, while before the policy was introduced 17% indicated that. In a similar notion, the share of founders with an academic background increased from 69% to 81%. While these differences may raise concerns about an increasing quality of startups after the policy, they may well also reflect the fact that according to OECD statistics the share of Germany's population with academic degrees has been rising in the last decades, while not all of this increase will be attributable to an

Table 2: First stage results of program effects on equity financing

	Founding cohorts relative to policy - Total				
	Before		After		
	N	Mean	N	Mean	Δ
Public subsidy	1,088	0.46	1,761	0.35	-0.107***
Sales (Y/N)	1,080	0.88	1,782	0.86	-0.026**
Sales (in tsd.)	895	719.38	1,474	737.62	18.231
Firm Characteristics					
Team	578	0.61	530	0.57	-0.041
Founding exp.	578	0.59	530	0.62	0.030
Success. exit before	578	0.17	530	0.23	0.059**
Industry exp. at start	578	12.86	530	12.07	-0.792
Opportunity	578	0.60	530	0.62	0.022
Founder holds PhD	578	0.18	530	0.20	0.020
Academic	578	0.69	530	0.81	0.121***
Female	578	0.04	530	0.07	0.025*
Patent	578	0.09	530	0.08	-0.014
Size at start	578	3.40	530	2.97	-0.435**
Limited	578	0.85	530	0.92	0.079***
Region					
West	578	0.81	530	0.74	-0.071***
Berlin	578	0.04	530	0.13	0.081***
East	578	0.14	530	0.13	-0.010
	Founding cohorts relative to policy - Eligible				
	Before		**After**		
	N	Mean	N	Mean	Δ
Public subsidy	757	0.49	1,451	0.38	-0.107***
Sales (Y/N)	752	0.86	1,450	0.84	-0.020
Sales (in tsd.)	609	708.15	1,175	663.66	-44.485
Firm Characteristics					
Team	408	0.66	428	0.59	-0.066**
Founding exp.	408	0.63	428	0.63	0.003
Success. exit before	408	0.19	428	0.23	0.033
Industry exp. at start	408	12.69	428	12.35	-0.348
Opportunity	408	0.67	428	0.63	-0.033
Founder holds PhD	408	0.23	428	0.22	-0.011
Academic	408	0.78	428	0.85	0.064**
Female	408	0.03	428	0.05	0.022
Patent	408	0.13	428	0.10	-0.034
Size at start	408	3.37	428	2.92	-0.445**
Limited	408	0.92	428	0.95	0.032*
Region					
West	408	0.80	428	0.75	-0.056*
Berlin	408	0.05	428	0.12	0.077***
East	408	0.15	428	0.13	-0.021

Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

increase in the population's intelligence. Likewise, as average age of founders (as well as of the population in general) in Germany is steadily increasing, the likelihood to having experienced a successful exit is also larger.

The size of the firms at start decreased slightly by half a percentage point to about 3

FTE employees. The share of firms that choose the limited liability legal form was about 7 percentage points larger after the policy, a trend which can be observed generally in the startup landscape. When looking at the location of business startups there is a clear trend away from West German States towards the Berlin region that has become very attractive for startups especially from the IT-services sectors. Apart from the basic firm characteristics and location we further include an indicator whether a firm received a public subsidy in the respective year and whether and if how much sales the firm generated in a year. We believe that these may serve as substitutes to finance R&D if equity is not available and should therefore be included into the regression. Interestingly, the share of firms funded with public subsidies has been decreasing substantially for founding cohorts after 2013, which may partly reflect a generally improving financial ecosystem for firms. The share for firms that already generates sales is slightly lower.

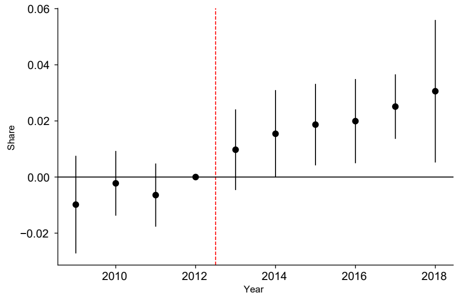
Compared to the upper part, the lower part of Table 2 shows a similar picture for eligible firms with most of the differences being slighly smaller of magnitude and significance. The only notable difference is that fewer eligible firms were founded in teams after the policy was introduced. A cautious interpretation could be that inside investors who play a more active role in an eligible (and funded) business may partly substitute for additional founders.

5 Results

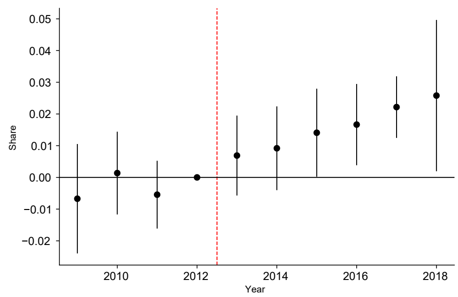
In this section we finally turn to the results of our empirical analysis. We start out in section 5.1 with a visualization of the unconditional and conditional ATET of the effects of the policy program on equity financing. The underlying basic OLS-regression will later serve as the first stage in our 2SLS regression framework. In the following section 5.2, we show the results of a reduced form OLS-regression of innovation outcomes R&D expenditure and R&D employment on Equity capital. Because of the nature of financing and investment decisions described in detail in in section 3.2, we believe that these basic OLS-coefficients are biased. In section 5.3 we therefore turn to a 2SLS analysis using program eligibility to the INVEST program as an instrument for the cost of external equity capital.

5.1 Effect of the program on equity financing decisions

Figures 5 shows the unconditional (Panel a) and conditional (Panel b) dynamic (i.e. yearly) Average Treatment Effects on the Treated (ATET) on the propensity of a firm to finance with equity and Figure 6 on the logarithm of firm's equity capital (Figure 6). Treatment is defined as program eligibility to the INVEST program after 2013. The definition of program eligibility is explained in detail in section 5.1. Controls included in Panel (b) are the variables discussed in the descriptive analysis of section 4.3. Moreover, a set of fixed effects on the levels of *year, founding cohort, industry and region* is employed. The corresponding regressions in a non-dynamic setup (only distinguishing pre- and post-policy periods are shown in tables 3 and 4. These tables at the same time mark the first stage

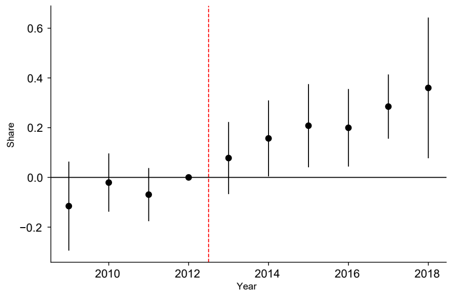


(a) Excluding controls

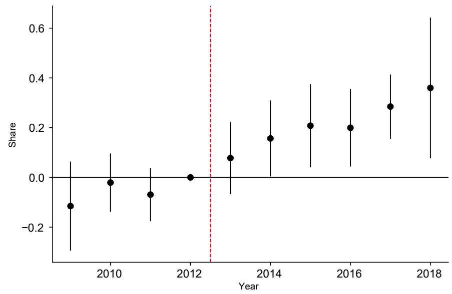


(b) Including controls

Figure 5: Marginal change in the probability to finance with equity between groups.



