

A Service of

ZBW

Leibniz-Informationszentrum Wirtschaft Leibniz Information Centre for Economics

Weuschek, Nadine

Article — Published Version Does public funding reduce financial constraints of young firms in Germany?

Journal of Business Economics

Provided in Cooperation with: Springer Nature

Suggested Citation: Weuschek, Nadine (2025) : Does public funding reduce financial constraints of young firms in Germany?, Journal of Business Economics, ISSN 1861-8928, Springer, Berlin, Heidelberg, Vol. 95, Iss. 1, pp. 103-154, https://doi.org/10.1007/s11573-024-01218-3

This Version is available at: https://hdl.handle.net/10419/318854

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.



http://creativecommons.org/licenses/by/4.0/

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



WWW.ECONSTOR.EU

ORIGINAL PAPER



Does public funding reduce financial constraints of young firms in Germany?

Nadine Weuschek¹

Accepted: 21 November 2024 / Published online: 3 January 2025 $\ensuremath{\textcircled{O}}$ The Author(s) 2024

Abstract

This paper examines the financing situation of young firms in Germany after receiving public funding. I find that, on average, public funding is associated with a significant reduction in the future probability of experiencing financial constraints. While grant tend to improve relationships with equity investors, subsidized loans or loan guarantees tend to improve relationships with external providers of both equity and debt capital. Additionally, I show that the effect of public funding is stronger for more financially constrained firms when provided as a subsidized loan or loan guarantee, and heterogeneous across entrepreneurs and startups. Furthermore, my results suggest that public funding is positively related to real outcomes, and that grants also help firms by stabilizing their economic position.

Keywords Public subsidies · Financial constraints · Subsidized loans · Loan guarantees · Grants · Young firms

JEL Classification $G38 \cdot H81 \cdot O38$

1 Introduction

Young firms play a crucial role in economic growth, employment, and innovation (Haltiwanger et al. 2013; Hallak and Harasztosi 2019). Germany is structurally disadvantaged in this regard, having one of the lowest shares of young firms among OECD countries (OECD 2022; Kulicke 2021). The availability of sufficient

I thank ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH, Mannheim, Germany, and in particular Sandra Gottschalk and Jakob Ehlich, for providing access to the data. Moreover, I am grateful to Christoph Schneider, Andreas Pfingsten, Jannis Bischof (the editor), the participants of the Finance Center Münster Research Seminar in October 2022, as well as two anonymous referees for valuable suggestions.

Nadine Weuschek nadine.weuschek@uni-muenster.de; n.weuschek@web.de

¹ University of Münster, Münster, Germany

financial resources is essential for starting an entrepreneurial activity. In 2022, 45% of new business projects in Germany could not be realized due to insufficient financing (Metzger 2023). OECD (2022) concludes that young firms contribute relatively little to research and development (R&D) and innovation in Germany.

Ensuring a competitive and growing economy is a key task of governments. Public support programs aim to eliminate market failure or to encourage certain behaviors of public interest (Hall 2002; Lenk and Schöbel 2013). Improving the ecosystem of young firms is currently of great interest to the German government. See, for example, the "Startup Strategy 2022", which was adopted in July 2022. One of its main targets is to strengthen the financing of startups (Federal Ministry for Economic Affairs and Climate Action 2022).

Effective implementation of public support programs requires sufficient knowledge about their effects. For this purpose, I empirically analyze how public funding affects the financing situation of young firms in Germany. My results based on the IAB/ZEW Start-up Panel indicate that public funding is associated with a significant reduction in the probability of experiencing financial constraints. On average, the probability of a young firm experiencing financing difficulties decreases by 5.0 percentage points one year after receiving public funding, which is a significant reduction of about 32.7%. Differentiating between the most common instruments shows that grants tend to be associated with a lower future probability of experiencing financial constraints with equity investors, while subsidized loans or public loan guarantees (hereafter referred to as "subsidized loans or guarantees") are associated with a lower future probability of experiencing financial difficulties with both equity and debt investors.

Estimating the effects of public funding on firms poses many challenges. First, it is impossible to observe the counterfactual outcome of a subsidized firm without public funding. Receiving public funding is not random. Selection bias could result from the firm's decision to apply for public subsidies, from the public agency, or, in some cases, from an intermediary, such as a private bank. Thus, a simple comparison of recipient and non-recipient firms could lead to biased results because they differ systematically. To reduce such selection bias, many studies construct a control group based on matching techniques with the goal of comparing the outcomes of treated and non-treated firms that are similar in pre-specified observable characteristics. However, unobservable characteristics, such as good managerial ability, could influence a firm's application for and receipt of public funds, as well as future financial constraints. As a result, differences in unobservable characteristics between recipient and non-recipient firms might not be captured, leading to omitted variable bias. To address potential concerns about selection and omitted variable bias, I use a linear probability model with firm and year fixed effects. The identification comes from the within variation of the subsidized firms over the observation period. This strategy has the advantage that potential unobservable differences between publicly and non-publicly funded firms cannot bias the estimation results as long as they are not time-varying.

I analyze the effect of public funding in more detail and examine whether it differs depending on the severity of financial constraints. My results show that more financially constrained firms show a larger reduction in the probability of experiencing financial constraints after receiving a subsidized loan or a guarantee. In contrast, the results for grants are mixed, which I explain by the wide range of purposes of grant programs.

Young firms are heterogeneous, and their financing needs can vary widely. Therefore, I investigate the effect of public funding on firms classified as entrepreneurs and startups. The results indicate that grants are associated with an improved financing situation with external capital providers, excluding equity investors, and also benefit entrepreneurs internally. In contrast, subsidized loans or guarantees specifically improve the financing situation of startups. I relate these results to the demand for financing and the share of financially constrained firms, both of which are larger for startups.

Finally, I estimate the effect of public funding on real outcomes. On average, grants are related to higher employment, investment, profits, R&D expenditures, and revenues, while subsidized loans or guarantees are related to higher employment and profits. Further analyses suggest that grants help firms by stabilizing their economic position and thereby improve their financial situation. Subsidized loans or guarantees are associated with a reduction in the probabilities of incurring losses and experiencing a reduction in net employment, but not in revenues.

My study makes several contributions to the literature. First, I analyze the effect of public funding on the financing situation of young firms in Germany. Public support programs are usually tailored to the specific setting. Germany is characterized by relatively low entrepreneurial activity and underdeveloped capital markets for young firms (Federal Ministry for Economic Affairs and Climate Action 2021). Hence, young firms in Germany are structurally disadvantaged compared to other countries and are likely to be more financially constrained. Hypothesizing that more financially constrained firms respond more strongly to public funding, one would expect a larger reduction in financial constraints. Therefore, empirical findings from other countries are unlikely to be applicable, making it necessary to specifically analyze the effects of public funding on the financing situation of young firms in Germany. So far, this field is relatively unexplored. Existing studies based on German datasets either focus on real effects (e.g., Caliendo et al. 2020; Hottenrott and Richstein 2020; Cantner and Kösters 2015, 2012; Czarnitzki and Delanote 2015; Caliendo and Künn 2011) or on venture capital (VC) financing (e.g., Berger and Hottenrott 2021). In contrast, I analyze how public funding affects the financing situation of young firms. In addition, while many studies analyze individual public support programs, I take a holistic perspective, differentiating between grants and subsidized loans or guarantees.

My results add to the literature on public funding by showing that grants and subsidized loans or guarantees alleviate the financial constraints of young firms in Germany in different ways. While grants help firms improve their internal economic position, subsidized loans or guarantees help firms reduce financing difficulties also vis-à-vis external capital providers. Moreover, in contrast to existing studies, I take into account the heterogeneity of young firms and point out that grants are associated with an improved financing situation especially for entrepreneurs, and that subsidized loans or guarantees are associated with an improved financing situation especially for startups. A recent strand of literature investigates the effect of grants provided to firms in Germany during the COVID-19 pandemic. These studies (e.g., Bertschek et al. 2024; Falck et al. 2024; Ragnitz 2023a, b; Bischof et al. 2021, 2020) mainly analyze the efficiency of COVID-19 support programs in helping firms stay in business. They generally find that government support has been successful in providing liquidity and increasing the probability of survival. Nevertheless, they criticize certain design features of these support programs, such as the restrictive nature of the amount, the eligibility criteria, and the cost structure (Ragnitz 2023a, b; Bischof et al. 2021), as well as the collection of data for subsequent evaluation (Falck et al. 2024). Different from these studies, which focus on government support programs during the COVID-19 pandemic, the results of my study are generalizable and applicable to periods beyond a crisis.

Second, my study contributes to the literature on the effects of public funding on VC financing. It is most closely related to Berger and Hottenrott (2021), who find that public funding is positively related to VC from governments and business angels, but not to independent VC or corporate VC. Unlike their work, I distinguish between the effect of grants and subsidized loans or guarantees on the financing situation of young firms with equity investors. My results suggest a VC stimulus effect for both types of instruments, consistent with Howell (2017), Söderblom et al. (2015), Chiappini et al. (2022), and Zhao and Ziedonis (2020). In addition, I show that this effect tends to be more pronounced for more financially constrained firms.

Third, I use an alternative empirical strategy to estimate the effect of public funding. Many studies in the German context (e.g., Caliendo et al. 2020; Hottenrott and Richstein 2020; Cantner and Kösters 2015; Czarnitzki and Delanote 2015; Caliendo and Künn 2011) rely exclusively on matching. However, matching is criticized for neglecting differences in unobservable characteristics. Using a linear probability model with firm fixed effects allows me to control for time-invariant unobservable characteristics.

My results suggest potential implications for economic policy. Specifically, my findings on the different effects of grants and subsidized loans suggest that it may be beneficial to combine grants and subsidized loans. In addition, it could be useful to include private institutions in the application process for grants. Thereby, public support programs could be structured in a way that helps young firms overcome different types of financial challenges.

The rest of this paper is structured as follows. Section 2 presents an overview of the financing situation of young firms and public funding in Germany, as well as my research hypotheses. Section 3 describes the data. Section 4 explains my empirical strategy. Section 5 presents the results, and Sect. 6 covers robustness tests. Section 7 concludes with implications for economic policy.

2 Institutional background and research hypotheses

2.1 Characteristics of the financing situation of young firms in Germany

Young firms are heterogeneous along several dimensions. The demand for capital and the financing structure can differ significantly depending on the business model and other factors. In Germany, business formations are typically distinguished between those of natural persons, referred to as new entrepreneurs ("Existenzgründer/innen"), and those of legal entities, known as company foundations ("Unternehmensgründungen") (Olschewski 2015). However, precise definitions for these categories do not exist. Startups form a subgroup of company foundations. According to the German Startup Monitor 2023 by Kollmann et al. (2023), startups are defined as firms younger than 10 years with a high growth potential and a highly innovative technology or business model. Large studies on business formations in Germany (KfW Entrepreneurship Monitor, Global Entrepreneurship Monitor Germany National Report, IAB/ZEW Startup Panel, Statistics on business set-ups of Institut für Mittelstandsforschung Bonn) do not differentiate between entrepreneurs and company foundations. For this reason, this study also includes new entrepreneurs and company foundations (hereafter referred to as "entrepreneurs").

The financing situation of entrepreneurs in Germany is related to the demand for external capital. According to Metzger (2023), 72.0% (61.8%) of the entrepreneurs surveyed in the KfW Entrepreneurship Monitor 2022 invested resources up to $\notin 25,000$ ($\notin 10,000$) in setting up their business. Most of the entrepreneurs use their own financial resources, with only 20% (average 2020-2022) using external resources. The major sources of external capital for young firms in Germany are bank loans (70% of the financing volume; average 2020-2022) and subsidized loans (15% of the financing volume; average 2020–2022), underlining the dominant role of banks in financing entrepreneurs. Other common financing instruments are loans from family and friends and external equity capital. The long-term average share of entrepreneurs experiencing financial constraints is 15%. However, this long-term average masks heterogeneity in the financing sources. For 2022, 36% of externally financed firms reported financing difficulties. Nevertheless, these figures are not representative of the overall entrepreneurial activity as 45% of new business projects in 2022 could not have been realized due to insufficient financing. Financing is therefore a critical factor in starting a business, and financial constraints occur particularly when entrepreneurs require external capital.

Startups often need more capital¹ to scale their business, resulting in a larger share of external capital providers (Kollmann et al. 2023). The German Startup Monitor 2023 presents an overview of funding sources utilized and preferred by startups in 2022. 45.0% of the surveyed startups received public funding, 32.6% received funding from business angels, 18.6% from venture capitalists, 14.1% from incubator or accelerator programs, 13.9% from strategic investors and 12.8% from banks. The proportion of startups financed by banks is significantly lower than that of entrepreneurs (48%; Metzger 2023). Compared to the preferred funding sources, the gap is largest for strategic investors (18.6%), venture capitalists (16.2%) and business angels (7.7%). While the financing conditions in the seed stage for young startups in Germany have shown a remarkable development in recent years, the

¹ Although the capital demand on average is larger, some types of startups do not require (external) capital for setting up their business. IT based and digital business models often can reach market maturity without external funding (Kulicke 2021).

country lags behind in international comparisons when it comes to the growth stages (Kulicke 2021). The absolute level of VC is rather low, with Germany ranking sixth internationally, and the venture and growth markets are described as being relatively underdeveloped (Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung 2023; OECD 2022). Funding conditions are particularly challenging for young technology firms and firms with pre-commercial projects (often academic spin-offs), even though such firms typically drive radical innovation (OECD 2022; Kulicke 2021). As a result, young firms cannot fully exploit their growth potential, they contribute relatively little to R&D and innovation, and they often move abroad for financing (OECD 2022).

In summary, young firms face particular challenges in the access to finance in Germany, suggesting that they are more financially constrained. This highlights the need for public support programs aimed at strengthening the financing situation to be well adapted to the structure of the German capital markets and to the preferences of firms and investors.

2.2 Public funding for young firms in Germany

Young firms face significant challenges in acquiring capital due to information asymmetries between management and capital providers, limited internal resources as collateral, and lack of market penetration (Carpenter and Petersen 2002; Hall 2002; Hall and Lerner 2010). Public support programs aim to address these market failures, promote productivity growth, and enhance competition. Additionally, some programs have specific objectives (Pflüger and Suedekum 2013), such as promoting R&D and innovation.

Public support programs for firms in Germany are usually set up by the European Union (EU), the federal government, or the federal states. The decentralized governance of the federal states of Germany allows for policies that are tailored to regional socio-economic needs (OECD 2022). A search for "Gründung" (foundation) in the funding database of the Federal Republic of Germany² yields over 300 funding programs, most of which support business establishment and growth. Some of these programs also offer non-material support such as consulting. Figure 1 provides an overview of the most common public support programs for young firms in Germany. A more detailed overview is provided by Federal Ministry for Economic Affairs and Climate Action (2023b) and Federal Ministry for Economic Affairs and Climate Action (2021). It is advisable for firms seeking support to conduct a comprehensive search.

Public funding in the form of *debt* is often provided as subsidized loans, loans backed by public loan guarantees, or "Micro-loans". Subsidized loans typically have lower interest rates and grace periods. Firms apply for subsidized loans through local banks, which share the liability risk with a development bank, such as the KfW Kreditanstalt für Wiederaufbau (KfW) or a state development bank. Public

² Förderdatenbank des Bundes, available under https://www.foerderdatenbank.de/FDB/DE/Home/home. html (checked on 2023/10/22).

Debt	Mezzanine	Equity
 Subsidized loans ERP Start-up Loan – Start- Up Money ERP Start-up Loan – Universal ERP Capital for Start-ups Public loan guarantees 	 Silent partnerships SME venture capital company ("Mittelständische Beteiligungsgesellsch (MBG) Micro-Mezzanine Fu 	Grants • Start-up Subsidies by Federal Employment Agency aft") • EXIST Start-up Grant • Regional programs by federal states • Industry-oriented programs
 Default guarantee provided by a guarantee bank 	Specific	programs for startups
("Bürgschaftsbank")	(Pre-)Seed	Growth
Guarantee fund for loansGerman Micro-loan Fund	 Venture capital High-tech Start-up Fund (HTGF) Grants for investors INVEST – Grant for Venture Capital 	Venture capital • ERP/EIF venture capital fund of funds • coparion • ERP Venture Capital Fund Financing • GFF/EIF Growth Facility • DeepTech & Climate Fonds (DTCF) • Venture Tech Growth Financing Venture debt • ERP/EIF/Länder Mezzanine Fund of Funds

Fig. 1 Overview of Public Funding Programs for Young Firms in Germany. This figure shows the most common public funding programs for young firms in Germany, broken down by debt, mezzanine, and equity instruments. The lower part of the figure illustrates specific public funding programs for startups

loan guarantees are typically offered as default guarantees by state guarantee banks ("Bürgschaftsbanken"), and firms apply directly to these banks. After a positive risk assessment by the guarantee bank, the firm can apply for a loan backed by the public loan guarantee at a local bank. Micro-loans ("Mikrokreditfonds Deutschland (REACT-EU)—Mein Mikrokredit ") are for small entrepreneurs and firms that lack access to credit. Micro-loans are granted by accredited micro banks and backed by a guarantee fund. The loan is paid out in installments, and amounts to a maximum of $\in 25,000$ (Federal Ministry for Economic Affairs and Climate Action 2023a; Federal Ministry of Labour and Social Affairs 2023).

Public funding in the form of *mezzanine capital* can be granted as a silent partnership by an SME venture capital company ["Mittelständische Beteiligungsgesellschaft" (MBG)] of a federal state. The terms vary by state. MBGs also provide silent partnerships of the Micro-Mezzanine Fund, that focuses on entrepreneurs that provide vocational training, are founded by unemployed persons, or are managed by individuals with a migration background. The maximum amount for such silent partnerships is \notin 50,000 (Federal Ministry for Economic Affairs and Climate Action 2023b).