(a) Excluding controls



(b) Including controls

Figure 6: Marginal change in equity capital (log) between groups.

regressions for the later 2SLS-regressions in section 5.3. For the linear probability models of Figure 5 the ATET are around zero and insignificant for pre-policy periods and increasing and positive by year starting from 2013 onwards while significance at the 5% level holds for the years starting from 2015 for the unconditional regressions and 2016 for the conditional ones. Using log equity as the outcome (Figure 6) shows a similar picture while significance in the conditional setting using firm controls and the set of fixed effects yields significant ATET already from 2015 onwards.

The magnitude of the effects seems reasonable with the propensity to finance with equity increasing by about 1.5% to 3.5%. While this may seem small, the effect is large when we relate it to the baseline probability to use equity financing which is 2%, implying that the policy increased the probability to use equity financing by about 65%. The percentage increase in the amount of equity capital raised is also large, lying around 20% to 35% each year. Yet, the larger coefficients do not come too much as a surprise as (in the startup context) many firms have not raised any equity capital before.

Table 3: First stage results of program effects on equity financing

	(1)	(2)	(3)	(4)
Eligible × Post-Period	0.026***	0.025***	0.021***	0.019***
	(0.006)	(0.006)	(0.005)	(0.004)
Eligible	0.015	0.017	0.007	0.007
	(0.011)	(0.010)	(0.011)	(0.011)
Constant	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Region Fixed Effect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68
R2	0.041	0.043	0.073	0.082

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: Team, Founding Experience, Opportunity driven startup, Academic startup, Female founders, Patent at foundation, Corporation, Foundation Year, Region (East, West, Berlin)

As already mentioned above Table 3 shows the ATET for the propensity to finance with equity and Table 4 for the (log) amount of equity capital raised. However, unlike the dynamic setting in Figures 5 and 6 now only distinguish pre- and post-policy periods. Each of the specifications (1) to (4) employs a constant and a set of fixed effects on the levels of *year, founding cohort and industry code*. Specification (2) includes regional fixed effects, specification (3) adds firm controls and specification (4) finally adds the control variables *public subsidy (Y/N) and sales (in logs)*.

The average effect sizes for specification (1) are 2.6% for propensities and 27.7% for the amount of equity capital raised. The more fixed effects and firm controls are included, the smaller effect sizes become with the propensity to raise equity capital being 1.9% and the

Table 4: First stage results of program effects on equity financing

	(1)	(2)	(3)	(4)
Eligible × Post-Period	0.277***	0.271***	0.229***	0.198***
	(0.058)	(0.056)	(0.045)	(0.041)
Eligible	0.069	0.087	-0.018	-0.019
	(0.103)	(0.101)	(0.100)	(0.103)
Constant	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Region Fixed Effect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68
R2	0.043	0.047	0.077	0.086

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Control Variables: Team, Founding Experience, Opportunity driven startup, Academic startup, Female founders, Patent at foundation, Corporation, Foundation Year, Region (East, West, Berlin)

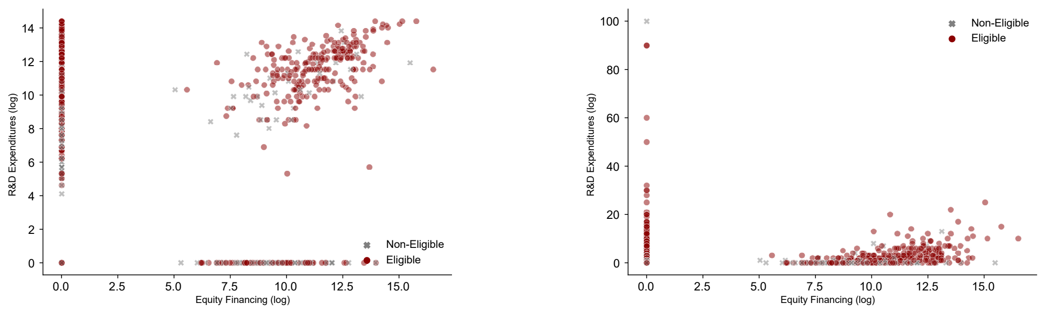
amount of equity capital raised being about 20% larger for treated firms after the policy was introduced in 2013 for the final specification (4). The fact that firm controls and fixed effects take up part of the treatment effect displays that equity financing depends on a variety of factors and is only partly determined by the shrinkage in the cost of equity capital imposed by the policy program.

In the next subsection we turn back to our actual main research question, i.e. whether a reduction in the cost of outside equity enables startups to make (more) risky investment decisions. After we briefly discuss the reduced form results of equity financing on risky investments, we turn to the 2SLS analysis where the regressions in specifications (4) of Tables 3 and 4 introduced here mark the first stage regressions.

Before moving on, these first stage results also already enable us to support our first hypothesis that we developed in our theory section 2.3, which states that a subsidy to angel investors has a positive effect on the supply of equity capital.

5.2 Reduced form results of equity financing on risky investments

In this subsection we briefly discuss the reduced form results of equity financing on firms' risky investment decsions. Before looking at the correlations between equity financing and firms' R%D activity it is important to recall that both are strategic choices of the firm that may or may not depend on each other. Figure 7 highlights this conjecture by plotting log R&D expenditures on the firm level against log equity financing in Panel (a). We see three main clusters, (i) firms with zero equity financing but with positive R&D expenditures, (ii) firms with positive equity and positive R&D expenditures and (iii) firms with positive equity but zero R&D expenditures. All three clusters consist of a considerable number of observations. While the second cluster seems to show at least a slightly positive relationship, the existence of (1) and (3) tells us that (in line with Hughes (1988) and Catalini et al. (2019)) equity capital seems to be neither a necessary nor a sufficient condition to conduct R&D. The same holds for R&D employment which is scattered against log equity in Panel (b).



(a) R&D Expenditures (log)

(b) R&D Employment

Figure 7: Relationship between equity financing and R&D activity.

Figure 7 shows scatter plots of firms' R&D-Expenditures (a) and R&D-Employment (b) against Equity Financing (in logs). Furthermore, eligible and non-eligible firms according to the program definition are distinguished.

Tables 5 shows reduced form regressions using a set of fixed effects and firm controls and confirm the visual interpretation of Figures 5 and 6 by showing a positive relationship between equity and firm's R&D activity. However, we cannot deduct anything about causality from these regressions. [15] Is equity driving firm innovation or is the relationship different? Firms may have high R&D expenditures because of their growth opportunities that are being rooted in the founders' human capital, ambitions and strategies. But these firms could in turn be more attractive for equity investors who observe the growth opportunities. On the contrary, some of these firms may not even need external financing because they are able to attract other financing sources or finance risky projects out of own cash reserves. In other words, it is a-priori unclear in what direction the endogeneity bias goes but it seems likely that the coefficients will be biased. In the next section, we therefore turn to the 2SLS analysis which will give us insights on the magnitude and direction of the bias.

[15] We refrain from going into more detail about coe□cient magnitudes at this point and keep this for later comparison with the 2SLS results.

Table 5: OLS - Correlation between Equity and Innovation Activity

	Outcome: R&D activity			
	(1)	(2)	(3)	(4)
Equity(t)	0.259***	0.255***	0.157***	0.145***
	(0.029)	(0.028)	(0.016)	(0.015)
Constant	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Region Fixed Effect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68
R2	0.225	0.228	0.289	0.293
	Outcome: R&D expenditures			
	(1)	(2)	(3)	(4)
Equity (log)	0.349***	0.345***	0.240***	0.230***
	(0.033)	(0.032)	(0.020)	(0.018)
Constant	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Region Fixed Effect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68
R2	0.253	0.256	0.328	0.333
	Outcome: R&D employment			
	(1)	(2)	(3)	(4)
Equity (log)	0.170***	0.169***	0.142***	0.138***
	(0.016)	(0.016)	(0.013)	(0.013)
Constant	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Region Fixed Effect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68
R2	0.104	0.105	0.130	0.135

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Control Variables: Team, Founding Experience, Opportunity driven startup, Academic startup, Female founders, Patent at foundation, Corporation, Foundation Year, Region (East, West, Berlin).
Column (4) also includes Public Subsidy and log Sales.

5.3 Two stage least squares results of equity financing on risky investments

The endogenous nature of firms' financing and investment decision creates an endogeneity problem when aiming to analyze the causal effect of firms' access to equity financing on their risky investment choices. Both financing and investment are strategic decisions of the firm and are confounded by the firm's growth opportunities, which are unobserved by the econometrician. In order to consistently estimate the marginal effect of equity financing on firm R&D, we therefore need an instrument for the propensity (and magnitude) of firm's equity issuance. As explained in detail above, the INVEST program that partly reimburses private early stage investors in the German seed capital market for their investment in young startup companies delivers us with exactly this kind of variation. It does so by constituting a shift to a firm's cost of equity that is independent of its growth opportunities and actual innovation activity.

The first stage of the 2SLS-approach has already been shown in Tables 3 and 4 where the propensity and magnitude of equity issuance of firms are regressed against the treatment of classifying as eligible for the policy program after the year 2013. In this section now, we present second stage results on firms' R&D activity, their R&D expenditures and R&D employment.

5.3.1 Equity Financing and Innovative Entrepreneurship

Table 6: TSLS - Effect of Equity on Innovation Probability

	(1)	(2)	(3)	(4)
Equity(t)	1.481***	1.429***	0.947**	0.768
	(0.485)	(0.489)	(0.461)	(0.494)
Constant	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Region Fixed Effect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Craig-Donald F	39.8	38.3	28.5	21.6
Robust F	20.0	20.3	22.2	21.1
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Control Variables: ...

Table 6 shows the 2SLS results for the effect of equity financing on overall R&D activity. The Table shows 4 specifications that include different sets of fixed effects and firm controls in the same manner as seen before. Both the ***Craig-Donald F*** and the more restrictive ***Robust F*** statistic support the validity of the employed instrument. The effect of the dummy of external equity issuance turning from 0 to 1 on R&D activity ranges from a 150% increase for the least restrictive specification (1) to about 77% for the most restrictive specification (4) which employs the full set of fixed effect and firm controls. In the most restrictive specification though, we do not find a significant effect on R&D activity. However, all coefficients of the 2SLS regressions of (1) to (4) are substantially larger than the coefficients from the respective OLS-specification in Table 5.

5.3.2 Equity Financing and Risky Investments

The same pattern that is observed for firms' R&D activity shows when looking at the effects of equity financing on the continuous measures R&D expenditure and R&D employment. In the following, the main variables are specified in logs such that we can interpret the coefficients as elasticities.

Table 7: TSLS - Effect of Equity Financing (log) on R&D Expenditure (log)

	(1)	(2)	(3)	(4)
Equity (log)	1.601***	1.556***	1.032**	0.825*
	(0.442)	(0.449)	(0.394)	(0.416)
Constant	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes
Region Fixed Effect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Craig-Donald F	40.2	38.6	28.6	21.4
Robust F	22.8	23.1	25.8	23.2
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Control Variables: ...

Table 7 shows the marginal effect of a 1% increase in equity capital on the total R&D expenditures, Table 8 on R&D employment. Again, the more restrictive the set of fixed effects and controls is, the smaller the elasticity of a 1% increase in equity capital gets. Scaling the effects by a 10% increase in equity, the effects range from 16.0% to 8.3% for R&D expenditure and from 6.3% to 4.5% for R&D employment. All coefficients are again about 4 to 6 times larger than in the OLS-regressions and remain (at least weakly) significant for all specifications. The results of the 2SLS regressions therefore suggest a negative bias of the effect of equity on innovation & R&D, meaning that the true effect of equity on innovation inputs is larger than a simple OLS-correlation would suggest.

Furthermore, the fact that some of the coefficients on R&D expenditures are larger than 1 suggests that the effects on R%D expenditure seem to be over-proportional on the investment amount. This could mean that VCs give the companies more cash through

Table 8: TSLS - Effect of Equity Financing (log) on R&D Employment

	(1)	(2)	(3)	(4)
Equity (log)	0.631***	0.632**	0.524**	0.447*
	(0.233)	(0.241)	(0.242)	(0.259)
Constant	Yes	Yes	Yes	Yes
Year Fixed E□ect	Yes	Yes	Yes	Yes
Founding Cohort Fixed E□ect	Yes	Yes	Yes	Yes
Industry Fixed E□ect	Yes	Yes	Yes	Yes
Region Fixed E□ect		Yes	Yes	Yes
Firm Controls			Yes	Yes
Craig-Donald F	40.2	38.6	28.6	21.4
Robust F	22.8	23.1	25.8	23.2
Number of Observations	34,723	34,723	34,723	34,723
Number of Clusters	68	68	68	68

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: ...

rapid commercialization, which they can then reinvest in R&D. The effect becomes smaller 0 as soon as one controls for sales. This result is in line with Himmelberg and Petersen (1994) who find that internal cash flows have an important impact on R&D expenditures.