Public *equity* funding is usually provided as non-repayable grants or equity participations. The Federal Employment Agency offers Start-up Subsidies for new entrepreneurs starting businesses out of unemployment (Federal Employment Agency 2023a, b). German public support programs focus on strengthening the startup culture at universities and supporting business startups, primarily targeting academics (Kulicke 2021), such as the EXIST Start-up Grant (Federal Ministry for Economic Affairs and Climate Action 2023b). Other programs focus on innovation, specific industries (e.g., crafts, health, agriculture), regions, or specific political objectives, such as energy efficiency or greenhouse gas neutrality. Despite progress in the startup culture, new business formations in Germany remain relatively few (Kulicke 2021).

Given the characteristics of startups, the public sector provides specific *public support programs for startups.*³ Financing needs vary across different lifecycle stages. At the (pre-)seed stage, the High-tech Start-up Fund (HTGF) invests in highly innovative startups that are no more than 3 years old, with initial investments of up to ϵ 1,000,000 and subsequent financing rounds up to a total amount of ϵ 4,000,000. The HTGF also provides management support. The INVEST program targets private investors, such as business angels, offering grants of up to 25% of their investment in innovative startups and an exit grant of 25% of the capital gain (Federal Ministry for Economic Affairs and Climate Action 2023b). Other public funds provide public VC or venture debt to more mature startups in the growth stage, with the public sector acting as a co-investor or investing in funds of funds.

3 Research hypotheses

Public support in the form of grants, subsidized loans, guarantees, or a combination of these instruments, has been widely shown to help young firms grow in terms of revenue (e.g., Horvath and Lang 2021; Hottenrott and Richstein 2020; Howell 2017; Söderblom et al. 2015) and employment (e.g., Horvath and Lang 2021; Hottenrott and Richstein 2020; Brown and Earle 2017; Söderblom et al. 2015; Cantner und Kösters 2015; Caliendo und Künn 2011; Lelarge et al. 2010). Additionally, receiving public funds is positively associated with the amount of external capital raised and the likelihood of staying in business (e.g., Hottenrott and Richstein 2020; Zhao and Ziedonis 2020; Howell 2017). Firstly, public funding could help firms to alleviate financial constraints by improving their economic position. Secondly, this positive development might induce capital providers to adjust their risk assessment and to increase their willingness to provide funding. Alternatively, or in addition, public funding could serve as a positive signal (e.g., Leleux and Surlemont 2003; Grilli and Murtinu 2012; Söderblom et al. 2015), thereby attracting future capital providers. From this reasoning, I derive the following hypothesis:

Hypothesis 1 The receipt of public funding is associated with a lower probability that a firm will face financial constraints.

Critics might argue that the effect of public funding on financing conditions is mechanically driven by the design of public funding programs. This is

³ An analysis of the propensity of the firms in my dataset to receive public funding (see Table 8 in the Appendix) shows that firms financed by external equity investors are more likely to receive public funding.

particularly relevant for subsidized loans and guarantees, as banks are always involved in the loan structure. The duration of a subsidized loan and a guarantee is equivalent to the duration of the underlying credit relationship. Previous studies document that public funding facilitates the establishment of a credit relationship and access to credit (Ono et al. 2013; Lelarge et al. 2010). I investigate this mechanism by distinguishing between instruments such as grants, which do not involve banks in the application process, and by using different proxies for financial constraints.

Although grants can be used for different purposes, depending on the grant program (see Sect. 2.2), prior literature suggests that grants tend to be used to finance R&D, while subsidized loans and guarantees tend to be used to finance investments in tangible assets (Hottenrott and Richstein 2020). Grants enable firms to pursue risky R&D that they might not otherwise consider undertaking (Howell 2017; Hottenrott and Richstein 2020). According to Howell (2017), grants affect firms through a prototyping channel. Grants may enable startups to prove the viability of their products or technologies, and to gain experience and reputation. Later, external capital investors face less uncertainty. Hottenrott und Richstein (2020) argue that public funding might affect a firm's investment decision via a policy instrument channel by creating different incentive structures.

Investments in intangibles, like R&D expenditures, are riskier than those in tangible assets (e.g., Li 2011; Amir et al. 2007; Kothari et al. 2002; Chan et al. 2001). Consequently, firms that receive grants may be riskier than firms that receive subsidized loans or guarantees. Thus, they may also be more likely to experience financial constraints than firms that receive subsidized loans or guarantees. Following this line, firms receiving grants have greater potential to experience a reduction in the probability of experiencing financial constraints in the future. Therefore, my second research hypothesis is defined as follows:

Hypothesis 2.1 Receiving a grant is associated with a greater reduction in the probability that a firm will face financial constraints than receiving a subsidized loan or a guarantee.

Conversely, relationship theory suggests that receiving a subsidized loan or a guarantee is related to a stronger reduction in the probability of experiencing financial constraints. Existing literature documents positive effects of a credit relationship on the financing situation of borrowers. For example, Cenni et al. (2015) find that the probability of a firm being credit rationed is negatively related to the length of the credit relationship. Bharath et al. (2011) show that firms that borrow money from an existing lender have, on average, a lower interest rate. The reduction in the interest rate is strongest when information asymmetries are larger. Since the duration of a subsidized loan and a guarantee is the same as the duration of the underlying credit relationship, the receipt of a subsidized loan or a guarantee could reduce the probability of firms experiencing financing difficulties with banks. Equity investors may value a strong credit relationship between a firm and its bank. First, borrowing money at a lower interest rate lowers the cost of capital. Second, a bank's decision to lend money to a firm may indicate that it has favorable information about the firm (e.g., James 1987; Lummer und McConnell 1989). This may be a positive signal for an equity investor. In support of this hypothesis, Bergbrant et al. (2017) document that the equity volume in the IPO market declines when lending standards tighten. Consequently, the receipt of a subsidized loan or a guarantee may also improve the financing situation of the recipient firm vis-à-vis external equity investors. Based on these theoretical and empirical findings, I propose the alternative to Hypothesis 2.1:

Hypothesis 2.2 Receiving a subsidized loan or a guarantee is associated with a greater reduction in the probability that a firm will face financial constraints than receiving a grant.

A primary objective of public support programs for young firms is to alleviate financial constraints. Young firms generally suffer from greater information asymmetries than older firms (Hall and Lerner 2010). Consequently, they should be more financially constrained. Empirical literature indicates that public funding has stronger positive effects on firms that are more financially constrained. Howell (2017) shows that the survival rate of young firms is positively affected by the receipt of grants, especially for financially constrained firms. Horvath and Lang (2021) find that younger firms, and in particular more financially constrained firms, respond more strongly to the receipt of subsidized loans; they invest more capital, have higher employment, and are more productive even 3 years later. Thus, I hypothesize that more financially constrained firms show stronger responses to the receipt of public funding than less financially constrained firms.

Hypothesis 3 The receipt of public funds is associated with a lower future probability of experiencing financial constraints for more financially constrained firms than for less financially constrained firms.

As outlined in Sect. 2.1, entrepreneurs and startups differ systematically in many characteristics, including their financing. Investments in startups are considered to be particularly risky, with failure rates typically in the high double digits. Previous literature largely documents a positive relationship between financial constraints and firm risk (Li 2011). Moreover, high-tech firms are riskier than low-tech firms (Pástor und Veronesi 2009; Schwert 2002). Startups tend to be innovative firms, and a large share of them are involved in high-tech activities. In my dataset, approximately two thirds of the firms receiving external equity capital during the observation period are classified as high-tech firms. High-tech firms are particularly financially constrained (OECD 2022; Kulicke 2021). If financially constrained firms respond more strongly to the receipt of public funding than less financially constrained firms (see Hypothesis 3), then the probability

of experiencing financial constraints should decrease more for startups than for entrepreneurs after receiving public funding.

Hypothesis 4 The receipt of public funds is associated with a stronger reduction in the future probability of experiencing financial constraints for startups than for entrepreneurs.

Previous literature reports positive effects of grants and subsidized loans on real outcomes. By their nature, grants are non-repayable and increase the firm's equity, while loans are repayable and increase the firm's debt. Debt obligations usually involve regular cash outflows for interest and principal payments. However, subsidized loans often have a grace period, so that the cash outflow of the subsidized firm is not affected by principal payments. Nevertheless, the interest expense reduces the net income of the firm and thereby increases its probability of incurring losses. As a result, the receipt of a grant may stabilize the internal economic position of a firm to a greater extent than the receipt of a subsidized loan or a guarantee, since grants do not require interest expense. Building on this argument, I derive the last research hypothesis:

Hypothesis 5 A grant is associated with a stronger reduction in the future probability of experiencing financial constraints based on real proxies for financial constraints than a subsidized loan or a guarantee.

Hypothesis 1, Hypothesis 2.1 and Hypothesis 2.2 are tested in Sect. 5.1, Hypothesis 3 is tested in Sect. 5.2, Hypothesis 4 is tested in Sect. 5.3, and Hypothesis 5 is tested in Sect. 5.4.

4 Data

4.1 Dataset

The empirical analyses are based on the IAB/ZEW Start-up Panel.⁴ Every year, the Institute for Employment Research (IAB) and the Leibniz Centre for European Economic Research (ZEW) conduct computer-assisted telephone interviews with about 5000 to 6000 new entrepreneurs and young firms. The selected firms represent a stratified random sample of the Mannheim Enterprise Panel.⁵ Once interviewed, the firms remain in the sample until they reach an age of seven years, after which they are replaced by younger firms, creating an unbalanced panel. The IAB/ZEW

⁴ Former names of the IAB/ZEW Start-up Panel are KfW/ZEW Start-up Panel, when ZEW cooperated with KfW and Creditreform between 2008 and 2013, and Mannheim Start-up Panel for the time period from 2014 to 2015. See Fryges et al. 2010 for a detailed description of the dataset.

⁵ The Mannheim Enterprise Panel includes all economically active firms in Germany based on the Creditreform database. According to Bersch et al. (2014) who compare the Mannheim Enterprise Panel with the German Business Register of the Federal Statistical Office, it "gives by and large a representa-

Start-up Panel contains information on general firm characteristics, the founding team, and the firm's financing situation including public support, specifically the type of instrument and the institution (Egeln et al. 2019). The instruments are grouped into credits or loans, grants, securities or guarantees, VC, and others (e.g., consulting). Thus, the dataset allows for an analysis of the relationship between different public funding instruments and the financing situation of young firms. The raw dataset covers fifteen waves for the reference years 2007 to 2021.

The samples for the empirical analyses include firms that meet the following criteria. First, a firm must be surveyed every year beginning from its founding year. This means that data must be available for each year between the first and the last individual firm observation year without time gaps. Second, information on public funding must be available continuously for each reference year. For example, if a firm is interviewed from the first to the third year and again in the fifth year, I only include observations for the first three years. This approach ensures that firms are correctly classified as either publicly funded or not, and it avoids bias from misspecification, e.g., such as defining a firm that received public funding in an unobserved year as not publicly funded. My final sample consists of 41,227 firm-year observations for 19,852 firms, including 8352 subsidized firms. Of these, 2395 firms received a grant as first public financing instrument, and 1680 firms received a subsidized loan or a guarantee as first public financing instrument. I consider subsidized loans and guarantees together because both instruments are related to bank debt, where the public sector takes on some or all of the risk.

4.2 Variable description

The objective of this study is to analyze how receiving public funding affects the financial constraints of young firms. For this purpose, the main independent variable, *Public funding*, indicates whether a firm received public funding in the reference year or any prior year.

The dependent variable measures whether a firm suffers from financial constraints. I use four proxies for financial constraints: *Financing difficulties, Financing difficulties banks, Financing difficulties VC*, and *Financing problems*. Table 1 provides an overview of the firm-related variables of this empirical study. A correlation table is presented in Table 9 in the Appendix.

Economic control variables include the firm age, *Age*, and proxies for size, investment level, and the macroeconomic environment, namely *Employees*, *GRW*, *Investment*, and *Revenue*. I control for these factors due to their potential relationship with financial constraints. Variables to control for industry or founder characteristics

Footnote 5 (continued)

tive picture of the corporate landscape in Germany" (p. 3). However, firms with minor business activities, such as freelancers or micro-enterprises in the agricultural sector, are underrepresented in the Mannheim Enterprise Panel, as it covers only 30% of these firms, compared to 40% in the Federal Statistical Office (Egeln et al. 2002).

Table 1 Variable definition

Variable	Definition
Independent variable	
Public funding	Dummy variable indicating whether the firm has received public funds
Dependent variables	
Financing difficulties	Dummy variable indicating whether the firm experiences financing difficulties with capital providers
Financing difficulties banks	Dummy variable indicating whether the firm experiences financing difficulties with banks
Financing difficulties VC	Dummy variable indicating whether the firm experiences financing difficulties with equity investors
Financing problems	Dummy variable indicating whether the firm has financing problems, e.g. cannot raise enough capital to carry out planned investments
Economic control variables	
Age	Natural logarithm of the firm age (in years)
Employees	Natural logarithm of the number of employees (headcount); winsorized at the 1st and 99th percentiles
GRW	Dummy variable indicating whether the firm is based in an assisted area of "Joint Federal/Länder Task for the Improvement of Regional Economic Structures" (GRW)
Investment	Natural logarithm of the amount (in euro) of investments; winsorized at the 1st and 99th percentiles
Revenue	Natural logarithm of the revenue (in euro); winsorized at the 1st and 99th percentiles
Financial control variables	
Funding share banks	Share of funding from banks (in percent)
Funding share owners	Share of funding from owners (in percent)
Funding share VC	Share of funding from equity investors (in percent)
Other variables	
Equity capital	Dummy variable indicating whether the firm is financed by external equity (e.g., by venture capitalists)
Industry	Categorical variable whether the firm is active in production, building and extension, repairs, leasing, trading, or other services
Losses	Dummy variable indicating whether the firm has incurred losses (i.e., negative net income)
Profits	Natural logarithm of profits (in euro); winsorized at the 1st and 99th percentiles
RD	Natural logarithm of R&D expenditure (in euro); winsorized at the 1st and 99th percentiles
Revenue reduction	Dummy variable indicating whether the revenues have decreased compared to the previous year (year $t - 1$)
Staff reduction	Dummy variable indicating whether the number of employees has decreased compared to the previous year (year $t - 1$)

This table provides information on the definitions of the variables. The source of all variables except for *GRW* is the IAB/ZEW Start-up Panel. Information on the GRW status of a region is obtained from the Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR) (2014). GRW ("Gemeinschaftsaufgabe ,Verbesserung der regionalen Wirtschaftsstruktur") is the most important instrument of German regional economic policy. Whether or not a region is classified as an assisted area is determined based on indicators of structural weakness (Clausen 2022). The geographical distribution of the GRW assisted areas is reviewed for each funding period of 7 years in accordance with EU state aid rules to ensure that public support is continuously allocated to the structur-

Table 1 (continued)

ally weakest regions. Thus, a variable that captures the GRW status of a firm's location seems to be a suitable proxy for the macroeconomic environment. I manually assign the GRW status to the counties using the official regional aid maps and match these data with the IAB/ZEW Start-up Panel

(e.g., education) are not necessary because these variables are usually time-invariant and captured by the firm fixed effects included in the regression model.

The effect of public funding on the financing situation of a firm might be biased by its financing structure. For example, firms financed by banks usually have a larger leverage than firms that are financed by equity investors only. A larger leverage might be related to stronger financial constraints. To mitigate potential bias, I include the *financial control variables Funding share banks*, *Funding share owners*, and *Funding share VC*, which express the share of funding from banks, owners, and equity investors, respectively.

The *other variables* are used for additional analyses, specifically for descriptive statistics (see Sect. 3.3) and for analyzing real effects of public funding on young firms (see Sect. 5.4).

4.3 Descriptive Statistics

Table 2 presents descriptive statistics for the samples of all publicly funded firms (Panel A), of firms receiving grants (Panel B), and of firms receiving subsidized loans or guarantees (Panel C), compared to non-publicly funded firms, respectively.

There are significant differences between publicly funded and non-publicly funded firms in several characteristics. Firms receiving grants spend more than twice as much on R&D compared to non-publicly funded firms, while firms receiving subsidized loans or guarantees spend 88.4% more on investment. These figures indicate that grants are primarily to finance R&D, while subsidized loans and guarantees are primarily to finance investments, consistent with Hottenrott and Richstein (2020). This more active investment behavior could relate to the larger size of firms receiving subsidized loans or guarantees in terms of employees and revenues.