6 Conclusion

In this paper we investigate whether equity financing in entrepreneurial firms is instrumental to firms R&D activity. In particular we study (i) whether equity capital increases the probability that firms start R&D projects, and (ii) how sensitive R&D expenditures and R&D employment react to changes in equity capital.

To account for the endogenous nature of equity financing decisions, we exploit the introduction of a major policy program for providers of early stage equity capital in Germany. The program partially reimburses private investors of equity capital (angel investors) when financing eligible companies. This results in exogenous variation in the cost of outside equity between eligible and non-eligible firms over time, and allows us to identify whether equity capital is instrumental for firms' risky investment decisions.

Consistent with theory, we find evidence of a causal link between the use of outside equity financing and innovative entrepreneurial activity. Our instrumented regressions suggest that equity financing doubles firms' propensity to engage in innovation activity (+95%). Looking at the sensitivity of R&D expenditures on equity financing, we find that a 10% increase in venture capital leads to a 10.32% increase in R&D expenditures, which corresponds to about 5 additional R&D employees. From there our results provide evidence that equity financing is instrumental for making risky investments and building innovation capacity in entrepreneurial firms.

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A List of industries

Table A.1: Description of variables.

Variable name	Type	Description
		Financial outcomes
Equity (Y/N)	Binary	Firm received equity capital in year t.
Equity (log)	Continuous	Log equity capital employed for investments or operating expenses in year t.
Subsidy (Y/N)	Binary	Firm received at least one public subsidy in year t.
Sales (log)	Continuous	Log sales in year t.
		Investment outcomes
R&D Activity	Binary	Indicator whether firm engages in R&D in year t.
R&D Expeditures (log)	Continuous	Amount spent on R&D activities in year t.
R&D Employees	Count	Number of employees working on R&D related tasks in year t.
		Firm characteristics
Opportunity	Binary	Startup was founded on a concrete business idea.
Female	Binary	At least one Female member in founding Team.
Founding Exp.	Binary	At least one member of founding Team had started a business before.
Team	Binary	Startup was founded by a Team.
Academic	Binary	At least one member of founding Team has academic background.
Founder holds PhD	Binary	At least one member of founding Team holds a PhD.
Industry Exp.	Count	Years of industry experience of founding Team.
Successful Exit	Binary	At least on member of founding Team has sold previous company.
Startup Age	Count	Age of the startup in reference year.
Size	Continuous	Number of full time equivalents employed at start of the company.
Patent	Binary	Business was started with at least one patent.
Region	Categorical	Location of startup: East/ West/ Berlin.
Industry	Categorical	Business sector of startup: Hightech Manufacturing/ Software & Technical Service/ Non-Hightech.

Table A.2: Industries in sample

Observed	N	NACE code
Non-eligible		
All periods	38	10, 11, 13[a] , 14, 15, 16, 17, 18, 24, 25[b], 31, 32[c], 41, 42, 43, 45, 46, 47, 49, 52, 53, 55, 56, 66, 68, 69, 70, 77, 78, 79, 80, 81, 82, 85, 92, 93, 95, 96
With gaps	8	12, 19, 35, 50, 51, 64, 65, 91
Eligible		
All periods	22	20, 21, 22, 23, 26, 27, 28, 29, 30, 33, 58, 59, 61, 62, 63, 71, 73, 74, 90, 25.6, 32.5
With gaps	2	60, 13.96

[a] Excluding NACE 13.96
[b] Excluding NACE 25.6
[c] Excluding NACE 32.5
The list was taken from .

B Eligible industries

Table B.3: NACE codes of eligible Industries 1/1

13.96	Manufacture of other technical and industrial textiles	eligible
20	Manufacture of chemicals and chemical products	eligible
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	eligible
22	Manufacture of rubber and plastic products	eligible
23	Manufacture of other non-metallic mineral products	eligible
25.6	Treatment and coating of metals; machining	eligible
26	Manufacture of computer, electronic and optical products	eligible
27	Manufacture of electrical equipment	eligible
28	Manufacture of machinery and equipment n.e.c.	eligible
29	Manufacture of motor vehicles, trailers and semi-trailers	eligible
30	Building of ships and boats	eligible
32.5	Manufacture of medical and dental instruments and supplies	eligible
33	Repair and installation of machinery and equipment	eligible
58	Publishing activities	eligible
59	Motion picture, video and television programme production, sound recording and music publishing activities	eligible
60	Programming and broadcasting activities	eligible
61	Telecommunications	eligible
62	Computer programming, consultancy and related activities	eligible
63	Information service activities	eligible
71	Architectural and engineering activities; technical testing and analysis	eligible
72	Scientific research and development	eligible
73	Advertising and market research	eligible
74	Other professional, scientific and technical activities	eligible
90	Creative, arts and entertainment activities	eligible

The list was taken from Schnabl and Zenker (2013)

Table B.4: NACE codes of non-eligible Industries 1/2

10	Manufacture of food products	non-eligible
11	Manufacture of beverage	non-eligible
12	Manufacture of tobacco products	non-eligible
13 (ex. 13.96)	Manufacture of textiles	non-eligible
14	Manufacture of wearing apparel	non-eligible
15	Manufacture of leather and related products	non-eligible
16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting material	non-eligible
17	Manufacture of paper and paper products	non-eligible
18	Printing and reproduction of recorded media	non-eligible
19	Manufacture of coke and refined petroleum product	non-eligible
24	Manufacture of basic metals	non-eligible
25 (ex. 25.6)	Manufacture of fabricated metal products, except machinery and equipment	non-eligible
31	Manufacture of furniture	non-eligible
32 (ex. 32.5)	Other manufacturing	non-eligible
35	Electricity, gas, steam and air conditioning supply	non-eligible
41	Construction of buildings	non-eligible
42	Civil engineering	non-eligible
43	Specialised construction activities	non-eligible
45	Wholesale and retail trade and repair of motor vehicles and motorcycles	non-eligible
46	Wholesale trade, except of motor vehicles and motorcycles	non-eligible
47	Retail trade, except of motor vehicles and motorcycles	non-eligible

The list was taken from Schnabl and Zenker (2013)

Table B.5: NACE codes of non-eligible Industries 2/2

49	Land transport and transport via pipeline	non-eligible
50	Water transport	non-eligible
51	Air transport	non-eligible
52	Warehousing and support activities for transportation	non-eligible
53	Postal and courier activities	non-eligible
55	Accommodation	non-eligible
56	Food and beverage service activities	non-eligible
64	Financial service activities, except insurance and pension funding	non-eligible
65	Insurance, reinsurance and pension funding (except compulsory social security)	non-eligible
66	Activities auxiliary to financial services and insurance activities	non-eligible
68	Real estate activities	non-eligible
69	Legal and accounting activities	non-eligible
70	Activities of head offices; management consultancy activities	non-eligible
77	Rental and leasing activities	non-eligible
78	Employment activities	non-eligible
79	Travel agency, tour operator reservation service and related activities	non-eligible
80	Security and investigation activities	non-eligible
81	Services to buildings and landscape activities	non-eligible
82	Office administrative, office support and other business support activities	non-eligible
85	Education	non-eligible
91	Libraries, archives, museums, botanical and zoological Gardens	non-eligible
92	Gambling and betting activities	non-eligible
93	Sports activities and amusement and recreation activities	non-eligible
95	Repair of computers and personal and household goods	non-eligible
96	Other personal service activities	non-eligible

The list was taken from Schnabl and Zenker (2013)

C Description of sample

Table C.6: Number of observations per firm by founding cohorts in full sample

Founding year	Full Sample						Working Sample					
	Eligible		Non-Eligible		Total		Eligible		Non-Eligible		Total	
	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean
2005	5	5.4	5	5.2	5	5.3	2	2.0	2	1.9	2	2.0
2006	4	4.5	4	4.2	4	4.3	2	2.0	2	1.9	2	2.0
2007	3	3.7	3	3.4	3	3.6	2	2.2	2	2.0	2	2.1
2008	3	3.9	3	3.3	3	3.6	2	2.4	2	2.1	2	2.3
2009	3	3.7	3	3.4	3	3.6	2	2.4	2	2.2	2	2.3
2010	4	4.0	3	3.4	3	3.7	2	2.4	2	2.2	2	2.3
2011	3	3.8	2	3.3	3	3.5	2	2.3	2	2.0	2	2.1
2012	3	3.8	3	3.3	3	3.6	2	2.4	1	2.0	2	2.2
2013	3	3.5	3	3.3	3	3.4	2	2.2	2	2.0	2	2.1
2014	3	3.2	3	3.0	3	3.1	2	2.1	1	1.8	2	2.0
2015	3	2.9	3	2.7	3	2.8	2	1.9	1	1.7	2	1.8
2016	3	2.4	3	2.4	3	2.4	1	1.6	1	1.5	1	1.6
2017	2	1.8	2	1.8	2	1.8	1	1.4	1	1.4	1	1.4
2018	1	1.0	1	1.0	1	1.0						
Total	3	3.4	3	3.1	3	3.2	2	2.1	2	1.9	2	2.0

...

Table C.7: Sample distribution

Founding year	First sampled in:							
	t+1		t+2		t+3		Total	
	No.	%	No.	%	No.	%	No.	%
2005	0	0	0	0	1,767	100	1,767	100
2006	0	0	1,934	89	227	11	2,161	100
2007	1,718	71	514	21	185	8	2,417	100
2008	1,430	72	394	20	153	8	1,977	100
2009	1,492	73	410	20	151	7	2,053	100
2010	1,340	68	363	19	254	13	1,957	100
2011	1,287	67	400	21	227	12	1,914	100
2012	1,234	69	363	20	192	11	1,789	100
2013	1,253	65	301	16	386	20	1,940	100
2014	1,269	59	544	25	328	15	2,141	100
2015	1,386	61	606	27	278	12	2,270	100
2016	1,322	66	694	34	0	0	2,016	100
2017	1,265	100	0	0	0	0	1,265	100
Total	14,996	58	6,523	25	4,148	16	25,667	100

...

Table C.8: Sample distribution

Founding year	Eligible industry					
	Non-eligible		Eligible		Total	
	No.	%	No.	%	No.	%
2005	934	53	833	47	1,767	100
2006	1,073	50	1,088	50	2,161	100
2007	1,258	52	1,159	48	2,417	100
2008	1,032	52	945	48	1,977	100
2009	1,076	52	977	48	2,053	100
2010	999	51	958	49	1,957	100
2011	888	46	1,026	54	1,914	100
2012	877	49	912	51	1,789	100
2013	933	48	1,007	52	1,940	100
2014	1,038	48	1,103	52	2,141	100
2015	1,174	52	1,096	48	2,270	100
2016	1,398	53	1,232	47	2,630	100
2017	1,283	55	1,043	45	2,326	100
2018	1,021	66	522	34	1,543	100
Total	14,984	52	13,901	48	28,885	100

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Table C.9: Sample distribution

Year	Non-eligible No.	Non-eligible %	Eligible No.	Eligible %	Total No.	Total %
	Eligible industry					
	Non-eligible		Eligible		Total	
	No.	%	No.	%	No.	%
2005	934	53	833	47	1,767	100
2006	2,007	51	1,921	49	3,928	100
2007	3,265	51	3,080	49	6,345	100
2008	3,419	51	3,350	49	6,769	100
2009	3,675	50	3,616	50	7,291	100
2010	3,745	50	3,709	50	7,454	100
2011	3,803	49	4,022	51	7,825	100
2012	3,609	47	4,094	53	7,703	100
2013	2,835	43	3,787	57	6,622	100
2014	3,197	45	3,881	55	7,078	100
2015	3,660	48	3,963	52	7,623	100
2016	3,940	49	4,113	51	8,053	100
2017	4,123	51	4,038	49	8,161	100
2018	3,840	54	3,297	46	7,137	100
Total	46,052	49	47,704	51	93,756	100

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Table C.10: Sample distribution

NACE	Full Sample					Working Sample				
	in total		by year			in total		by year		
	N_{Firms}	$N_{Obs.}$	Median	Min.	Max.	N_{Firms}	$N_{Obs.}$	Median	Min.	Max.
20	211	695	57	10	76	133	272	26	0	48
21	54	223	21	1	28	40	94	11	0	13
22	149	561	49	7	56	105	226	22	0	29
23	119	433	34	10	41	71	170	16	0	20
26	717	2,666	220	43	236	502	1,115	112	0	134
27	422	1,456	136	11	152	294	640	72	0	83
28	771	2,772	224	36	258	508	1,135	114	0	132
29	131	469	37	6	52	83	187	17	0	30
30	84	285	26	6	37	57	118	15	0	18
33	441	1,602	122	33	177	233	510	45	0	74
58	170	532	52	9	57	112	222	25	0	31
59	257	738	86	5	119	182	345	46	0	67
60	11	36	4	1	8	6	10	1	0	3
61	34	102	9	2	13	19	43	4	0	8
62	4,505	14,614	1,123	311	1,349	2,778	5,743	550	0	657
63	487	1,445	113	41	135	298	532	47	0	76
71	2,622	9,660	763	156	903	1,744	4,095	412	0	497
72	202	717	57	9	74	134	315	28	0	46
73	524	1,685	145	36	179	316	612	56	0	80
74	522	1,600	165	21	194	319	627	85	0	92
90	96	245	39	2	45	54	100	14	0	24
256	416	1,405	117	21	149	277	540	51	0	81
325	949	3,727	305	56	384	629	1,330	132	0	183
1396	7	36	4	1	8	7	21	3	0	6
Total	13,901	47,704				8,901	19,002			