The descriptive statistics on financial constraints show that almost one in five to one in six young firms face financing problems, consistent with Metzger (2023). Firms that have received public funding are more likely to report financial constraints compared to those that have not (Panel A). For example, 15.3% of publicly funded firms report financing difficulties with external capital providers, compared to just 12.9% of non-publicly funded firms. This suggests that public funds tends to be allocated to financially constrained firms. Thereby, firms receiving grants (Panel B) are more likely than non-publicly funded firms to report financial constraints based on all four proxies for financial constraints. On the contrary, firms receiving subsidized loans or guarantees (Panel C) are more likely than non-publicly funded firms to report financial constraints based on two proxies (*Financing difficulties banks*). This may indicate, for example, that less recipient firms of subsidized loan or a guarantee has a significantly positive influence on

	(1) Pub funded	licly firms	(2) Non- funded f	publicly ìrms	(1)–(2)		
	Mean	SD	Mean	SD	Abs. diff	Rel. diff	T-stat
Panel A: Publicly funded fin	rms versu	is non-put	olicly fund	led firms			0
Age	2.3	1.6	1.9	1.3	0.5	26.1%	- 34.48
Employees	3.3	5.2	2.1	4.2	1.2	54.2%	- 24.50
Equity capital	7.9%	0.3	4.6%	0.2	3.3 pp	71.5%	- 13.81
Financing difficulties	15.3%	0.4	12.9%	0.3	2.4 pp	18.4%	- 6.92
Financing difficulties banks	11.4%	0.3	8.4%	0.3	3.0 pp	35.1%	- 10.00
Financing difficulties VC	2.6%	0.2	2.1%	0.1	0.5 pp	23.9%	- 3.31
Financing problems	18.8%	0.4	17.3%	0.4	1.5 pp	8.8%	- 4.03
GRW	38.2%	0.5	29.9%	0.5	8.3 pp	27.8%	- 17.66
Investment	38.1	90.5	27.3	70.6	10.8	39.7%	- 12.76
Losses	31.3%	0.5	31.6%	0.5	– 0.3 pp	- 0.9%	0.56
Profits	13.6	123.0	- 33.8	6285.3	47.3	- 140.2%	- 0.95
RD	15.7	52.8	10.6	39.9	5.1	47.9%	- 10.84
Revenue	358.4	635.3	256.9	553.2	101.5	39.5%	- 16.32
Revenue reduction	10.1%	0.3	8.3%	0.3	1.8 pp	21.9%	- 6.22
Staff reduction	12.0%	0.3	7.3%	0.3	4.8 pp	65.3%	- 14.41
Observations		20,589		20,638			
Firms		8352		11,500			
Panel B: Recipient firms of	grants ve	ersus non-	publicly f	unded firm	ns		
Age	2.5	1.6	1.9	1.3	0.6	33.3%	31.73
Employees	3.0	4.9	2.1	4.2	0.9	42.8%	14.35
Equity capital	7.3%	0.3	4.6%	0.2	2.7 pp	58.2%	8.41
Financing difficulties	15.5%	0.4	12.9%	0.3	2.5 pp	19.4%	5.11
Financing difficulties banks	11.6%	0.3	8.4%	0.3	3.1 pp	37.3%	7.58
Financing difficulties VC	3.1%	0.2	2.1%	0.1	1.0 pp	47.6%	4.56
Financing problems	19.6%	0.4	17.3%	0.4	2.3 pp	13.4%	4.24
GRW	41.5%	0.5	29.9%	0.5	11.6 pp	38.7%	17.08
Investment	28.3	69.9	27.3	70.6	1.1	3.9%	1.00
Losses	28.5%	0.5	31.6%	0.5	- 3.1 pp	- 9.9%	- 4.45
Profits	15.9	114.3	- 33.8	6285.3	49.6	- 147.0%	0.55
RD	21.5	62.5	10.6	39.9	10.9	103.2%	16.26
Revenue	344.6	619.7	256.9	553.2	87.7	34.1%	10.13
Revenue reduction	11.3%	0.3	8.3%	0.3	3.0 pp	35.7%	7.03
Staff reduction	13.3%	0.3	7.3%	0.3	6.1 pp	83.2%	13.03
Observations	6420	20,638			11		
Firms	2395	11,500					
Panel C: Recipient firms of	subsidize	ed loans or	r guarante	ees versus	non-public	ly funded fir	ms
Age	2.2	1.5	1.9	1.3	0.4	19.4%	15.55
Employees	3.9	5.6	2.1	4.2	1.8	84.0%	22.42
Equity capital	6.7%	0.3	4.6%	0.2	2.1 pp	46.6%	5.61

Table 2 Descriptive statistics

-0.2%

47.3%

-0.04

6.50

Table 2 (continued)							
	(1) Pub funded	licly firms	(2) Non funded	-publicly firms	(1)–(2)		
	Mean	SD	Mean	SD	Abs. diff	Rel. diff	T-stat
Financing difficulties	14.0%	0.3	12.9%	0.3	1.0 pp	8.0%	1.72
Financing difficulties banks	11.0%	0.3	8.4%	0.3	2.6 pp	30.4%	5.09
Financing difficulties VC	1.2%	0.1	2.1%	0.1	– 0.9 pp	- 41.9%	- 3.54
Financing problems	17.2%	0.4	17.3%	0.4	– 0.1 pp	- 0.4%	- 0.11
GRW	29.4%	0.5	29.9%	0.5	– 0.5 pp	- 1.5%	- 0.57
Investment	51.4	105.6	27.3	70.6	24.1	88.4%	16.77
Losses	34.9%	0.5	31.6%	0.5	3.3 pp	10.5%	3.77
Profits	23.2	87.8	- 33.8	6285.3	56.9	- 168.6%	0.49
RD	7.9	33.4	10.6	39.9	- 2.7	- 25.3%	- 3.86
Revenue	427.0	693.4	256.9	553.2	170.1	66.2%	15.72

8.3%

10.7%

0.3

0.3

3806

1680

Table 2 (continued)

Revenue reduction

Staff reduction

Observations

Firms

This table reports descriptive statistics for the full sample of publicly funded firms (Panel A), for the sample of recipient firms of grants (Panel B), and for the sample of recipient firms of subsidized loans or guarantees (Panel C), and non-publicly funded firms, respectively, over the period from 2007 to 2021. The left part of the table shows the mean and the standard deviation (SD) for the publicly funded firms (1) and for the firms that have not received public funding during the observation period (2). The right part of the table shows the absolute (Abs. diff.) and the relative (Rel. diff.) difference in mean values; for binary variables, the absolute difference in means is expressed in percentage points (pp). The t-statistic (T-stat) of a t-test on the difference of means is displayed in the right column. Table 1 provides descriptions of all variables, whereas *Age* is reported in years, *Employees* is reported in headcount, and *Investment, Profits, RD*, and *Revenue* are reported in k euro, respectively

8.3%

7.3%

0.3

0.3

20,638

11,500

0.0 pp

3.4 pp

equity investors. Comparing firms receiving grants and firms receiving subsidized loans or guarantees, firms receiving grants are more likely to be financially constrained. In the following part of this paper, I empirically examine the financing situation of firms after receiving public funding in more detail.

5 Methodology

The optimal empirical strategy for analyzing the effect of public funding on a firm's financing situation would be to estimate what the financing situation of a recipient firm would have been in the absence of public funding. The difference between the level of financial constraints of recipient firms (treatment group) and the level of financial constraints of non-recipient firms (control group), if they had received public funding, is referred to as the "average treatment effect on the treated" (ATET). Obviously, the level of financial constraints of non-publicly

funded firms if they had received public funding is not observable and represents a counterfactual outcome. Therefore, specific econometric tools are needed. In this section I explain my methodology.

I estimate the relationship between public funding and financial constraints using an ordinary least squares (OLS) linear probability model with firm and year fixed effects. Binary choice models are typically used when the dependent variable is binary, as in this study. The probability that a firm i experiences financial constraints in year t is given by the following model:

$$y_{it} = \alpha_0 + \beta_0 \cdot Public \ funding_{it-1} + \beta_1 \cdot X_{it-1} + \eta_i + v_t + \varepsilon_{it}.$$
 (1)

The dependent variable y_{it} is a proxy for financial constraints and can be *Financing difficulties, Financing difficulties banks, Financing difficulties VC*, or *Financing problems* as defined in Sect. 3.2. The main independent variable is *Public funding*_{it-1}. X_{it-1} is a vector of control variables; these control variables are described in Sect. 3.2. As the time subscript t_{-1} indicates, all independent variables are lagged by one year. η_i are firm fixed effects, v_t are year fixed effects, and ϵ_{it} is an error term. Standard errors are computed as panel-robust standard errors to account for serial correlation and heteroskedasticity (Brüderl and Ludwig 2015) and are clustered at the industry level.

A first major concern with many studies of the effects of public funding based on observational data relates to selection bias. Publicly funded firms may differ systematically from non-publicly funded firms because the receipt of public funding is not random. Selection bias could arise from the self-selection process of applicant firms (self-selection into treatment), from the decision of the public agency, and, in the case of some public support programs, from the decision of an intermediary between the firm and the agency (e.g., banks). Therefore, a simple comparison of publicly funded firms and non-publicly funded firms is likely to produce biased results. I address this concern by including firm fixed effects in the regression model. In this way, the identification of the effect of public funding comes solely from the variation of the treated firms within the sample period, i.e., from those firms that change their status from not being publicly funded to being publicly funded. Thus, potential systematic, time-invariant differences become irrelevant.

A second major concern relates to omitted variables. In this setting, unobservable factors that could affect the dependent and independent variables include personal characteristics of the founders, managerial skills, the financial situation of the founders, historical bank relationships, and relevant factors for the risk assessment of capital providers. Such unobservable factors could bias my estimation results in either direction. Unfortunately, my dataset does not contain information on these characteristics. However, the inclusion of firm fixed effects allows for accounting for time-invariant unobservable factors through mean-differencing. Consequently, potential differences in characteristics between publicly and nonpublicly funded firms will not bias the results as long as they do not change over time. The inclusion of year fixed effects compensates for time trends; hence, the linear probability model holds under the assumption of temporal homogeneity. While specific characteristics of publicly and non-publicly funded firms may differ, time trends during the observation period are expected to hold for all types of young firms in Germany, regardless of the public funding status.

A third major concern that potentially threatens endogeneity is reverse causality. In this context, reverse causality implies that firms receive public funding because the public agency expects that financing difficulties will diminish. Such a scenario is implausible because the existence of financial constraints is a major motive for the establishment of public support programs. Moreover, my model includes the receipt of public funding as a lagged effect. The effect of public funding is assumed to appear in the year following its receipt. The firms of this study are largely classified as microenterprises (see Sect. 3.3). Capital providers, such as banks, usually base their risk assessment of small firms on the financial statements. Thus, they adjust ratings with a time lag after the preparation of the financial statements. However, if the time lag between the receipt of public funding and its impact on the financial situation is longer (shorter) than one year, the estimation results will be biased downward (upward or downward, depending on the intensity and duration). For robustness, I analyze the effect of public funding without a time lag and with a time lag of two years.

Other biases may result from the nature of the panel dataset. Measurement errors can lead to attenuation biases in all directions. Such measurement errors could arise, for example, from response effects in the interviews, incorrect answers, or an adjusted behavior of the surveyed founders within the interviews (panel conditioning). In addition, firms that go out of business within the observation period could bias the estimation results through panel attrition. Although measurement error can never be completely avoided in a survey, the regular and professional conduct of the structured interviews via telephone interviews suggests that measurement error and panel conditioning should not play a major role in this setting. With respect to panel attrition, the structure of the panel data allows for running regressions on subsamples of firms for a larger and equal time period. For robustness, I analyze subgroups of firms with observations available for at least three years.

Idiosyncratic errors in panel data estimates are potentially heteroskedastic and autocorrelated. However, my linear probability model is based on OLS, so idiosyncratic errors are assumed to be serially uncorrelated and homoscedastic. In particular, OLS-based models may suffer from heteroskedasticity when the dependent variable is binary (Marin and Olivier 2008). To mitigate potential concerns arising from this, I calculate robust standard errors that are clustered at the industry level.

I conduct regression analyses in four steps. First, I run regressions on the full sample to test Hypothesis 1. Moreover, I run regressions on a sample of firms that received a grant as the first public financing instrument and non-publicly funded firms, and on a sample of firms that received a subsidized loan or a guarantee as first public financing instrument and non-publicly funded firms. This allows for the estimation of differentiated effects of these instruments and to test Hypothesis 2.1 and Hypothesis 2.2.

Second, I run regressions on subsamples depending on the severity of financial constraints to test Hypothesis 3. I classify firms as more or less financially constrained based on the income level (losses versus profits) and the net change in

employees (reduction versus increase). The choice of losses as a proxy for financial constraints is based on Ge (2022), who uses several measures of losses as proxies for financial constraints of insurance companies. The choice of a reduced number of employees as a proxy for financial constraints is based on Bäurle et al. (2021), who document that financially constrained firms lay off more employees. In addition, this analysis allows for investigating the alternative of Hypothesis 1. It could be criticized that the null hypothesis of public funding having no effect on financial constraints is credible. This could be the case if a firm receiving public funding is not financially constrained because it has sufficient financial resources. Whether public funding does not affect the financial situation of a firm in such circumstances can be analyzed based on the subsamples of less financially constrained firms. If the alternative of Hypothesis 1 is supported, estimated coefficients on the main independent variable *Public funding*_{*i*-1} for the less financially constrained firms should be insignificant and less pronounced.

Third, I test Hypothesis 4 by examining the heterogeneity of the effect of public funding on young firms by differentiating between entrepreneurs and startups. I define entrepreneurs as firms with fewer than two employees in the observation year that have not received any funding from external equity investors during the observation period, and startups as firms that have received external equity capital during the observation period.

Fourth, I run regressions with dependent variables that proxy for real outcomes to test Hypothesis 5. First, I investigate how public funding is related to the business growth of firms. Second, I use real outcome variables, namely *Losses, Revenue reduction*, and *Staff reduction*, as dependent variables. This second set of variables serves as alternative proxies for financial constraints. It is economically intuitive that firms experiencing losses and negative growth in revenues and employment are in a more difficult economic situation and thus likely to be more financially constrained. This is in line with the findings of Schauer et al. (2019), who show that more financially constrained firms have, on average, a negative return on assets and a negative sales growth, as well as with Bäurle et al. (2021). Moreover, financial constraints have been proxied by losses in previous literature (e.g., Ge 2022).

6 Empirical results

6.1 Public funding and financial constraints

Table 3 reports the results of regressions examining how the receipt of public funding in year t - 1 affects the probability of a firm experiencing financial constraints in year t for the full sample [columns (1)–(3)], for the sample of firms receiving grants and non-publicly funded firms [columns (4)–(6)], and for the sample of firms receiving subsidized loans or guarantees and non-publicly funded firms [columns (7)–(9)]. I begin with a baseline fixed effects model without controls [columns (1), (4), (7)], add economic controls [columns (2), (5), (8)], and finally add financial controls as specified in Eq. (1) [columns (3), (6), (9)]. If public funding reduces financial

Table 3 Regression results c	of financial constra	aints with the inde	pendent variab	le Public funding					
Dependent variable	Full sample			Grants			Subsidized loans	or guarantees	
	(1)	(2)	(3)	(4)	(5)	(9)	(7)	(8)	(6)
Financing difficulties	- 0.036*	- 0.042*	- 0.050*	0.001	0.009	0.046	- 0.085	- 0.071	- 0.124
	(0.017)	(0.019)	(0.022)	(0.013)	(0.008)	(0.028)	(0.054)	(0.060)	(0.09)
Financing difficulties	-0.042^{**}	-0.048^{**}	-0.042	-0.010	- 0.002	0.052	-0.094^{*}	- 0.081	- 0.132
banks	(0.016)	(0.017)	(0.022)	(0.010)	(0.007)	(0.040)	(0.045)	(0.050)	(0.098)
Financing difficulties VC	-0.014*	-0.019^{**}	-0.041^{**}	- 0.005	-0.011	- 0.034	-0.015^{*}	- 0.022**	- 0.029*
	(0.007)	(0.006)	(0.016)	(6000)	(0.006)	(0.021)	(0.007)	(0.008)	(0.013)
Financing problems	- 0.028	-0.038	-0.037*	0.003	0.007	0.028*	-0.086^{**}	- 0.061	- 0.052
	(0.019)	(0.025)	(0.019)	(0.015)	(0.016)	(0.011)	(0.032)	(0.032)	(0.079)
Observations	19,113-19,120	15,903-15,909	7685-7690	11,909-11,913	9906-9910	4454-4457	10,030-10,035	8383-8387	3925-3928
\mathbb{R}^2	0.003 - 0.011	0.004 - 0.010	0.013-0.021	0.002-0.011	0.004 - 0.010	0.015-0.028	0.004-0.019	0.006-0.018	0.018-0.035
Adjusted R ²	0.002 - 0.010	0.003-0.010	0.011-0.018	0.001 - 0.010	0.002 - 0.009	0.011 - 0.024	0.003 - 0.018	0.004 - 0.016	0.013 - 0.030
Economic controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Financial controls	No	No	Yes	No	No	Yes	No	No	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
This table reports the regres- ing financial constraints in y firms receiving grants and 1 firms [columns (7)–(9)]. Th R-squared (Adjusted \mathbb{R}^2) are the (adjusted) R-squared can standard errors are clustered	sion results of a li lear <i>t</i> . A descripti ion-publicly funde ion-publicly funde includes reported as range be interpretated <i>i</i> at the industry lev	near probability n on of all variable ed firms [column: controls and fixe s between the mi as the difference b vel and reported in	nodel examinin s is provided in s (4)-(6)], and ed effects (FE) inimum and m between the ave	ig how the receiping frame of the sample of for the sample of as shown in the aximum values of arage predicted pr. *, **, and **** ind	t of public func- ter of public func- f firms receivi- table. The nur f the model sp obability of pu icate a signific:	ling in year <i>t</i> – luts for the full ng subsidized mber of observ ceifications sho blicly and non- ance level of 10	<i>I</i> affects the prologange of the prologans or guarante leans or guarante attions, the R-squ with a sach colum publicly funded f 1%, 5%, and 1%, the prologange of the prologange of the product of the prologange of the product of th	bability of a fine $(1)^{-1}(3)$, for $(3)^{-1}(3)$, for $(3)^{-1}(3)$, for $(3)^{-1}$	m experienc- the sample of blicly funded I the adjusted n this setting, (998). Robust

constraints of firms, the coefficient on the independent variable $Public funding_{it-1}$ should be negative.

Receiving public funding is, on average, associated with a decrease in the probability of experiencing financial constraints one year later, as indicated by all proxies [columns (1)–(3)]. Without controls [column (1)] and with only economic controls [column (2)], the results are both economically and statistically significant for all types of external capital providers, as proxied by *Financing difficulties*, *Financing* difficulties banks, and Financing difficulties VC. After including financial controls [column (3)], the results still document an economically significant reduction in the probability of experiencing financial constraints based on all four proxies. However, the results lose statistical significance for financing difficulties with banks, while they become statistically significant with *Financing problems* as the dependent variable, which includes internal financing difficulties in addition to financing difficulties with external capital providers. The estimated coefficients can be interpreted as the change in the probability of experiencing financial constraints in percentage points one year after receiving public funding. For example, on average, receiving public funding is associated with a 5.0 percentage point lower probability of experiencing financing difficulties with external capital providers one year later [column (3)]. Compared to an average share of publicly funded firms experiencing financing difficulties of 15.3% over the period from 2007 to 2021 (see Table 2), these results represent a significant reduction of about 32.7%, i.e., from 15.3 to 10.3% (10.3%/15.3%-1).