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Table C.11: Sample distribution

NACE	Full Sample					Working Sample				
	in total		by year			in total		by year		
	N_{Firms}	$N_{Obs.}$	Median	Min.	Max.	N_{Firms}	$N_{Obs.}$	Median	Min.	Max.
10	252	756	58	14	75	140	260	25	0	33
11	56	163	25	2	32	40	78	14	0	16
12	1	2	1	1	1	1	2	1	1	1
13	96	345	27	12	31	54	105	9	0	16
14	55	149	11	2	21	29	50	4	0	12
15	24	83	7	1	12	11	23	3	0	6
16	221	648	54	10	74	125	254	24	0	34
17	20	68	6	1	9	13	30	3	0	5
18	180	664	54	13	72	107	226	21	0	34
19	2	8	1	1	2	0		0	0	0
24	43	166	13	5	20	23	41	3	0	7
25	409	1,427	112	28	121	260	554	55	0	66
31	161	531	39	16	51	108	214	20	0	31
32	144	431	34	8	43	86	150	15	0	19
35	0	1	1	1	1	0		0	0	0
41	297	976	72	41	118	170	339	31	0	45
42	127	403	33	15	39	76	166	16	0	23
43	2,676	8,161	641	168	686	1,604	3,248	327	0	371
45	851	2,504	200	55	236	486	824	91	0	122
46	573	1,775	142	28	197	340	612	67	0	96
47	2,029	6,257	473	147	640	989	1,728	185	0	297
49	259	759	58	18	86	114	186	18	0	35
50	9	30	4	1	4	4	8	1	0	2
51	5	9	1	1	2	3	4	0	0	2
52	206	567	48	7	59	122	236	22	0	31
53	111	312	26	4	33	48	91	9	0	14
55	128	439	33	10	60	84	176	13	0	36
56	632	1,855	164	50	184	315	540	57	0	99
64	112	305	37	5	45	54	87	10	0	15
65	11	35	3	1	4	5	9	1	0	2
66	295	890	78	14	109	167	288	25	0	49
68	282	753	68	6	94	127	209	22	0	33
69	427	1,559	130	27	151	253	599	63	0	73
70	1,404	4,480	342	59	517	765	1,526	143	0	201
77	160	492	39	9	50	89	180	18	0	26
78	241	750	67	9	87	148	289	30	0	43
79	115	375	30	9	39	59	95	9	0	16
80	31	81	6	2	14	14	27	4	0	7
81	599	1,610	149	19	189	340	661	69	0	85
82	251	795	61	25	86	119	221	19	0	29
85	671	1,849	228	22	315	389	695	86	0	132
91	9	28	4	1	6	5	10	2	0	3
92	18	63	5	1	8	11	17	2	0	4
93	193	609	51	15	61	112	203	19	0	32
95	228	786	74	22	124	120	212	14	0	47
96	370	1,043	92	28	106	150	248	23	0	47
Total	14,984	45,992				8,279	15,721			

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Table C.12: Sample distribution

NACE 1	Full Sample				Working Sample			
	Non-Eligible		Eligible		Non-Eligible		Eligible	
	N_{Firms}	$N_{Obs.}$	N_{Firms}	$N_{Obs.}$	N_{Firms}	$N_{Obs.}$	N_{Firms}	$N_{Obs.}$
3: Manufacturing	1,664	5,441	4,471	16,330	997	1,987	2,939	6,358
4: Electricity and gas	0	1	0	0	0	0	0	0
6: Construction	3,100	9,540	0	0	1,850	3,753	0	0
7: Wholesale and retail trade	3,453	10,536	0	0	1,815	3,164	0	0
8: Transporting and storage	590	1,677	0	0	291	525	0	0
9: Accomm. and food service activities	760	2,294	0	0	399	716	0	0
10: Information and communication	0	0	5,464	17,467	0	0	3,395	6,895
11: Financial and insurance activities	418	1,230	0	0	226	384	0	0
12: Real estate activities	282	753	0	0	127	209	0	0
13: Prof., scien. and techn. activities	1,831	6,039	3,870	13,662	1,018	2,125	2,513	5,649
14: Admin. and support service activities	1,397	4,103	0	0	769	1,473	0	0
16: Education	671	1,849	0	0	389	695	0	0
18: Arts, entertainment and recreation	220	700	96	245	128	230	54	100
19: Other services activities	598	1,829	0	0	270	460	0	0
Total	14,984	45,992	13,901	47,704	8,279	15,721	8,901	19,002

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C.1 Time trends

Table C.13: First Stage Trends: Equity Financing

	(1) Coef.	CI 95%	(2) Coef.	CI 95%	(3) Coef.	CI 95%	(4) Coef.	CI 95%
2009	-0.010	[-0.026,0.006]	-0.010	[-0.026,0.007]	-0.007	[-0.024,0.010]	-0.007	[-0.024,0.011]
2010	-0.004	[-0.017,0.009]	-0.004	[-0.017,0.009]	0.000	[-0.013,0.013]	0.001	[-0.012,0.014]
2011	-0.007	[-0.018,0.005]	-0.007	[-0.018,0.005]	-0.005	[-0.016,0.006]	-0.005	[-0.016,0.005]
2013	0.011	[-0.004,0.026]	0.011	[-0.004,0.026]	0.009	[-0.004,0.022]	0.007	[-0.006,0.019]
2014	0.014*	[-0.001,0.029]	0.013*	[-0.001,0.028]	0.011	[-0.003,0.024]	0.009	[-0.004,0.022]
2015	0.019**	[0.004,0.033]	0.018**	[0.004,0.033]	0.016**	[0.002,0.030]	0.014**	[0.000,0.028]
2016	0.021***	[0.006,0.035]	0.020***	[0.005,0.035]	0.019***	[0.005,0.034]	0.017**	[0.004,0.029]
2017	0.027***	[0.016,0.038]	0.027***	[0.016,0.038]	0.025***	[0.015,0.036]	0.022***	[0.012,0.032]
2018	0.033**	[0.008,0.057]	0.032**	[0.007,0.057]	0.029**	[0.004,0.054]	0.026**	[0.002,0.050]
Constant	Yes		Yes		Yes		Yes	
Year Fixed Effect	Yes		Yes		Yes		Yes	
Founding Cohort Fixed Effect	Yes		Yes		Yes		Yes	
Industry Fixed Effect	Yes		Yes		Yes		Yes	
Region Fixed Effect			Yes		Yes		Yes	
Firm Controls					Yes		Yes	
Number of Observations	34,723		34,723		34,723		34,723	
Number of Clusters	68		68		68		68	
R2	0.041		0.044		0.073		0.082	

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: ...

Table C.14: First Stage Trends: Equity Financing (log)

	(1) Coef.	CI 95%	(2) Coef.	CI 95%	(3) Coef.	CI 95%	(4) Coef.	CI 95%
2009	-0.116	[-0.282,0.051]	-0.111	[-0.283,0.062]	-0.084	[-0.256,0.087]	-0.078	[-0.252,0.096]
2010	-0.036	[-0.168,0.096]	-0.036	[-0.169,0.097]	0.007	[-0.118,0.131]	0.020	[-0.107,0.146]
2011	-0.070	[-0.176,0.035]	-0.070	[-0.177,0.038]	-0.053	[-0.158,0.051]	-0.056	[-0.156,0.044]
2013	0.095	[-0.057,0.247]	0.093	[-0.055,0.241]	0.069	[-0.064,0.203]	0.047	[-0.080,0.173]
2014	0.143**	[0.001,0.284]	0.133*	[-0.005,0.271]	0.105	[-0.027,0.236]	0.086	[-0.044,0.216]
2015	0.207**	[0.045,0.368]	0.204**	[0.044,0.363]	0.181**	[0.019,0.344]	0.159*	[-0.001,0.318]
2016	0.210***	[0.060,0.359]	0.204***	[0.056,0.352]	0.196***	[0.052,0.341]	0.166**	[0.032,0.300]
2017	0.305***	[0.184,0.427]	0.302***	[0.180,0.423]	0.286***	[0.170,0.402]	0.252***	[0.145,0.358]
2018	0.384***	[0.108,0.659]	0.379***	[0.097,0.660]	0.346**	[0.071,0.621]	0.309**	[0.043,0.575]
Constant	Yes		Yes		Yes		Yes	
Year Fixed Effect	Yes		Yes		Yes		Yes	
Founding Cohort Fixed Effect	Yes		Yes		Yes		Yes	
Industry Fixed Effect	Yes		Yes		Yes		Yes	
Region Fixed Effect			Yes		Yes		Yes	
Firm Controls					Yes		Yes	
Number of Observations	34,723		34,723		34,723		34,723	
Number of Clusters	68		68		68		68	
R2	0.043		0.047		0.077		0.087	

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Control Variables: ...

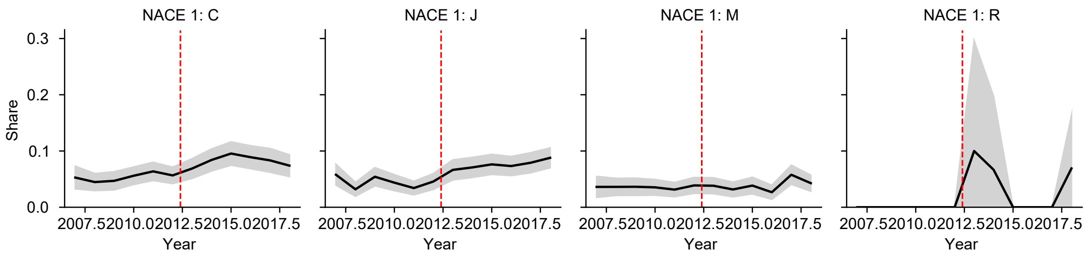

Figure C1: Share of Equity Financed Startups by Industries in Eligible Industries.

This figure shows the share of startups in eligible industries receiving an equity investment by reference year.

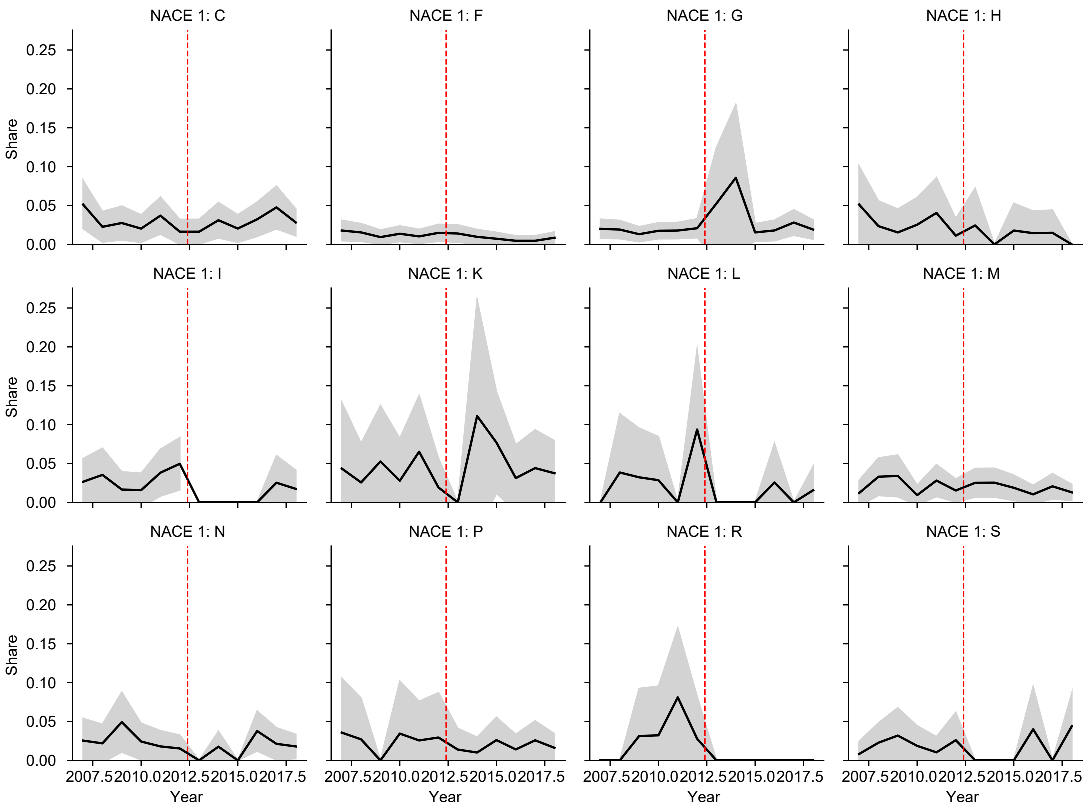

Figure C2: Share of Equity Financed Startups by Industries in Non-Eligible Industries.