The distinction between grants and subsidized loans or guarantees shows that they are related differently to the financial situation of firms. In contrast to the results based on the full sample [columns (1)-(3)], the results based on the sample of firms receiving grants and non-publicly funded firms [columns (4)-(6)] are both economically negligible and statistically insignificant in many specifications. The estimation results slightly suggest that, on average, a grant is associated with a 3.4 percentage point (not statistically significant) reduction in the probability of experiencing financing difficulties only with equity investors, after controlling for the financing structure [column (6)]. Interestingly, the other coefficients indicate that, on average, firms receiving a grant are more likely to experience financing difficulties with external capital providers other than equity investors, as well as general financing problems after controlling for the financing structure. One possible explanation for this could be that grants are used by firms to undertake risky projects that are generally not favored by banks or other external (non-equity) investors. Overall, I interpret these results as indicating that grants tend to help young firms raise internal financing and external equity, but not external debt.

Receiving a subsidized loan or a guarantee is, on average, associated with a reduction in the probability of experiencing financial constraints as measured by all proxies. Compared to the full sample, these results show a larger reduction in the probability of experiencing financial constraints for all specifications except for the specification with all controls and *Financing difficulties VC* as the dependent variable [column (9)]. In the specification without any controls [column (7)], the results are statistically significant for *Financing difficulties banks*, *Financing difficulties VC*, and *Financing problems*. When controls are included [column (8)], the statistical

significance disappears, except for *Financing difficulties VC*. The estimated reduction in the probability of experiencing financial constraints after receiving a subsidized loan or a guarantee is most pronounced for financing difficulties with banks, with a reduction of 13.2 percentage points after controlling for the financing structure [column (9)], although not statistically significant. In addition, firms receiving subsidized loans or guarantees have a statistically significant 2.9 percentage point lower probability of experiencing financing difficulties with external equity investors. Overall, these results suggest that subsidized loans or guarantees are associated with easier access to equity and debt capital.

In summary, my results indicate that public funding is, on average, related to a reduction in the probability of firms experiencing financial constraints, supporting Hypothesis 1. Grants and subsidized loans or guarantees affect the financing situation of firms in different ways. While the results are mixed for grants, indicating either an economically small reduction or an increase in the probability of experiencing financial constraints except for financing difficulties with equity investors, the receipt of a subsidized loan or a guarantee is associated with an economically significant reduction in the probability of experiencing financial constraints based on all proxies for financial constraints. This suggests that a grant is associated with easier access to equity capital but not to debt capital, while a subsidized loan or a guarantee is associated with easier access to both equity and debt capital, as well as with a more relaxed financing situation in general. Hence, for financing difficulties with external capital providers other than equity investors and for general financing problems, Hypothesis 2.1 is rejected, and Hypothesis 2.2 is accepted. For financing difficulties with equity investors, the results tend to support Hypothesis 2.2 rather than Hypothesis 2.1.

Considering the particularities of the financing situation of young firms in Germany (see Sect. 2.1), my results on grants partly contradict Chiappini et al. (2022), who show that the receipt of innovation subsidies facilitates access to bank debt, with this bank debt substituting for equity. Meanwhile, this could explain the lower probability of experiencing financing difficulties with equity investors. My results on subsidized loans or guarantees are consistent with, for example, Hackney (2023) and Bach (2014).

The different effects of grants and subsidized loans or guarantees on the financing situation of young firms vis-à-vis external equity investors contribute to the existing literature on the VC stimulus effect. My findings of a reduction in the probability of experiencing financing difficulties with equity investors, which I interpret as easier access to equity capital, are consistent with Howell (2017) and Söderblom et al. (2015) for grants, and with Zhao and Ziedonis (2020) for subsidized loans or guarantees.⁶

⁶ To address potential concerns about panel attrition bias, I run the same regressions based on samples of firms with observations available for at least three years. The results according to Eq. (1) are identical and thereby support my main findings.

Dependent variable	Panel A: Losses	s versus profits			Panel B: Staff r	eduction versus inc	rease	
	(1)	(2)	(3)	(4)	(5)	(9)	(1)	(8)
	Grants		Subsidized loan	is or guarantees	Grants		Subsidized loan	is or guarantees
	Losses	Profits	Losses	Profits	Reduction	Increase	Reduction	Increase
Financing difficulties	- 0.003	- 0.003	-0.610^{***}	- 0.029*	- 0.079	- 0.026	- 0.073	0.007
	(0.024)	(0.024)	(0.038)	(0.014)	(0.172)	(0.027)	(0.051)	(0.078)
Financing difficulties banks	0.026	-0.019	-0.556^{***}	-0.048^{**}	0.027	-0.015	-0.172	0.005
	(0.025)	(0.018)	(0.019)	(0.018)	(0.173)	(0.032)	(0.107)	(0.077)
Financing difficulties VC	-0.011	-0.014	-0.217*	0.011	-0.107^{**}	-0.034^{***}	-0.203^{**}	0.052
	(0.019)	(0.011)	(0.100)	(0.043)	(0.041)	(0.008)	(0.058)	(0.042)
Financing problems	-0.029	0.022	-0.644^{***}	- 0.058	- 0.063	-0.015	- 0.038	0.046
	(0.031)	(0.033)	(0.087)	(0.040)	(0.147)	(0.035)	(0.052)	(0.061)
Observations	2051-2051	7070-7073	1781-1782	5910-5912	1406-1408	3686–3687	1166-1168	3222-3223
\mathbb{R}^2	0.041 - 0.064	0.002 - 0.014	0.055 - 0.082	0.007 - 0.017	0.065 - 0.136	0.016 - 0.028	0.086 - 0.162	0.009 - 0.042
Adjusted R ²	0.033 - 0.056	0.000-0.012	0.046 - 0.074	0.004 - 0.014	0.054-0.126	0.011-0.024	0.074-0.152	0.004 - 0.037
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
This table reports the regress ing financial constraints in y and (6) report results for the loans or guarantees and non- (2) and (4)]. Panel B shows 1 (8)]. The model includes ecc	ion results of a lin- ear <i>t</i> depending on sample of firms rec publicly funded firm the results for firm nomic controls an	ear probability mc the presumed sev ceiving grants and rms. Panel A show s experiencing a n d fixed effects (Fl	del examining ho erity of financial non-publicly func we the results for the staff reduction (E) as shown in th	w the receipt of p constraints. A des led firms, and colt firms incurring lo [columns (5) and te table. The num	ublic funding in y- cription of all var- mns $(3), (4), (7),$ sses [columns (1) (7)], and for firms ber of observation	tear $t - I$ affects the labels is provided and (8) for the sar and (3)], and for the sar and (3)], the R-seperiencing a number of the R-squared supersection r_{15} , the R-squared supersection	the probability of a in Table 1. Colum nple of firms recei firms generating 1 det staff increase [c (R ²), and the adji	firm experienc- ms (1), (2), (5), ving subsidized profits [columns columns (6) and usted R-squared

R-squared can be interpretated as the difference between the average predicted probability of publicly and non-publicly funded firms (Gronau 1998). Robust standard errors are clustered at the industry level and reported in parentheses. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively

6.2 Sample splits by the severity of financial constraints

Table 4 presents the results for the subsamples based on the presumed severity of financial constraints, separately for firms that received grants and non-publicly funded firms, and for firms that received subsidized loans or guarantees and non-publicly funded firms. In Panel A, the samples are split up by net income (losses versus profits) and in Panel B by net change in staff (reduction versus increase). A firm is included in the samples "Losses" and "Staff reduction" ("Profits" and "Staff increase"), if, in the year of observation, it incurred losses (generated profits) and reduced (increased) the number of employees compared to the previous year, respectively. The subsamples of firms incurring losses [columns (1) and (3)] and of firms experiencing a net reduction in staff [columns (5) and (7)] represent more financially constrained firms. The subsamples of firms generating profits [columns (2) and (4)] and of firms increasing their staff [columns (6) and (8)] represent less financially constrained firms (Ge 2022; Bäurle et al. 2021; Schauer et al. 2019). If the effect of public funding is stronger for more financially constrained firms, the coefficient on the main independent variable should be negative and smaller for such firms.

The regressions are conducted according to Eq. (1), where I include only the economic control variables in the vector of control variables. This choice is motivated by avoiding a further reduction in the number of observations. Through the sample splits, the number of observations decreases significantly because, regarding the sample split by net income, not every surveyed firm has reported its net income, and regarding the sample split by the net change in staff, firms whose number of employees does not change are excluded.⁷

The results show that the change in the probability of experiencing financial constraints after receiving public funding differs across instruments, consistent with the main results reported in Table 3 of Sect. 5.1. In the following, I first present the estimation results of the analyses based on the sample of recipient firms of grants and non-publicly funded firms, followed by the analyses based on the sample of recipient firms of subsidized loans or guarantees and non-publicly funded firms.

For recipient firms of grants, the estimation results are heterogeneous with respect to the proxy for financial constraints. With *Financing difficulties* as the dependent variable, the results are economically negligible and not statistically significant in Panel A, similar to the corresponding main results reported in column (5) of Table 3, but suggest a reduction in the probability of experiencing financing difficulties with external capital providers one year after receiving a grant in Panel B. This could be related to the construction of the samples in Panel B, which requires information on the change in the number of employees. Therefore, the samples are more likely to

⁷ For robustness, I also run regressions according to Eq. (1) with both economic controls and financial controls. While the estimation results point in the same direction, the number of observations reduces significantly. For example, for the sample of firms receiving grants and non-publicly funded firms experiencing losses (profits), the number of observations decreases from a range of 2051–2051 (7070–7073) to a range of 1399–1399 (2621–2623), and for the sample of firms receiving grants and non-publicly funded firms experiencing a net reduction (increase) in staff, from a range of 1406–1408 (3686–3687) to a range of 593–595 (1721–1721).

consist of larger, more established firms with dynamic employment. As expected, more financially constrained recipient firms of grants [column (5)] show a greater reduction in the probability of experiencing financial constraints than less financially constrained recipient firms of grants [column (6)], supporting Hypothesis 3.

With *Financing difficulties banks* as the dependent variable, the regressions yield opposite results. They document that more (less) financially constrained firms receiving grants show an increase (a decrease) in the probability of experiencing financing difficulties with banks, rejecting Hypothesis 3. This heterogeneity may be masked by the corresponding estimation result in column (5) of Table 3. I interpret these results as indicating that banks avoid exposure to risky firms. Firms that experience losses and reductions in staff are expected to be, on average, more financially constrained and, consequently, riskier. If banks are reluctant to provide capital to riskier firms, such firms may experience stronger financing difficulties with banks.

Receiving a grant is associated with a reduction in the probability of experiencing financing difficulties with equity providers across all subsamples, consistent with the main results. The results are economically slightly stronger for firms generating profits [column (2)], although not statistically significant, and economically much stronger, negative, and statistically significant for firms with net staff reductions [column (5)], supporting Hypothesis 3 according to Panel B, but not according to Panel A.

Finally, the estimation results for firms receiving grants and non-publicly funded firms with *Financing problems* as the dependent variable show a reduction in the probability of experiencing financing problems for firms incurring losses in Panel A [column (1)] and for both subsamples in Panel B [columns (5) and (6)]. The main coefficients are economically smaller for firms incurring losses [column (1)] and experiencing a net reduction in staff [column (5)] than for firms generating profits (column (2); for such firms, the main coefficient is positive) and experiencing a net increase in staff [column (6)], respectively, supporting Hypothesis 3.

The regression results based on the subsamples of more financially constrained recipient firms of subsidized loans or guarantees and non-publicly funded firms [columns (3) and (7)] indicate a negative relationship between the receipt of a subsidized loan or a guarantee and the probability of experiencing financial constraints according to all proxies. This is consistent with the main results with economic controls shown in column (8) of Table 3. Similar to the above specifications for the subsamples of firms receiving grants and non-publicly funded firms, the average results reported in column (8) of Table 3 may also mask heterogeneity for firms receiving subsidized loans or guarantees. The estimation results for more financially constrained firms [columns (4) and (8)] show an increase in the probability of experiencing financing difficulties with equity investors in Panel A, as well as an increase in the probability of experiencing financial constraints according to all proxies in Panel B [column (8)], although they are not statistically significant and some of these results are economically negligible. Thus, Hypothesis 3 is strongly supported with respect to subsidized loans or guarantees.

Overall, the magnitude of the change in the probability of experiencing financial constraints varies across instruments and proxies for financial constraints. While a subsidized loan or a guarantee is, on average, consistently associated with better access to capital for more financially constrained firms, the effect of a grant is heterogeneous. This may be explained by the wide range of purposes of different grant programs (see Sect. 2.2), i.e., grants may have different effects on young firms depending on their specific objectives.

The results for the subsamples of less financially constrained firms allow me to examine the alternative of Hypothesis 1. Many of the main coefficients of these subsamples are economically negligible, positive, not statistically significant, or less pronounced compared to the corresponding subsample of more financially constrained firms. Note that firms expected to be *less* financially constrained may still be financially constrained; given the sample construction, they should, however, be less financially constrained than those expected to be more financially constrained. Nevertheless, firms that are not financially constrained at one point in time may become financially constrained in the future. Given this overall picture, the alternative of Hypothesis 1 cannot be rejected.

In summary, my results of the subsamples split up by net income and net change in staff suggest that public funding affects a firm's financing situation when it faces financial constraints. Specifically, they indicate that the effect of public funding on the probability of experiencing financial constraints is strongest when it is provided to more financially constrained firms in the form of a subsidized loan or a guarantee. This also holds for the VC stimulus effect. Hence, Hypothesis 3 is strongly supported for subsidized loans or guarantees. I interpret this as a positive outcome of subsidized loan or guarantee programs, as they seem to ease the financing situation of subsidized firms that are more financially constrained. For grants, my results weakly support Hypothesis 3 with respect to general financing problems, but neither fully support nor reject it for financing difficulties with external capital providers other than banks. With respect to financing difficulties with banks, Hypothesis 3 is rejected for grants.

6.3 Effects of public funding on entrepreneurs versus startups

In this section, I examine the effect of public funding on the financing situation of entrepreneurs compared to startups. I conduct regressions according to Eq. (1). As in Sect. 5.2, I include only the economic control variables in the vector of control variables. Table 5 reports the results for the subsamples of entrepreneurs in Panel A and for the subsamples of startups in Panel B.

The results show that, on average, both entrepreneurs and startups face a reduction in the probability of experiencing financial constraints after receiving public funding [columns (1) and (4)], consistent with the corresponding main results reported in column (2) of Table 3 in Sect. 5.1. While public funding is associated

Table 5 Regression results of fin:	ancial constraints with	the independent variab	le Public funding: entrepren	eurs versus startups		
Dependent variable	Panel A: Entrepre	neurs		Panel B: Startups		
	Full sample	Grants	Subsidized loans or guarantees	Full sample	Grants	Subsidized loans or guar- antees
	(1)	(2)	(3)	(4)	(5)	(9)
Financing difficulties	- 0.072	- 0.048	0.045	- 0.071	0.006	- 0.259
	(0.038)	(0.071)	(0.111)	(0.037)	(0.063)	(0.189)
Financing difficulties banks	-0.089^{**}	- 0.056	- 0.044	-0.070	0.061	- 0.213
	(0.029)	(0.072)	(0.065)	(0.047)	(0.066)	(0.169)
Financing difficulties VC	- 0.016	0.011	0.001	-0.076^{***}	- 0.053	-0.147
	(0.012)	(0.025)	(0.011)	(0.012)	(0.046)	(0.091)
Financing problems	-0.095^{**}	- 0.072	- 0.043	-0.055*	0.015	-0.179
	(0.038)	(0.050)	(0.176)	(0.023)	(0.059)	(0.145)
Observations	7045-7046	4939-4940	3991–3992	1274–1274	646-646	532-532
\mathbb{R}^2	0.009 - 0.018	0.010-0.017	0.015 - 0.028	0.020 - 0.032	0.048 - 0.078	0.049 - 0.091
Adjusted R ²	0.007-0.016	0.006-0.014	0.011-0.024	0.007-0.019	0.024 - 0.054	0.019-0.063
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes
This table reports the regression encing financial constraints in ye Table 1. The table reports results non-publicly funded firms [colur includescontrols and fixed effects ranges between the minimum and tated as the difference between t industry level and reported in part	results of a linear prol results of a linear prol s for the full sample of anns (2) and (5)], and fo ans (2) as shown in the d maximum values of the average predicted I thetess. *, ***, and ***	bability model examini (Panel A) and for firms f publicly funded enter ar recipient firms of sub- table. The number of the model specification probability of publicly * indicate a significanc	ing how the receipt of publi i funded by external equity i preneurs and startups, respe sidized loans or guarantees observations, the R-squaree observation in each column. N and non-publicly funded fi e level of 10%, 5%, and 1%,	c funding in year <i>t</i> – nvestors (Panel B). A ccively, [columns (1) and non-publicly func 1 (R ²) and the adjuste ote that in this setting tims (Gronau 1998). I respectively	1 affects the probabil- description of all vari and (4)], for recipient led firms [columns (3) d R-squared (Adjusted) t, the (adjusted) R-squa tobust standard errors	ity of a firm experi- iables is provided in firms of grants and and (6). The model \mathbb{R}^2) are reported as weed can be interpre- are clustered at the

with an economically more pronounced reduction in the probability of experiencing financing difficulties with banks for entrepreneurs (- 8.9 percentage points; statistically significant at the 5% level), it is associated with an economically more pronounced reduction in the probability of experiencing financing difficulties with equity investors for startups (- 7.6 percentage points; statistically significant at the 1% level). In addition, the general financing situation of entrepreneurs (*Financing problems*) shows a stronger improvement compared to startups (- 9.5 percentage points compared to -5.5 percentage points, statistically significant at the 5% and 10% levels).