This figure shows the share of startups in non-eligible industries receiving an equity investment by reference year The red line shows the point in time when the policy program was introduced. The shares are weighted by population sampling weights. Sampling weights are available for startups at most four years old.

C.2 Robustness tests on different smples

Table C.15: Robustness Test on different samples

	full				excluding INVEST 2.0			
	OLS		TSLS		OLS		TSLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equity(t)	0.240***	0.141***	1.561***	1.051**	0.234***	0.134***	1.056*	0.408
	(0.024)	(0.012)	(0.377)	(0.413)	(0.030)	(0.018)	(0.594)	(0.537)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls		Yes		Yes		Yes		Yes
Craig-Donald F			58.1	37.7			24.0	17.2
Robust F			20.8	21.1			11.6	10.9
Number of Observations	48,771	47,138	48,771	47,138	28,386	28,386	28,386	28,386
Number of Clusters	69	69	69	69	67	67	67	67

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: ...

Table C.16: Robustness Test on different samples

	full				excluding INVEST 2.0			
	OLS		TSLS		OLS		TSLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equity (log)	0.349***	0.241***	1.849***	1.242***	0.325***	0.216***	1.282**	0.560
	(0.032)	(0.019)	(0.439)	(0.423)	(0.035)	(0.021)	(0.592)	(0.482)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls		Yes		Yes		Yes		Yes
Craig-Donald F			43.4	31.6			22.6	15.8
Robust F			25.3	25.9			11.1	9.8
Number of Observations	39,688	38,454	39,688	38,454	28,386	28,386	28,386	28,386
Number of Clusters	68	68	68	68	67	67	67	67

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: ...

Time trends

Table C.17: Robustness Test on different samples

	full				excluding INVEST 2.0			
	OLS		TSLS		OLS		TSLS	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equity (log)	0.169***	0.135***	0.791***	0.669**	0.150***	0.122***	0.473	0.313
	(0.015)	(0.014)	(0.258)	(0.274)	(0.016)	(0.013)	(0.317)	(0.302)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Founding Cohort Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls		Yes		Yes		Yes		Yes
Craig-Donald F			39.2	28.3			22.6	15.8
Robust F			23.9	24.3			11.1	9.8
Number of Observations	40,862	39,587	40,862	39,587	28,386	28,386	28,386	28,386
Number of Clusters	69	69	69	69	67	67	67	67

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: ...

Table C.18: First Stage Trends: Equity Financing

	full				excluding INVEST 2.0			
	(1) Coef.	CI 95%	(2) Coef.	CI 95%	(3) Coef.	CI 95%	(4) Coef.	CI 95%
2007	-0.001	[-0.012,0.010]	0.007	[-0.005,0.018]				
2008	-0.012**	[-0.023,-0.002]	-0.007*	[-0.016,0.001]				
2009	-0.002	[-0.015,0.011]	0.001	[-0.015,0.016]	-0.010	[-0.026,0.007]	-0.007	[-0.024,0.010]
2010	0.001	[-0.008,0.011]	0.005	[-0.005,0.016]	-0.004	[-0.017,0.009]	0.000	[-0.013,0.013]
2011	-0.003	[-0.016,0.010]	-0.000	[-0.012,0.012]	-0.007	[-0.018,0.005]	-0.005	[-0.016,0.006]
2013	0.018***	[0.006,0.030]	0.015**	[0.003,0.028]	0.012	[-0.003,0.026]	0.009	[-0.004,0.023]
2014	0.019**	[0.004,0.033]	0.016**	[0.002,0.030]	0.014*	[-0.001,0.028]	0.011	[-0.002,0.025]
2015	0.029***	[0.013,0.044]	0.025***	[0.009,0.041]	0.018**	[0.004,0.033]	0.016**	[0.002,0.031]
2016	0.020**	[0.004,0.035]	0.020***	[0.005,0.035]	0.020***	[0.006,0.035]	0.020***	[0.006,0.034]
2017	0.028***	[0.015,0.040]	0.027***	[0.015,0.039]				
2018	0.036***	[0.013,0.058]	0.034***	[0.012,0.055]				
Constant	Yes		Yes		Yes		Yes	
Year Fixed Effect	Yes		Yes		Yes		Yes	
Founding Cohort Fixed Effect	Yes		Yes		Yes		Yes	
Industry Fixed Effect	Yes		Yes		Yes		Yes	
Region Fixed Effect	Yes		Yes		Yes		Yes	
Firm Controls			Yes				Yes	
Number of Observations	48,771		47,138		28,386		28,386	
Number of Clusters	69		69		67		67	
R2	0.040		0.072		0.044		0.073	

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: ...

Table C.19: First Stage Trends: Equity Financing (log)

	full				excluding INVEST 2.0			
	(1) Coef.	CI 95%	(2) Coef.	CI 95%	(3) Coef.	CI 95%	(4) Coef.	CI 95%
2009	-0.083	[-0.221,0.055]	-0.056	[-0.217,0.106]	-0.110	[-0.281,0.061]	-0.085	[-0.255,0.085]
2010	-0.024	[-0.124,0.076]	0.016	[-0.081,0.114]	-0.036	[-0.167,0.096]	0.006	[-0.117,0.129]
2011	-0.061	[-0.155,0.034]	-0.055	[-0.145,0.034]	-0.069	[-0.176,0.038]	-0.053	[-0.158,0.052]
2013	0.114**	[0.003,0.226]	0.085	[-0.034,0.205]	0.098	[-0.049,0.245]	0.074	[-0.061,0.208]
2014	0.146**	[0.019,0.274]	0.112*	[-0.006,0.229]	0.137**	[0.001,0.274]	0.108	[-0.022,0.238]
2015	0.209***	[0.061,0.358]	0.177**	[0.021,0.334]	0.203**	[0.040,0.366]	0.183**	[0.017,0.348]
2016	0.187***	[0.050,0.325]	0.193***	[0.060,0.326]	0.205***	[0.058,0.352]	0.200***	[0.055,0.345]
2017	0.291***	[0.187,0.395]	0.280***	[0.177,0.382]				
2018	0.363***	[0.115,0.612]	0.345***	[0.100,0.591]				
Constant	Yes		Yes		Yes		Yes	
Year Fixed Effect	Yes		Yes		Yes		Yes	
Founding Cohort Fixed Effect	Yes		Yes		Yes		Yes	
Industry Fixed Effect	Yes		Yes		Yes		Yes	
Region Fixed Effect	Yes		Yes		Yes		Yes	
Firm Controls			Yes				Yes	
Number of Observations	39,688		38,454		28,386		28,386	
Number of Clusters	68		68		67		67	
R2	0.045		0.074		0.047		0.078	

Standard errors in parentheses. Clustered at the industry level.
Significance levels: *** p<0.01, ** p<0.05, * p<0.1.
Control Variables: ...