Differentiating between instruments, the results indicate that grants tend to be associated with a reduction in the probability of experiencing financing difficulties with external capital providers other than equity investors, especially banks, and with general financing problems for entrepreneurs [column (2)]. These results differ from those reported in column (5) of Table 3 in Sect. 5.1, which are based on all firms receiving grants and non-publicly funded firms. Interestingly, the sample of startups shows opposite results [column (5)]. In contrast, startups respond much more strongly than entrepreneurs to the receipt of a subsidized loan or guarantee, with a reduction in the probability of experiencing financial constraints, ranging from 14.7 to 25.9 percentage points, depending on the proxy [column (6)]. Since startups are, on average, more financially constrained, these results align with the regression analyses based on subsamples of more financially constrained firms reported in Table 4. Conversely, the receipt of a subsidized loan or a guarantee is, on average associated with an increase in the probability of entrepreneurs facing financing difficulties with external capital providers other than banks, and a decrease of 4.4 and 4.3 percentage points in the probability of experiencing financing difficulties with banks and general financing problems (i.e., including internal financing), respectively.

In summary, public funding is, on average, associated with a lower probability of experiencing financial constraints for both entrepreneurs and startups. My results suggest that public funding has heterogeneous effects depending on the type of firm. While a grant is associated with a better financing situation for entrepreneurs both externally with capital providers other than equity investors and internally, a subsidized loan or a guarantee is associated with a significantly better financing situation for startups. Hence, on average, Hypothesis 4 is supported with respect to financing difficulties with equity investors, but rejected with respect to financing difficulties with banks and financing problems, and neither supported nor rejected concerning financing difficulties with any external capital provider. Differentiating between grants and subsidized loans or guarantees, Hypothesis 4 is rejected regarding grants with respect to financing difficulties with external capital providers other than equity investors and financing problems, and is supported with respect to financing difficulties with equity investors. Regarding subsidized loans or guarantees, Hypothesis 4 is strongly supported. The different responses of entrepreneurs and startups depending on the instrument may be explained by their differing needs for external capital and levels of financial constraints. First, the firms in the entrepreneurs sample are much smaller than those in the startups sample, with average annual revenues of 119.1 k euros compared to 431.9 k euros. Therefore, they are likely to have a higher demand for capital. The volume of a grant is limited, so, after controlling for size in terms of revenues, entrepreneurs are likely to benefit more from a grant in relative terms. Second, a larger share of firms in the startups sample face financial constraints than those in the entrepreneurs sample. For instance, 27.2% (31.9%) of startups face financing difficulties (financing problems) compared to 12.3% (16.1%) of entrepreneurs. Consequently, startups have a higher potential to face a reduction in the probability of experiencing financial constraints.

6.4 Real effects of public funding

Given that young firms in Germany are structurally disadvantaged and cannot fully exploit their growth potential (OECD 2022), it is worthwhile to examine the real effects of public funding in this study. Therefore, I conduct regression analyses according to Eq. (1), but with different dependent variables (y_{it}). I retain the lagged economic control variables to focus on changes. First, I investigate how the receipt of public funding is related to the business growth of young firms, using *Employees*, *Investment*, *Profits*, *RD*, and *Revenue* as dependent variables. Second, I analyze how public funding relates to the dependent variables *Losses*, *Revenue reduction*, and *Staff reduction*, which serve as proxies for financial constraints.

Table 6 presents the regression results for the full sample [columns (1) and (2)], for the sample "Grants" [columns (3) and (4)], and for the sample "Subsidized loans or guarantees" [columns (5) and (6)]. Panel A reports the results with indicators of business growth as dependent variables, and Panel B with indicators of financial constraints as dependent variables. If public funding is positively related to the real growth of young firms, the coefficient on *Public funding* should be positive in Panel A. Conversely, if public funding is related to a reduction in the probability of experiencing financial constraints, the coefficient on *Public funding* should be negative in Panel B, as in Sects. 5.1 to 5.3.

On average, public funding is associated with increases in employment, profits, R&D expenditure, and revenue, and a decrease in investment [Panel A; columns (1) and (2)]. These results are consistent with the analyses using indicators of financial constraints as dependent variables, suggesting that the probability of experiencing losses, a reduction in revenues, and a net reduction in staff decreases after receiving public funding.

Differentiating between grants [columns (3) and (4)] and subsidized loans [columns (5) and (6)] reveals heterogeneous effects. While a grant is associated with an increase in investment, firms receiving a subsidized loan or guarantee experience a decrease in investment one year later. These results support previous findings that subsidized loans or guarantees tend to be used to finance investment (cf. Sect. 3.3).

Dependent variable	Full sample		Grants		Subsidized lo antees	ans or guar-
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Indica	tors of business g	rowth				
Employees	0.034	0.083	0.047	0.118	0.012	0.162
	(0.042)	(0.070)	(0.047)	(0.071)	(0.085)	(0.204)
Investment	- 0.125	- 0.043	0.112	0.572*	- 0.127	-0.070
	(0.295)	(0.168)	(0.339)	(0.266)	(0.420)	(0.633)
Profits	0.753	0.471	0.583***	0.452	0.134	0.714
	(0.389)	(0.919)	(0.141)	(1.060)	(0.694)	(1.183)
RD	0.028	0.422**	0.041	0.503***	- 0.220**	0.568
	(0.078)	(0.122)	(0.135)	(0.121)	(0.086)	(0.302)
Revenue	0.255*	0.335	0.373**	0.455*	0.103	- 0.098
	(0.112)	(0.183)	(0.111)	(0.225)	(0.326)	(0.709)
Observations	13,706–15,752	6595-7601	8539–9819	3834-4405	7234-8307	3361-3882
(Within) R ²	0.009-0.112	0.025-0.133	0.013-0.105	0.041-0.114	0.012-0.096	0.046-0.119
Adjusted R ²	0.008-0.112	0.023-0.133	0.011-0.105	0.037-0.114	0.010-0.096	0.041-0.114
Panel B: Indicat	tors of financial c	onstraints				
Losses	- 0.038	- 0.024	- 0.022	0.006	- 0.032	- 0.056
	(0.021)	(0.061)	(0.011)	(0.062)	(0.062)	(0.092)
Revenue reduc- tion	- 0.069***	- 0.028	- 0.094*	- 0.105**	0.042	0.158
	(0.018)	(0.030)	(0.039)	(0.037)	(0.057)	(0.104)
Staff reduction	- 0.057**	- 0.099	- 0.057	- 0.189*	- 0.116	- 0.197
	(0.022)	(0.082)	(0.052)	(0.093)	(0.106)	(0.126)
Observations	8698-14,737	4289-7024	5106-9137	2320-4027	4399–7704	2082-3551
\mathbb{R}^2	0.027-0.250	0.074-0.247	0.018-0.263	0.070-0.281	0.027-0.268	0.099-0.285
Adjusted R ²	0.026-0.248	0.072-0.244	0.016-0.261	0.066-0.275	0.025-0.265	0.094-0.278
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes
Financial con- trols	No	Yes	No	Yes	No	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 6 Regression results of real effects with the independent variable Public funding

This table reports the regression results of a linear probability model examining how the receipt of public funding in year t - 1 affects the economic situation of a firm in year t. In Panel A, the dependent variable is an indicator of business growth, namely *Employees, Investment, Profits, RD*, or *Revenue*. In Panel B, the dependent variable is a proxy for financial constraints, namely *Losses, Revenue reduction*, or *Staff reduction*. A description of all variables is provided in Table 1. The table reports results for the full sample [columns (1) and (2)], for recipient firms of grants and non-publicly funded firms [columns (3) and (4)], and for recipient firms of subsidized loans or guarantees and non-publicly funded firms [columns (5) and (6)]. The model includes controls and fixed effects (FE) as shown in the table. The number of observations, the (within) R-squared ((Within) R²), and the adjusted R-squared (Adjusted R²) are reported as ranges between the minimum and maximum values of the model specifications shown in each column. Note that in this setting, the (adjusted) R-squared can be interpretated as the difference between the average predicted probability of publicly and non-publicly funded firms (Gronau 1998). Robust standard errors are clustered at the industry level and reported in parentheses. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively

If firms undertake investments financed partly or completely by subsidized loans or loans backed by public guarantees in the year of receipt, they may face high investments in that year and lower investments in subsequent years.

Similarly, the results with R&D expenditure as the dependent variable indicate that firms receiving grants spend more on R&D (cf. Sect. 3.3). However, the results based on the sample "Subsidized loans or guarantees" are inconsistent. Without financial controls [column (5)], the coefficient indicates a reduction in R&D expenditures one year later (statistically significant at the 5% level); with financial controls [column (6)], the coefficient is positive.

Regarding profits, the results show that both firms receiving grants and those receiving subsidized loans or guarantees generate higher profits one year later. The probability of incurring losses does not consistently decrease after receiving a grant, as indicated by the positive but economically negligible coefficient in the version with financial controls [column (4)]. This may be related to heterogeneity in the distribution of net income across firms. While some firms may experience a significant increase in profits after receiving a grant, there may be more firms that, on average, do not experience an increase in profits.

There are significant differences in the change in revenues after receiving a grant or a subsidized loan or guarantee. For the sample "Grants", the results show a significant increase in revenue and a significant decrease in the probability of a decrease in revenue. For the sample "Subsidized loans or guarantees", the results are mixed. Without controlling for the financing structure [column (5)], the coefficient is positive; after controlling for the financing structure [column (6)], it is negative. On average, a subsidized loan or guarantee is associated with an increase in the probability of experiencing a reduction in revenue, although not to a statistically significant degree.

Overall, the estimation results with real indicators of business growth and financial constraints as dependent variables vary depending on the specific real outcome variable. Thus, Hypothesis 5 is neither fully rejected nor fully supported. The results suggest that a grant is associated with higher employment, investment, profits, R&D expenditures, and revenues, while a subsidized loan or a guarantee is associated with higher employment and profits. The results with real outcome variables support my main findings that public funding is associated with a relaxed financing situation. In addition, they complement my main findings by showing that firms receiving grants are less likely to experience a reduction in revenue and employment. This suggests that the receipt of a grant helps a firm stabilize its internal economic position, thereby improving its financial situation. Subsidized loans or guarantees, on the other hand, are related to a reduction in the probability of incurring losses and experiencing a reduction in net employment but not with a reduction in revenues.

7 Robustness tests

7.1 Propensity score matching

Propensity score matching (PSM) (Rosenbaum and Rubin 1983) aims to estimate the ATET by matching treated firms with untreated firms that have similar pre-specified observable characteristics summarized in a propensity score. The conditional independence assumption is assumed to hold conditional on this propensity score. By further assuming that the treated and untreated firms are identical in observable and unobservable characteristics and that they would have experienced the same development if the recipient firms had not received public funds (parallel trends assumption), the counterfactual outcomes of the control firms can serve as proxies for the potential outcomes of the treatment firms in the absence of public funding. PSM is a common method for estimating the effects of public funding based on observational data.⁸

On the one hand, matching models have the advantage over regression models in that they do not require assuming a functional form of the relationship between dependent and independent variables (Armstrong et al. 2010), thus avoiding potential biases due to misspecification. On the other hand, matching models have several limitations. First, firms are matched based on observable characteristics; however, they may differ in unobservable characteristics like risk preferences. Second, if publicly and non-publicly funded firms differ too much in observable characteristics, such that no matching counterpart can be assigned, the results may not be valid for the whole population. Third, the sample size is reduced because matching requires information on the full set of control variables (Minutti-Meza 2013). Fourth, PSM involves many subjective design decisions, e.g., the matching variables, the number of matching counterparts, replacement, and the caliper width (DeFond et al. 2017). For these reasons, my main analysis is based on a linear probability regression model, which is consistent with Angrist and Pischke (2009) who suggest starting with a regression model before applying PSM. Nevertheless, using a matching model allows for testing the sensitivity of results to the chosen econometric design. For this reason, I use a matching technique with elements of exact matching and PSM as a second empirical strategy.

First, I estimate the propensity score based on a probit model. In this setting, the propensity score expresses the probability that a firm receives public funding in a year conditional on a set of lagged covariates $(t - 1^9)$. This means that matching is generally performed based on covariates lagged by one year. My motivation for calculating the propensity score based on lagged variables, where possible, is to avoid bias due to effects immediately after a firm receives public funding; if a firm

⁸ Examples include Horvath and Lang (2021), Hottenrott and Richstein (2020), Huergo and Moreno (2017), Cantner and Kösters (2015), Czarnitzki and Delanote (2015), Söderblom et al. (2015), Grilli and Murtinu (2014), Caliendo and Künn (2011).

 $^{^{9}}$ Note the different timing compared to the regression model explained in Sect. 4, where *t* refers to the year in which the level of financing difficulties is measured.

receives public funding within a year, this may already influence the financial and economic situation in the year of receipt. Therefore, I match treatment and control firms based on pre-funding characteristics. However, this would exclude firms that received public funding in their founding year, as data for the year prior to founding are not available. Since my dataset includes many such firms, I estimate the probit models for these firms based on covariates measured in the year of public funding (t), similar to Hottenrott and Richstein (2020). The results of the probit estimates are reported in Table 10 in the Appendix.

I construct control groups by matching without replacement, following the recommendation of Whited and Roberts (2013). One publicly funded firm is matched with one firm that did not receive public funding during the observation period (one-to-one matching) and is identical in age, founding year, industry, GRW status, and the level of financing problems. In addition, I require that matched firms belong to the same decile of investments and R&D expenditure and are similar in observable characteristics as closest in terms of the propensity score. The difference in the propensity score of two matched firms must not exceed a caliper width of 0.03. Requiring a maximum distance increases the matching quality because the treatment and control firms are not allowed to differ too much in observable characteristics.

I check the matching quality using two statistical measures. First, I report the results of t-tests on the difference in means of observable characteristics of the treatment and the control groups for the year of matching. DeFond et al. (2017) suggest that sufficient covariate balance is achieved when the mean of each covariate is insignificantly different between the treatment and the control groups based on a two-tailed test with a p-value greater than 0.1. Second, I report the normalized difference according to Imbens and Wooldridge (2009), which compares the means of two samples normalized by the standard deviation. Unlike the t-statistic, the normalized difference is not affected by the sample size. The normalized difference is suggested to be in the range of -0.25 and +0.25 for sufficient covariate balance.

Table 11 in the Appendix presents summary statistics for the treatment and the control groups for the year of matching. The t-statistics and the normalized differences for the variables indicate that matching has largely generated covariate balance between the treatment and control groups of all samples. This is particularly evident when comparing the differences in means of the reported variables before matching (see Table 2) and after matching (see Table 11). Before matching, the treatment and control groups differ significantly on almost all characteristics. After matching, the values of the normalized difference are well within the range of -0.25 and +0.25 for all samples. Importantly, the control and treatment groups do not differ significantly in the four proxies for financial constraints that are used as dependent variables.

Next, I run regressions on the matched samples. I use the following differencein-differences regression model inspired by Schüwer et al. (2019) to estimate the probability that a firm i experiences financial constraints in year t:

Dependent vari- able	Full sample		Grants		Subsidized lo guarantees	ans or
	(1)	(2)	(3)	(4)	(5)	(6)
Financing dif-	- 0.003	0.035	0.004	0.140	- 0.137*	- 0.342*
ficulties	(0.059)	(0.117)	(0.069)	(0.121)	(0.063)	(0.167)
Financing dif-	- 0.051	0.013	- 0.014	0.188	- 0.128*	- 0.323
ficulties banks	(0.057)	(0.126)	(0.084)	(0.117)	(0.053)	(0.167)
Financing dif-	0.032	0.003	0.002	-0.007	- 0.017	0.056
ficulties VC	(0.018)	(0.020)	(0.032)	(0.076)	(0.014)	(0.052)
Financing	- 0.067	- 0.059	- 0.051	0.011	- 0.119***	- 0.222
problems	(0.048)	(0.059)	(0.050)	(0.066)	(0.020)	(0.134)
Observations	2501-2501	1313-1313	1363-1363	651-651	812-812	463-463
Within R ²	0.024-0.033	0.060-0.071	0.026-0.047	0.132-0.212	0.075-0.082	0.205-0.276
Adjusted R ²	0.017-0.027	0.046-0.057	0.014-0.036	0.106-0.188	0.058-0.065	0.173-0.246
Economic con- trols	Yes	Yes	Yes	Yes	Yes	Yes
Financial controls	No	Yes	No	Yes	No	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes

 Table 7 Difference-in-differences regression results of financial constraints with the independent Variable Public funding

This table reports the regression results of a difference-in-differences regression model according to Eq. (2) examining how the receipt of public funding in year t - I affects the probability of a firm experiencing financial constraints in year t. A description of all variables is provided in Table 1. The table reports results for the full matched sample [columns (1) and (2)], for the sample of matched recipient firms of grants and control firms [columns (3) and (4)], and for the sample of matched recipient firms of subsidized loans or guarantees and control firms [columns (5) and (6)]. The model includes controls and fixed effects (FE) as shown in the table. The number of observations, the within R-squared (Within R²), and the adjusted R-squared (Adjusted R²) are reported as ranges between the minimum and maximum values of the model specifications shown in each column. Note that in this setting, the (adjusted) R-squared can be interpretated as the difference between the average predicted probability of publicly and non-publicly funded firms (Gronau 1998). Robust standard errors are clustered at the industry level and reported in parentheses. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively

$$y_{it+1} = \alpha_0 + \beta_0 \cdot Public \, funding_{it} + \beta_1 \cdot X_{it} + \eta_i + v_t + \varepsilon_{it}, \tag{2}$$

where y_{i+1t} , *Public funding*_{it}, X_{it} , η_i , v_t , and ε_{it} are defined as in Sect. 4. Note the different timing in the dependent and independent variables. Difference-in-differences regression models have the advantage of accounting for potential unobservable characteristics both between treatment and control firms and over time. Thus, the level of financial constraints prior to the receipt of public funding is taken into account.

Table 7 reports the difference-in-differences regression results for the full matched sample [columns (1) and (2)], for the matched sample of firms receiving grants and control firms [columns (3) and (4)], and for the matched sample of firms receiving subsidized loans or guarantees and control firms [columns (5) and (6)]. I run regressions including economic controls in the vector of control

variables [columns (1), (3), and (5)] and including both economic and financial controls [columns (2), (4), and (6)]. The results are heterogeneous across instruments and proxies for financial constraints. For these reasons, I begin by explaning the results for the subsamples by instrument, as the results for the full samples mask the heterogeneity.

The regression results based on the matched sample "Grants" show that, on average, a grant is associated with an increase in the probability of experiencing financing difficulties with external capital providers, although the coefficient is economically negligible when only economic controls [column (3)] are used. Regarding the probability of experiencing financing difficulties with banks, the results indicate a decrease with economic controls [column (3)] and an increase after including financial controls [column (4)]. These results are consistent with the main results reported in Table 3 of Sect. 5.1, although the economic magnitude of the coefficients varies. Unlike the main results, the results with *Financing difficulties VC* and *Financing problems* as dependent variables are mixed. Given the different signs of the main coefficients, these results neither support nor reject my main findings.

The results based on the matched sample "Subsidized loans or guarantees" indicate an improved relationship with external capital investors other than equity investors, especially banks, and a generally improved financing situation (*Financing problems*), consistent with my main results reported in Table 3. However, the economic magnitude and statistical significance are more pronounced in the differencein-differences regression analyses. Unlike the main results, the results do not clearly indicate whether a subsidized loan or a guarantee is associated with a better or worse relationship with external equity investors. While the main results suggest a statistically significant reduction in the probability of experiencing financing difficulties with external equity investors, the difference-in-differences estimation results suggest an increase after controlling for the financing structure.

In summary, the difference-in-differences regression analyses based on matched samples support my main findings that a grant is not associated with an improved financing relationship with external capital providers other than equity investors, while a subsidized loan or a guarantee is associated with an improved financing situation with external capital providers other than equity investors. Regarding my other main findings, particularly better access to external equity capital, the difference-indifferences regression analyses neither support nor contradict my main conclusions.

To test the robustness of my results, I construct additional samples by matching one control firm to two treatment firms and by using a more extensive caliper width of 0.05. The results are very similar to those reported in this section.

7.2 Further robustness tests

To validate my estimation results, I conduct several robustness tests concerning the model design, the independent variables, the sample construction, and the observation period, as summarized below.

7.2.1 Logit model with fixed effects

A major drawback of a linear probability model with a binary dependent variable is the assumption of a linear conditional probability function. Wooldridge (2010) suggests that a linear probability model can approximate estimates when the covariates have common values. My OLS regression results (see Sect. 5.1) show that all coefficients on the main independent variable fall well between zero and one. Hence, the chosen model specification appears appropriate in this setting. Nevertheless, I also run regressions based on a nonlinear function. Commonly used models for binary dependent variables are logit and probit models. According to Chamberlain (1980), probit models with fixed effects do not provide consistent estimators; the same holds true for standard logit models. To address these issues, Chamberlain (1980) proposes a conditional maximum likelihood estimator. I estimate the probability that a firm *i* experiences financial constraints in year *t* using the conditional maximum likelihood model

$$y_{it} = \Phi(\beta_0 \cdot Public \, funding_{it-1}, \cdot \beta_1 \cdot X_{it}, \eta_i, v_t), \tag{3}$$

where y_{it} , Public funding_{it-1}, X_{it-1} , η_i , and v_t , are defined as in Sect. 4.

The regression results are presented in Table 12 in the Appendix. Note that due to the logistic distribution, the point estimates of this model cannot be interpreted in the same way as those from the linear probability model. Therefore, the odds ratio is also presented to facilitate interpretation. An odds ratio below one indicates that the probability of not experiencing financial constraints after receiving public funding is higher than the probability of experiencing financial constraints. For example, the probability of experiencing financing difficulties with external equity investors one year after receiving public funding is reduced by a factor of 0.5 for the full sample [column (2)]. In summary, the results are similar in economic direction to those in Sect. 5.1 and thus support my main findings.

7.2.2 Alternative timing of the main independent variable

Second, I vary the timing of the main independent variable. The results are presented in Table 13 in the Appendix. Initially, it could be argued that public funding immediately reduces financing difficulties because external capital providers may rely on the positive decision of the public agency to provide capital. To test this hypothesis, I replace the independent variable *Public funding*_{*it*-1} with *Public funding*_{*it*} (without a time lag). The coefficients largely become economically and statistically insignificant. This suggests that the effect of public funding on financial constraints first appears in the following year, which is why the main independent variable is lagged by one year (see Sect. 4). Additionally, public funding might have effects that last for more than one period. To test this, I replace the main independent variable *Public funding*_{*it*-1} with *Public funding*_{*it*-2} (time lag of two years). The magnitude of the coefficients changes slightly for the full sample and for the sample "Subsidized loans or guarantees", but the interpretation of the results, except for the probability of experiencing financing difficulties with external equity investors, remains similar to Sect. 5.1. Unlike the main results, this robustness test indicates an increase in the probability of experiencing financing difficulties with external equity investors two years after receiving a subsidized loan or a guarantee. Moreover, the results based on the sample of firms receiving grants and non-publicly funded firms document a reduced probability of experiencing financial constraints for all proxies except for financing difficulties with external equity investors in the second year after receipt.

7.2.3 Trimmed instead of winsorized variables

For the main analyses, all continuous variables are winsorized at the 1st and 99th percentiles to reduce biases from potential outliers. Although this is common practice in empirical accounting and finance studies, critics could argue that regression results might be biased by the method of dealing with outliers. Therefore, third, I run my main regressions using variables that are trimmed at the 1st and 99th percentiles. The results of this robustness test are reported in Panel A of Table 14 in the Appendix and are very similar to my main results in Sect. 5.1.

7.2.4 Alternative samples

Fourth, I exclude firms that received public funding more than once to account for potential dilution effects. Previous literature suggests that the effects of public funding vary over time (e.g., Horvath and Lang 2021). The results are reported in Panel B of Table 14 in the Appendix. As expected, the coefficients on the main independent variable become significantly stronger.

7.2.5 Samples without non-publicly funded firms and fixed effects

Last, I test the validity of my model by running regressions according to Eq. (1), but without firm fixed effects, based on samples of publicly funded firms. In other words, I exclude firms that did not receive public funding during the observation period. I do not include firm fixed effects because systematic differences between publicly funded and non-publicly funded firms are not relevant with this sample design. The results are reported in Table 15 in the Appendix. Most coefficients on the main independent variable are much stronger compared to the baseline regression results in Sect. 5.1. Hence, this robustness test also supports my main findings.

8 Conclusion and discussion

In this paper, I examine the effect of public funding on the financing situation of young firms in Germany. Entrepreneurial activity in Germany is relatively low, and young firms are structurally disadvantaged compared to firms in other countries due to underdeveloped capital markets (Federal Ministry for Economic Affairs and Climate Action 2021). Consequently, young firms in Germany are likely to be more financially constrained than young firms in other countries, making empirical results from abroad potentially unapplicable. Therefore, it is essential to analyze the effect of public funding on young firms in Germany individually.

In this study, I estimate how the probability of experiencing financial constraints changes after a firm receives public funding. I differentiate between grants and subsidized loans or guarantees, as well as different types of financial constraints. To address potential concerns about selection bias, omitted variable bias, and to account for unobserved, time-invariant heterogeneity between recipient and non-recipient firms of public funding, I employ a linear probability model with firm and year fixed effects.

My results, based on the IAB/ZEW Start-up Panel, document that publicly funded young firms have, on average, a significantly lower probability of experiencing financial constraints. Adding to the existing literature, I highlight that grants and subsidized loans or guarantees alleviate financial constraints differently. While grants tend to improve the relationship with equity investors, subsidized loans or guarantees tend to enhance relationships with external providers of both equity and debt capital. Moreover, I find that the effect of public funding is stronger for more financially constrained firms when provided in the form of subsidized loans or guarantees. I interpret this as evidence that German public loan and guarantee programs generally succeed in targeting more financially constrained firms. I also show that public funding affects entrepreneurs and startups differently. My results indicate that grants are associated with an improved financing situation both internally and with external capital providers other than equity investors for entrepreneurs, and that subsidized loans or guarantees specifically improve the financing situation of startups. In addition to easing financial constraints, I find that public funding is positively related to real outcomes.

This study has several limitations. First, public support programs are heterogeneous in terms of target group, purpose, and amount. This paper adopts a holistic view. An in-depth analysis would require information on the key parameters of the public support provided, such as the basis of individual support programs. This poses a challenge for researchers, as the support programs of the German federal states are not evaluated regularly. Second, my estimates are based on survey data. The perception of whether the surveyed firms experience financing difficulties, which is relevant in my study as a proxy for financial constraints in the form of financing difficulties with capital providers, is subjective, and thus the results may suffer from behavioral bias. Third, my hypotheses assume that public funding impacts the financing situation of recipient firms. However, this is not always the case. Public funding may have no effect on the financing situation of a recipient firm if it does not face any financial constraints, e.g., if the firm has sufficient funds at its disposal. Fourth, I cannot control for the degree of financial constraints because my dependent variables are binary. Fifth, almost every second business idea in Germany is not realized due to insufficient financing (Metzger 2023). Firms that have not started a business for this reason are not covered by this study.

Despite these limitations, my results have several implications for economic policy. First, my finding that grants and subsidized loans or guarantees affect the financing situation of firms differently suggests rethinking the structure of public support programs. One possibility would be to offer a grant in combination with a subsidized loan or guarantee to leverage the positive effects of each instrument on different types of financial constraints. For example, a subsidized loan could include a contingent repayment obligation. Initial analyses based on young firms that received both a grant and a subsidized loan or guarantee in the year they first received public funding show that such firms are less likely to experience financing difficulties with capital providers other than banks compared to firms that received only a grant or only a subsidized loan or guarantee. Further research is needed to examine the detailed effects of the combined use of grants and subsidized loans or guarantees. Another possibility would be to involve private institutions as intermediaries in the grant application process. Similar to the involvement of banks with subsidized loans or guarantees, experienced private institutions could assist in selecting the most advantageous engagements. Second, my findings of stronger effects for more financially constrained firms suggest that public support should focus on very young firms and other groups of firms that are generally more financially constrained. This could be achieved, for example, through higher subsidy rates for more financially constrained firms.

Appendix

See Tables 8, 9, 10, 11, 12, 13, 14and 15.

	Full sample	
	Mean	SE
Firm-related variables		
Age	- 0.580***	(0.024)
Employees	0.055***	(0.007)
Equity capital	0.405***	(0.109)
Export activity	0.232***	(0.061)
GRW	0.623***	(0.055)
High-tech	- 0.158***	(0.059)
Industry		
Production	0.385***	(0.068)
Building/extension	0.142	(0.091)
Repairs	0.397***	(0.128)
Leasing	- 0.505*	(0.283)
Trading	0.094	(0.088)
Other services	_	-
Investment	0.004***	(0.000)
Profits	0.000**	(0.000)
RD	0.004***	(0.001)
Revenue	- 0.000***	(0.000)
Tangible assets	- 0.006***	(0.001)
Founder-related variables		
Founding members	0.068	(0.055)
Opportunity-driven foundation	- 0.043	(0.063)
Team	0.001	(0.095)
University degree	- 0.406***	(0.065)
Woman in founding team	0.095	(0.072)
Observations	21,757	
Firms	10,430	

Table 8 Regression results of a logit model with the dependent variable Public funding

This table reports the regression results of a logit model for estimating the relationship between different firm-related and founder-related characteristics shown in the left column on the probability of receiving public funding (dependent variable *Public funding*). A description of the firm-related variables except for *Export activity*, *High-tech* and *Tangible assets* is provided in Table 1; *Export activity* is a dummy variable indicating whether the firm has export sales revenues in the reference year; *High-tech* is a dummy variable indicating whether the firm is active in a high-tech industry; *Tangible assets* is the natural logarithm of the volume (in euro) of tangible assets; winsorized at the 1st and 99th percentiles. The founder-related variables are defined as follows: *Founding members* indicates the number of founders; *Opportunity-driven foundation* is a dummy variable indicating whether the foundation was motivated by opportunistic (1) or monetary (0) reasons; *Team* is a dummy variable indicating whether at least one founding member has a university degree (1) or not (0); *Woman in founding team* is a dummy variable indicating whether at least one founder is a woman (1) or not (0). The regressions are run on the full sample. Robust standard errors (SE) are reported in parentheses and clustered at the industry level. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively

ab	e 9 Correl	ation table														
	1	2	3	4	5	6	7	8	6	10	11	12	13	14	15	16
	Age	Em- ployees	Equity capital	Financing difficul- ties	Financing difficul- ties banks	Financing difficul- ties VC	Financing problems	GRW	Invest- ment	Losses	Profits	Public funding	RD	Revenue	Revenue reduc- tion	Staff reduc- tion
_	1.000															
7	0.232*	1.000														
з	0.040*	0.129*	1.000													
4	-0.075*	0.037*	*960.0	1.000												
5	-0.032*	0.056^{*}	0.062*	0.864^{*}	1.000											
9	0.006	0.017*	0.166^{*}	0.401*	0.228^{*}	1.000										
7	- 0.047*	0.031*	0.093*	0.863*	0.737*	0.342^{*}	1.000									
8	0.033*	0.020*	0.000	0.005	0.001	0.001	*600.0	1.000								
6	-0.294^{*}	0.143*	0.022*	0.066*	0.059*	- 0.009	0.039*	-0.007	1.000							
10	-0.233*	- 0.065*	0.190*	0.176^{*}	0.124^{*}	0.142^{*}	0.178^{*}	-0.023*	0.020*	1.000						
11	0.306*	0.151^{*}	-0.144^{*}	-0.157*	-0.104^{*}	-0.122*	-0.161^{*}	0.013	0.022*	- 0.969*	1.000					
12	0.199*	0.141^{*}	0.050*	0.023*	0.040*	0.007	0.00	0.086^{*}	0.045*	-0.019*	0.063*	1.000				
13	0.070*	0.136^{*}	0.250*	0.109*	0.074^{*}	0.170^{*}	0.106^{*}	-0.004^{*}	0.069*	0.156^{*}	-0.109*	0.005*	1.000			
14	0.314^{*}	0.375*	-0.052*	- 0.062*	0.006	-0.098*	- 0.060*	-0.002	0.082*	-0.431*	0.463*	0.153*	-0.030*	1.000		
15	0.396*	0.026^{*}	0.006	-0.010*	0.004	0.010	0.006	0.008	-0.174^{*}	-0.031*	0.055*	0.042*	0.008	0.029*	1.000	
16	0.443*	0.056^{*}	0.028^{*}	0.006	0.026^{*}	0.034^{*}	0.023^{*}	0.012	-0.184^{*}	-0.052*	0.089*	0.091^{*}	0.036^{*}	0.153*	0.309*	1.000
This	table pres	ents the co	rrelation cc	efficients o	of the firm-r	elated vari	ables. * inc	licates the	95% signif	icance leve	l. A descri	ption of a	ll variables	is provide	ed in Tabl	1

2 Springer

	Full sample		Grants		Subsidized loans or guarantees	
	(1)		(2)		(3)	
	Mean	SE	Mean	SE	Mean	SE
Firm-related variables						
Employees	0.013***	(0.003)	0.007	(0.005)	0.016***	(0.005)
Equity capital	0.291***	(0.046)	0.179***	(0.064)	0.112	(0.079)
Export activity	0.167***	(0.027)	0.258***	(0.036)	0.117***	(0.044)
Industry	- 0.051***	(0.005)	- 0.034***	(0.007)	- 0.034***	(0.009)
Investment	0.002***	(0.000)	- 0.000	(0.000)	0.002***	(0.000)
RD	- 0.000	(0.000)	0.001***	(0.000)	-0.004^{***}	(0.001)
Revenue	-0.000^{***}	(0.000)	-0.000^{***}	(0.000)	-0.000	(0.000)
Tangible assets	-0.002^{***}	(0.001)	- 0.001	(0.001)	- 0.003***	(0.001)
Founder-related variables						
Founding members	0.016	(0.021)	0.040	(0.029)	- 0.041	(0.041)
Opportunity-driven foundation	- 0.069**	(0.027)	-0.108^{***}	(0.038)	0.020	(0.045)
Team	- 0.017	(0.038)	-0.008	(0.053)	0.048	(0.069)
University degree	- 0.196***	(0.026)	- 0.121***	(0.036)	- 0.188***	(0.044)
Woman in founding team	0.048	(0.030)	- 0.012	(0.043)	0.119**	(0.047)
Observations	16,331		14,022		13,599	

Table 10 Propensity score matching: probit estimations for obtaining the propensity score

This table reports the regression results of a probit model for estimating the propensity score with the dependent variable indicating whether a firm *i* received public funding during the observation period or not and the independent variables shown in the left column. Descriptions of the variables are provided in Table 1 and in Table 8. The propensity score is estimated using a larger number of variables than those included in the main regressions according to Eq. (1). The reason is that the main regressions contain firm fixed effects, such that the inclusion of variables whose values do not change during the observation period (e.g., the number of founding members) is not necessary. For the matching process, however, they are relevant to include. The regressions are run on the full sample [column (1)], on a sample of firms receiving grants and non-publicly funded firms [column (2)]. Robust standard errors (SE) are reported in parentheses and clustered at the firm level. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively

	(1) Treatment group		(2) Con	(2) Control group		(1)–(2)		
	Mean	SD	Mean	SD	Abs. diff	T-stat	Norm. diff	
Panel A: Full sample								
Age	1.0	0.2	1.0	0.2	0.0	0.00	0.000	
Employees	1.6	3.3	1.8	3.5	- 0.1	- 1.08	- 0.027	
Equity capital	4.0%	0.2	2.8%	0.2	1.2 pp	1.92	0.047	
Financing difficulties	10.7%	0.3	9.7%	0.3	1.0 pp	0.98	0.024	
Financing difficulties banks	8.6%	0.3	7.7%	0.3	0.9 pp	0.96	0.024	
Financing difficulties VC	0.7%	0.1	0.8%	0.1	– 0.1 pp	- 0.20	- 0.005	
Financing problems	12.6%	0.3	12.6%	0.3	0.0 pp	0.00	0.000	
GRW	28.9%	0.5	28.9%	0.5	0.0 pp	0.00	0.000	
Investment	34.0	58.8	34.7	60.9	- 0.7	- 0.33	-0.008	
Losses	39.8%	0.5	35.7%	0.5	0.0 pp	2.33	0.059	
Profits	5.5	59.6	2.4	118.9	3.1	0.90	0.023	
RD	6.1	30.4	5.7	27.6	0.4	0.37	0.009	
Revenue	145.2	288.1	146.9	271.3	- 1.6	- 0.17	- 0.004	
Revenue reduction	0.2%	0.0	0.1%	0.0	0.0 pp	0.44	0.011	
Staff reduction	0.1%	0.0	0.2%	0.0	0.0 pp	- 0.45	- 0.011	
Observations		1642		1642				
Panel B: Grants								
Age	1.0	0.3	1.0	0.3	0.0	0.00	0.000	
Employees	1.6	3.9	1.5	3.2	0.2	0.79	0.030	
Equity capital	4.4%	0.2	3.3%	0.2	1.0 pp	0.98	0.037	
Financing difficulties	10.8%	0.3	9.4%	0.3	1.3 pp	0.80	0.031	
Financing difficulties banks	8.4%	0.3	7.0%	0.3	1.5 pp	1.01	0.039	
Financing difficulties VC	0.7%	0.1	1.2%	0.1	– 0.4 pp	- 0.84	- 0.032	
Financing problems	12.5%	0.3	12.5%	0.3	0.0 pp	0.00	0.000	
GRW	33.7%	0.5	33.7%	0.5	0.0 pp	0.00	0.000	
Investment	29.1	74.0	31.3	79.4	- 2.2	- 0.53	- 0.020	
Losses	36.5%	0.5	33.8%	0.5	0.0 pp	1.01	0.040	
Profits	5.8	62.7	10.4	83.5	- 4.6	- 1.10	- 0.044	
RD	7.4	28.7	6.3	23.6	1.0	0.73	0.028	
Revenue	142.7	309.8	143.2	288.1	- 0.5	- 0.03	- 0.001	
Revenue reduction	0.1%	0.0	0.3%	0.1	0.0 pp	-0.58	- 0.022	
Staff reduction	0.1%	0.0	0.4%	0.1	0.0 pp	- 1.00	- 0.038	
Observations		688		688				
Panel C: Subsidized loans o	r guarant	ees						
Age	1.0	0.2	1.0	0.2	0.0	0.00	0.000	
Employees	2.3	3.7	2.4	4.4	- 0.1	- 0.51	- 0.023	
Equity capital	5.5%	0.2	3.8%	0.2	1.7 pp	1.23	0.057	
Financing difficulties	10.3%	0.3	10.1%	0.3	0.2 pp	0.11	0.005	

Table 11 Differences in outcome variables between treatment and control groups after matching (year before receipt of public funding, t - 1)

	(1) Trea group	tment	(2) Con	(2) Control group		(1)–(2)		
	Mean	SD	Mean	SD	Abs. diff	T-stat	Norm. diff	
Financing difficulties banks	8.2%	0.3	8.4%	0.3	– 0.2 pp	- 0.12	- 0.005	
Financing difficulties VC	0.6%	0.1	1.5%	0.1	– 0.8 pp	- 1.27	-0.058	
Financing problems	11.1%	0.3	11.1%	0.3	0.0 pp	0.00	0.000	
GRW	23.7%	0.4	23.7%	0.4	0.0 pp	0.00	0.000	
Investment	51.8	77.7	54.9	88.2	- 3.1	-0.57	- 0.026	
Losses	46.4%	0.5	39.5%	0.5	0.1 pp	2.07	0.098	
Profits	6.9	57.1	1.9	100.7	5.0	0.89	0.043	
RD	3.4	17.8	4.0	23.9	- 0.6	-0.48	- 0.022	
Revenue	192.1	344.2	225.0	431.2	- 32.8	- 1.30	- 0.059	
Revenue reduction	0.0%	0.0	0.2%	0.0	– 0.2 pp	- 1.00	- 0.046	
Staff reduction	0.2%	0.0	0.2%	0.0	0.0 pp	0.00	0.000	
Observations		477		477				

This table reports descriptive statistics forfirm-related and financing-related variables for the year of matching; the year of matching is individual for each firm and refers to one year before the respective firm receives public funding if the firm age at receipt is two years or older. Firms that receive public funding at the age of one are matched based on their characteristics in the year of foundation (i.e., the year in which they first received public funding). Panel A reports statistics for the full sample, Panel B reports statistics for the sample "Grants" and Panel C reports statistics for the sample "Subsidized loans or guarantees". The left part of the table shows the mean and the standard deviation (SD) for the treatment group (1) and the control group (2) of the sample (full sample, recipient firm of grants, recipient firms of subsidized loans or guarantees, and control firms, respectively). The right part of the table shows the difference in means (Abs. diff.) of the treatment group (1) and the control group (2); the difference in means of binary variables is reported in percentage points (pp). The statistic of a t-test on the difference in means (T-stat), and the normalized difference (Norm. diff.) according to Imbens and Wooldridge (2009), which compares the mean values of the treatment group (1) and the control group (2) normalized by the standard deviation, are reported in the last two columns. The normalized difference is suggested to be within the range of -0.25 and +0.25 for sufficient covariate balance. Table 1 provides descriptions of all variables, whereas Age is reported in years, Employees is reported in headcount, and Investment, Profits, RD, and Revenue are reported in k euro, respectively

Dependent vari- able	ependent vari- Full sample		Grants		Subsidized loans or guarantees	
	(1)	(2)	(3)	(4)	(5)	(6)
		Odd's		Odd's		Odd's
Financing dif-	- 0.390	0.677	0.338	1.403	- 0.982	0.375
ficulties	(0.277)	(0.187)	(0.397)	(0.557)	(0.747)	(0.280)
Financing	- 0.387	0.679	0.502	1.652	- 1.152	0.316
difficulties banks	(0.299)	(0.203)	(0.453)	(0.748)	(0.869)	(0.275)
Financing dif-	- 0.675	0.509	- 0.639	0.528	- 0.690	0.501
ficulties VC	(0.467)	(0.238)	(0.653)	(0.345)	(1.481)	(0.742)
Financing	- 0.364	0.695	0.261	1.298	- 0.728	0.483
problems	(0.281)	(0.195)	(0.384)	(0.498)	(0.720)	(0.347)
Observations	400-1372	400-1372	232-754	232-754	137–577	137–577
Pseudo-R ²	0.048-0.113	0.048-0.113	0.051-0.098	0.051-0.098	0.111-0.231	0.111-0.231
Economic and financial con- trols	Yes	Yes	Yes	Yes	Yes	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes

 Table 12 Regression results of a conditional maximum likelihood model with the independent variable

 Public funding

This table reports the regression results of a conditional maximum likelihood examining how the receipt of public funding in year t - I affects the probability of a firm experiencing financial constraints in year t. A description of all variables is provided in Table 1. The table reports results for the full sample [columns (1) and (2)], for a sample of firms receiving grants and non-publicly funded firms [columns (3) and (4)], and for a sample of firms receiving subsidized loans or guarantees and non-publicly funded firms [columns (5) and (6)]. The model includes controls and fixed effects (FE) as shown in the table. The number of observations and the pseudo-R-squared (Pseudo-R²) are reported as ranges between the minimum and maximum values of the model specifications shown in each column. Note that in this setting, the R-squared can be interpretated as the difference between the average predicted probability of publicly and non-publicly funded firms (Gronau 1998). Robust standard errors are clustered at the industry level and reported in parentheses. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively

Table 13 Regression Results of Fina Dependent variable	ncial Constraints with Al Panel A: Public fund	lternative Timing of th	ne Main Independent Varia	able Panel R: <i>Public fi</i>	<i>undino</i> (time lao of	7 vears)
	т апст А. т иоис јин	ung _t (no unic iag)			<i>mumg_t-2</i> (mile 1ag of	2 yearsy
	Full sample	Grants	Subsidized loans or guarantees	Full sample	Grants	Subsidized loans or guar- antees
	(1)	(2)	(3)	(4)	(5)	(9)
Financing difficulties	0.013	- 0.010	- 0.009	- 0.079	- 0.060	- 0.093
	(0.013)	(0.012)	(0.042)	(0.049)	(0.063)	(0.113)
Financing difficulties banks	0.038	0.034^{*}	0.029	-0.073	- 0.056	-0.079
	(0.030)	(0.017)	(0.067)	(0.040)	(0.054)	(0.115)
Financing difficulties VC	0.007	-0.007	- 0.007	- 0.026	0.011	0.022*
	(0.013)	(0.007)	(0.035)	(0.033)	(0.044)	(0.010)
Financing problems	- 0.004	-0.020	0.016	- 0.058	- 0.005	-0.152
	(0.010)	(0.020)	(0.044)	(0.062)	(0.054)	(0.097)
Observations	13,850-14,024	8662-8796	7965-8103	4488-4490	2509-2510	2133–2134
\mathbb{R}^2	0.009-0.015	0.010-0.018	0.012-0.027	0.014-0.036	0.015 - 0.048	0.036 - 0.050
Adjusted R ²	0.007-0.013	0.008-0.016	0.010-0.024	0.010 - 0.032	0.008 - 0.041	0.028 - 0.041
Economic and financial controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes
This table reports the regression rest probability of a firm experiencing fin (1) and (4)], for the sample "Grants" fixed effects (FE) as shown in the ta minimum and maximum values of th between the average predicted probal in parentheses. *, ***, and **** indicat	ults of a linear probabilit ancial constraints in yea [columns (2) and (5)], i ble. The number of obs in model specifications si oility of publicly and nor e a significance level of	y model examining h r t. A description of a and for the sample "S ervations, the R-squan hown in each column. 1-publicly funded firm 10%, 5%, and 1%, resi	ow the receipt of public fill variables is provided in ubsidized loans or guaranted (R^2) , and the adjusted Note that in this setting, is (Gronau 1998). Robust pectively	inding in year <i>t</i> (Pan Table 1. The table re tees" [columns (3) a R-squared (Adjuste the (adjusted) R-squ standard errors are <i>c</i>	el A) or in year $t-2$ (ports results for the find (6)]. The model in nd (6)]. The model in the form that R^2 are reported as ured can be interpreted autostructed at the industr	Panel B) affects the ull sample [columns neludes controls and ranges between the ted as the difference y level and reported

Table 14 Regression results of finance	cial constraints with al	ternative designs with	the independent variable P	ublic funding		
Dependent variable	Panel A: Trimme	d control variables		Panel B: No multi	iple public funding	
	Full sample	Grants	Subsidized loans or guarantees	Full sample	Grants	Subsidized loans or guar- antees
	(1)	(2)	(3)	(4)	(5)	(9)
Financing difficulties	-0.054^{**}	0.043	- 0.130	- 0.112	- 0.054	- 0.203
	(0.016)	(0.024)	(0.101)	(0.086)	(0.137)	(0.151)
Financing difficulties banks	-0.048^{**}	0.046	- 0.136	- 0.052	0.064	-0.257
	(0.019)	(0.041)	(660.0)	(0.057)	(0.110)	(0.149)
Financing difficulties VC	- 0.042	-0.035	-0.030*	-0.108^{**}	-0.105*	-0.140
	(0.022)	(0.030)	(0.015)	(0.040)	(0.044)	(0.097)
Financing problems	-0.040	0.023	-0.050	-0.078	-0.030	- 0.056
	(0.022)	(0.027)	(0.080)	(0.084)	(0.079)	(0.101)
Observations	7482–7487	4364-4367	3830–3833	2242-2244	689–689	550-551
\mathbb{R}^2	0.014 - 0.022	0.012-0.031	0.016 - 0.036	0.053-0.066	0.113-0.199	0.192-0.314
Adjusted R ²	0.011-0.019	0.008-0.027	0.011-0.031	0.045-0.058	0.088-0.176	0.164-0.291
Economic and financial controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm and year FE	Yes	Yes	Yes	Yes	Yes	Yes
This table reports the regression residencing financial constraints in year <i>t</i> (Panel B). A description of all varial and (5), and for the sample "Subsidi of observations, the R-squared $(R^2)_1$ tions shown in each column. Note the and non-publicly funded firms (Gron level of 10%, 5%, and 1%, respectively	ults of a linear probab with trimmed control bles is provided in Tal zed loans or guarantee and the adjusted R-seq at in this setting, the (au 1998). Robust stan by	ulity model examining variables (Panel A) a ole 1. The table repor ss" [columns (3) and (ared (Adjusted \mathbb{R}^2) an adjusted) \mathbb{R} -squared c dard errors are cluster	g how the receipt of public and for samples of firms ex is results for the full sampl (6)]. The model includes co re reported as ranges betwe an be interpretated as the d red at the industry level and	funding in year <i>t</i> – cluding firms that ha e [columns (1) and (introls and fixed effec en the minimum and ifference between the i reported in parenthe	<i>I</i> affects the probability ve received public fun ver received public fun (4), for the sample "G ts (FE) as shown in th maximum values of t average predicted pro- sses. *, **, and *** inc	ty of a firm experi- ding multiple times rants" [columns (2) e table. The number he model specifica- bability of publicly licate a significance

Dependent vari- able	ri- Full sample		Grants		Subsidized loans or guarantees	
	(1)	(2)	(3)	(4)	(5)	(6)
Financing dif-	- 0.067***	- 0.073***	- 0.002	- 0.002	- 0.140***	- 0.222***
ficulties	(0.012)	(0.014)	(0.008)	(0.007)	(0.040)	(0.058)
Financing	- 0.060***	- 0.063***	- 0.004	0.005	- 0.136***	-0.204^{***}
difficulties banks	(0.011)	(0.011)	(0.008)	(0.008)	(0.037)	(0.054)
Financing dif-	- 0.022**	- 0.022	- 0.004	0.002	-0.040***	- 0.056**
ficulties VC	(0.009)	(0.017)	(0.013)	(0.027)	(0.013)	(0.022)
Financing	- 0.080***	- 0.095***	- 0.026	- 0.031	- 0.123***	- 0.175***
problems	(0.020)	(0.028)	(0.026)	(0.025)	(0.027)	(0.045)
Observations	9227-9230	4722-4725	3230-3231	1491–1492	1707-1708	962–963
\mathbb{R}^2	0.002-0.008	0.002-0.010	0.003-0.012	0.002-0.012	0.015-0.030	0.026-0.069
Economic con- trols	Yes	Yes	Yes	Yes	Yes	Yes
Financial controls	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

 Table 15
 Regression results of financial constraints based on samples without non-publicly funded firms and fixed effects with the independent variable *Public funding*

This table reports the regression results of a linear probability model examining how the receipt of public funding in year t - 1 affects the probability of a firm experiencing financial constraints in year t for samples of publicly funded firms only. A description of all variables is provided in Table 1. The table reports results for the full sample of publicly funded firms [columns (1) and (2)], for recipient firms of grants [columns (3) and (4)], and for recipient firms of subsidized loans or guarantees [columns (5) and (6)]. The model includes controls and fixed effects (FE) as shown in the table. The number of observations, and the R-squared (R²) are reported as ranges between the minimum and maximum values of the model specifications shown in each column. Note that in this setting, the (adjusted) R-squared can be interpretated as the difference between the average predicted probability of publicly and non-publicly funded firms (Gronau 1998). Robust standard errors are clustered at the industry level and reported in parentheses. *, **, and *** indicate a significance level of 10%, 5%, and 1%, respectively

Funding Open Access funding enabled and organized by Projekt DEAL. The author declares that no funds, grants, or other support were received for the preparation of this manuscript.

Data availability The dataset analyzed in this study is not publicly available due to confidential data. It is available with permission of ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH, Mannheim, Germany, upon reasonable request.

Declarations

Competing interests The author is employed as a manager at PricewaterhouseCoopers GmbH WPG, Frankfurt am Main, Germany, where she advises public sector clients on economic promotion. It is not possible to draw conclusions about individual support programs from the underlying dataset. The views expressed in this manuscript are the personal views of the author. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicate otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

- Amir E, Guan Y, Livne G (2007) The association of R&D and capital expenditures with subsequent earnings variability. J Bus Finance Account 34(1–2):222–246. https://doi.org/10.1111/j.1468-5957. 2006.00651.x
- Angrist JD, Pischke JS (2009) Mostly harmless econometrics. An empiricist's companion. Princeton University Press, New Jersey
- Armstrong CS, Jagolinzer AD, Larcker DF (2010) Chief executive officer equity incentives and accounting irregularities. J Acc Res 48(2):225–271. https://doi.org/10.1111/j.1475-679X.2009.00361.x
- Bach L (2014) Are small businesses worthy of financial aid? Evidence from a French targeted credit program. Rev Finance 18(3):877–919. https://doi.org/10.1093/rof/rft022
- Bäurle G, Lein SM, Steiner E (2021) Employment adjustment and financial tightness: evidence from firm-level data. J Int Money Finance 115:102358. https://doi.org/10.1016/j.jimonfin.2021.102358
- Bergbrant MC, Bradley D, Hunter DM (2017) Does bank loan supply affect the supply of equity capital? Evidence from new share issuance and withdrawal. J Financ Intermed 29(1):32–45. https://doi.org/ 10.1016/j.jfi.2016.05.001
- Berger M, Hottenrott H (2021) Start-up subsidies and the sources of venture capital. J Bus Ventur Insights 16:e00272. https://doi.org/10.1016/j.jbvi.2021.e00272
- Bersch J, Gottschalk S, Müller B, Niefert M (2014) The Mannheim Enterprise Panel (MUP) and Firm Statistics for Germany. Discussion Paper No. 14-104. ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH. Mannheim. https://ftp.zew.de/pub/zew-docs/dp/dp14104.pdf. Accessed 9 July 2022
- Bertschek I, Block J, Kritikos AS, Stield C (2024) German financial state aid during covid-19 pandemic: higher impact among digitalized self-employed. Entrep Region Dev 36(1):76–97. https://doi.org/10. 1080/08985626.2023.2196267
- Bharath ST, Dahiya S, Saunders A, Srinivasan A (2011) Lending relationships and loan contract terms. Rev Financ Stud 24(4):1141–1203. https://doi.org/10.1093/rfs/hhp064
- Bischof J, Dörrenberg P, Rostam-Afschar D, Simons D, Voget J (2020) German business panel: November 2020. Unternehmen in der Corona-Krise. Empirische Erkenntnisse zum zweiten Lockdown: Wer trägt die Last und wie wirken die staatlichen Hilfsmaßnahmen? https://www.accounting-for-trans parency.de/wp-content/uploads/2020/11/gbp_ergebnisbericht_november_2020.pdf. Accessed 15 Sept 2024
- Bischof J, Eble F, Karlsson C, Rostam-Afschar D, Simons D, Voget J (2021) German business panel: Januar 2021. Empirische Erkenntnisse zum zweiten Lockdown: Rückgang und Umverteilung von Unternehmensgewinnen trotz Staatshilfen. https://backend.gbpanel.org/app/uploads/2020/11/ gbp_ergebnisbericht_januar_2021.pdf. Accessed 15 Sept 2024
- Brown JD, Earle JS (2017) Finance and growth at the firm level: evidence from SBA loans. J Finance 72(3):1039–1080. https://doi.org/10.1111/jofi.12492
- Brüderl J, Ludwig V (2015) Fixed-effects panel regression. In: Best H, Wolf C (eds) The SAGE handbook of regression analysis and causal inference. Sage, Los Angeles, pp 327–357
- Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR) im Bundesamt für Bauwesen und Raumordnung (BBR) (2014) Vergleich der GRW-Fördergebietskulissen. Bonn. https://www.bbsr. bund.de/BBSR/DE/forschung/fachbeitraege/raumentwicklung/2011-2015/foerdergebiete-mitte laufteilung/Karte_VergleichGRW_Foerdergebietskulissen.pdf?__blob=publicationFile&v=1. Accessed 25 Sept 2022

- Caliendo M, Künn S (2011) Start-up subsidies for the unemployed: Long-term evidence and effect heterogeneity. J Public Econ 95(3–4):311–331. https://doi.org/10.1016/j.jpubeco.2010.11.003
- Caliendo M, Künn S, Weissenberger M (2020) Catching up or lagging behind? The long-term business and innovation potential of subsidized start-ups out of unemployment. Res Policy 49(10):104053. https://doi.org/10.1016/j.respol.2020.104053
- Cantner U, Kösters S (2012) Picking the winner? Empirical evidence on the targeting of R&D subsidies to start-ups. Small Bus Econ 39(4):921–936. https://doi.org/10.1007/s11187-011-9340-9
- Cantner U, Kösters S (2015) Public R&D support for newly founded firms effects on patent activity and employment growth. J Innov Econ Manag 16(1):7–37
- Carpenter RE, Petersen BC (2002) Is the growth of small firms constrained by internal finance? Rev Econ Stat 84(2):298–309. https://doi.org/10.1162/003465302317411541
- Cenni S, Monferrà S, Salotti V, Sangiorgi M, Torluccio G (2015) Credit rationing and relationship lending. Does firm size matter? J Bank Finance 53(4):249–265. https://doi.org/10.1016/j.jbankfin.2014.12.010
- Chamberlain G (1980) Analysis of covariance with qualitative data. Rev Econ Stud 47(1):225–238. https://doi.org/10.2307/2297110
- Chan LKC, Lakonishok J, Sougiannis T (2001) The stock market valuation of research and development expenditures. J Finance 56(6):2431–2456. https://doi.org/10.1111/0022-1082.00411
- Chiappini R, Montmartin B, Pommet S, Demaria S (2022) Can direct innovation subsidies relax SMEs' financial constraints? Res Policy 51(5):104493. https://doi.org/10.1016/j.respol.2022.104493
- Clausen H (2022) Neues Fördergebiet für die regionale Strukturpolitik. Ab 1. Januar 2022 gilt für die Gemeinschaftsaufgabe "Verbesserung der regionalen Wirtschaftsstruktur" (GRW) die neue Fördergebietskarte 2022 – 2027. In Federal Ministry for Economic Affairs and Climate Action (ed) Schlaglichter der Wirtschaftspolitik. Monatsbericht 01/2022, 01/2022, 15–23. https://www.bmwk. de/Redaktion/DE/Infografiken/Schlaglichter/2022/01/05-im-fokus-regionale-strukturpolitik.pdf?_____ blob=publicationFile&v=4. Accessed 5 June 2022
- Czarnitzki D, Delanote J (2015) R&D policies for young SMEs: input and output effects. Small Bus Econ 45:465–485. https://doi.org/10.1007/s11187-015-9661-1
- DeFond M, Erkens DH, Zhang J (2017) Do client characteristics really drive the big N audit quality effect? New evidence from propensity score matching. Manag Sci 63(11):3628–3649. https://doi. org/10.1287/mnsc.2016.2528
- Egeln J, Gottschalk S, Höwer D, Müller B (2002) Existenzgründungsgeschehen in Bayern. Studie im Auftrag des Bayerischen Staatsministeriums für Wirtschaft, Infrastruktur, Verkehr, Technologie. ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH. Mannheim. https://www. stmwi.bayern.de/fileadmin/user_upload/stmwi/publikationen/pdf/Mittelstand_Gruendungen-Bayern_220813.pdf. Accessed 9 July 2022
- Egeln J, Gottschalk S, Lubczyk M (2019) IAB-ZEW Gründungspanel. Technischer Anhang zur Befragung 2018. Edited by ZEW—Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH. Mannheim
- Falck O, Pfaffl C, Ruthardt F, Wichert S (2024) Evaluierung der Corona-Wirtschaftshilfen in Bayern (Teil I). Inanspruchnahme und Umsetzung. Studie im Rahmen des Vertrags zur Erstellung volkswirtschaftlicher Studien, IHK für München und Oberbayern. ifo Institut – Leibniz-Institut für Wirtschafts-forschung an der Universität München e.V. Munich, Germany. https://www.ifo.de/ DocDL/20240409_ifo_Studie_Ueberbrueckungshilfen.pdf. Accessed 12 Oct 2024
- Federal Employment Agency (2023a) Einstiegsgeld für eine Selbstständigkeit. https://www.arbeitsage ntur.de/arbeitslos-arbeit-finden/buergergeld/arbeit-finden/einstiegsgeld-fuer-selbststaendigkeit. Accessed 27 Oct 2023
- Federal Employment Agency (2023b) Gründungszuschuss beantragen. https://www.arbeitsagentur.de/ arbeitslos-arbeit-finden/arbeitslosengeld/gruendungszuschuss-beantragen. Accessed 27 Oct 2023
- Federal Ministry for Economic Affairs and Climate Action (2021) Überblick zu Förderinstrumenten zur Gründungs- und Wachstumsfinanzierung. Berlin. https://www.bmwk.de/Redaktion/DE/Downl oads/U/ueberblick-zu-foerderinstrumenten-zur-gruendungs-und-wachstumsfinanzierung.pdf?____ blob=publicationFile&v=25. Accessed 9 July 2022
- Federal Ministry for Economic Affairs and Climate Action (2022) Die Start-up-Strategie der Bundesregierung. Berlin. https://www.bmwk.de/SUS/PDF/start-up-strategie-der-bundesregierung.pdf?___ blob=publicationFile&v=2. Accessed 19 May 2024
- Federal Ministry for Economic Affairs and Climate Action (2023a) Mikrokreditfonds Deutschland Mein Mikrokredit. https://www.bmwk.de/Redaktion/DE/Artikel/Mittelstand/gruendungsfinanzierungmikrokreditfonds.html. Accessed 27 Oct 2023

- Federal Ministry for Economic Affairs and Climate Action (2023b) Überblick der Förderinstrumente zur Gründungs-, Nachfolge- und Wachstumsfinanzierung. Berlin. https://www.bmwk.de/Redaktion/ DE/Downloads/U/ueberblick-zu-foerderinstrumenten-zur-gruendungs-und-wachstumsfinanzierung. pdf?__blob=publicationFile&v=7. Accessed 22 Oct 2023
- Federal Ministry of Labour and Social Affairs (2023) Mein Mikrokredit Ihre Möglichkeiten. https:// www.bmas.de/DE/Arbeit/Arbeitsfoerderung/Foerderung-der-Erwerbstaetigkeit/Mikrokredit/mikro kredit.html. Accessed 27 Oct 2023
- Fryges H, Gottschalk S, Kohn K (2009) The KfW/ZEW Start-up Panel: Design and Research Potential. Edited by Institute for the Study of Labour. IZA Discussion Paper No. 4441
- Ge S (2022) How do financial constraints affect product pricing? Evidence from weather and life insurance premiums. J Finance 77(1):449–503. https://doi.org/10.1111/jofi.13093
- Grilli L, Murtinu S (2012) Do public subsidies affect the performance of new technologybased firms? The importance of evaluation schemes and agency goals. Prometheus 30(1):97–111. https://doi.org/ 10.1080/08109028.2012.676836
- Grilli L, Murtinu S (2014) Government, venture capital and the growth of european high-tech entrepreneurial firms. Res Policy 43(9):1523–1543. https://doi.org/10.1016/j.respol.2014.04.002
- Gronau R (1998) A useful interpretation of R-squared in binary choice models (Or, Have We Dismissed the Good Old R-Squared; Prematurely). Working Papers Princeton University, Industrial Relations Section: 397
- Hackney J (2023) Small business lending in financial crises: the role of government-guaranteed loans. Rev Finance 27(1):247–287. https://doi.org/10.1093/rof/rfac002
- Hall BH (2002) The financing of research and development. Oxf Rev Econ Policy 18(1):35–51. https:// doi.org/10.1093/oxrep/18.1.35
- Hall BH, Lerner J (2010) The Financing of R&D and Innovation. In: Hall BH, Rosenberg N (eds) Handbook of the economics of innovation, 1st edn. Elsevier, North-Holland, pp 609–639
- Hallak I, Harasztosi P (2019) Job creation in Europe: A firm-level analysis. Edited by Publications Office of the European Union. Luxembourg
- Haltiwanger J, Jarmin RS, Miranda J (2013) Who creates jobs? Small versus large versus young. Rev Econ Stat 95(2):347–361. https://doi.org/10.1162/REST_a_00288
- Horvath A, Lang P (2021) Do loan subsidies boost the real activity of small firms? J Bank Finance 122:105988. https://doi.org/10.1016/j.jbankfin.2020.105988
- Hottenrott H, Richstein R (2020) Start-up subsidies: does the policy instrument matter? Res Policy 49(1):103888. https://doi.org/10.1016/j.respol.2019.103888
- Howell ST (2017) Financing innovation: evidence from R&D grants. Am Econ Rev 107(4):1136–1164. https://doi.org/10.1257/aer.20150808
- Huergo E, Moreno L (2017) Subsidies or loans? Evaluating the impact of R&D support programmes. Res Policy 46(7):1198–1214. https://doi.org/10.1016/j.respol.2017.05.006
- Imbens GW, Wooldridge JM (2009) Recent developments in the econometrics of program evaluation. J Econ Lit 47(1):5–86. https://doi.org/10.1257/jel.47.1.5
- James C (1987) Some evidence on the uniqueness of bank loans. J Financ Econ 19(2):217–235. https:// doi.org/10.1016/0304-405X(87)90003-1
- Kollmann T, Hirschfeld A, Gilde J, Walk V, Pröpper A (2023) Deutscher Startup Monitor 2023. Eine neue Zeit. Edited by Bundesverband Deutsche Startups e.V. Berlin. https://startupverband.de/filea dmin/startupverband/mediaarchiv/research/dsm/dsm_2023.pdf. Accessed 15 Oct 2023
- Kothari SP, Laguerre TE, Leone AJ (2002) Capitalization versus expensing: evidence on the uncertainty of future earnings from capital expenditures versus R&D outlays. Rev Account Stud 7(4):355–382. https://doi.org/10.1023/a:1020764227390
- Kulicke M (2021) Innovative start-ups in der initialphase fördern. In: Bertelsmann Stiftung (ed) Innovation for Transformation – Wie die Verbindung von Innovationsförderung und gesellschaftlicher Problemlösung gelingen kann, Gütersloh
- Lelarge C, Sraer D, Thesmar D (2010) Entrepreneurship and Credit Constraints: Evidence from a French Loan Guarantee Program. In: Lerner J, Schoar A (eds) International differences in entrepreneurship. University of Chicago Press, Chicago, pp 243–273
- Leleux B, Surlemont B (2003) Public versus private venture capital: Seeding or crowding out? A Pan-European Analysis. J Bus Ventur 18(1):81–104. https://doi.org/10.1016/S0883-9026(01)00078-7
- Lenk T, Schöbel E (2013) Möglichkeiten und Grenzen der Evaluierung von Förderprogrammen durch die Rechnungshöfe: Finanzwissenschaftliche Perspektiven zur Verbesserung. List Forum Für Wirtschafts- und Finanzpolitik 39(2):122–136. https://doi.org/10.1007/BF03373045

- Li D (2011) Financial constraints, R&D investment, and stock returns. Rev Financ Stud 24(9):2974– 3007. https://doi.org/10.1093/rfs/hhr043
- Lummer SL, McConnell JJ (1989) Further evidence on the bank lending process and the capital-market response to bank loan agreements. J Financ Econ 25(1):99–122. https://doi.org/10.1016/0304-405X(89)90098-6
- Marin JM, Olivier JP (2008) The dog that did not bark: insider trading and crashes. J Finance 63(5):2429–2476. https://doi.org/10.1111/j.1540-6261.2008.01401.x
- Metzger G (2023) KfW-Gründungsmonitor 2023. Gründungstätigkeit in Deutschland: im Spannungsfeld zwischen Fachkräftemangel und Corona-Blues. Edited by KfW Bankengruppe. Frankfurt a.M. https://www.kfw.de/PDF/Download-Center/Konzernthemen/Research/PDF-Dokumente-Gr%C3% BCndungsmonitor/KfW-Gr%C3%BCndungsmonitor-2023.pdf. Accessed 28 Nov 2023
- Minutti-Meza M (2013) Does auditor industry does auditor industry specialization improve audit quality? J Acc Res 51(4):779–817. https://doi.org/10.1111/1475-679X.12017
- OECD (2022) OECD reviews of innovation policy: Germany 2022: Building agility for successful transitions. OECD Publishing (OECD Reviews of Innovation Policy), Paris
- Olschewski S (2015) Gründen in Deutschland. Von Existenz-, Unternehmens- und Startup Gründern und Gründerinnen. Edited by Konrad-Adenauer-Stiftung e. V. Berlin. http://library.kas.de/GetObject. ashx?GUID=d015f891-84bf-e511-a95a-005056b96343&IDUSER=NotAllowed. Accessed 21 Oct 2023
- Ono A, Uesugi I, Yasuda Y (2013) Are lending relationships beneficial or harmful for public credit guarantees? Evidence from Japan's Emergency Credit Guarantee Program. J Financ Stab 9(2):151–167. https://doi.org/10.1016/j.jfs.2013.01.005
- Pástor L, Veronesi P (2009) Technological revolutions and stock prices. Am Econ Rev 99(4):1451–1483. https://doi.org/10.1257/aer.99.4.1451
- Pflüger M, Suedekum J (2013) Subsidizing firm entry in open economies. J Public Econ 97(1):258–271. https://doi.org/10.1016/j.jpubeco.2012.07.002
- Rosenbaum PR, Rubin DB (1983) The Central role of the propensity score in observational studies for causal effects. Biometrika 70(1):41–55. https://doi.org/10.2307/2335942
- Ragnitz J (2023a) Effiziente Unterstützung von Unternehmen in gesamtwirtschaftlichen Krisen. Kurzexpertise im Auftrag der Industrie- und Handelskammer Chemnitz. Edited by ifo Institut – Leibniz-Institut für Wirtschaftsforschung an der Universität München e.V
- Ragnitz J (2023b) Staatliche Hilfsprogramme während der Corona-Pandemie Eine Bewertung aus ökonomischer Sicht. In: ifo Institut – Leibniz-Institut für Wirtschaftsforschung an der Universität München e.V. (ed) ifo Dresden berichtet, 30th edn
- Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (2023) Wachstumsschwäche überwinden - In die Zukunft investieren. Jahresgutachten 2023/24. Wiesbaden. https://www.sachverstaendigenrat-wirtschaft.de/fileadmin/dateiablage/gutachten/jg202324/JG202 324_Gesamtausgabe.pdf#page=239. Accessed 19 Nov 2023
- Schauer C, Elsas R, Breitkopf N (2019) A new measure of financial constraints applicable to private and public firms. J Bank Finance 101:270–295. https://doi.org/10.1016/j.jbankfin.2019.01.008
- Schüwer U, Lambert C, Noth F (2019) How do banks react to catastrophic events? Evidence from Hurricane Katrina. Rev Finance 23(1):75–116. https://doi.org/10.1093/rof/rfy010
- Schwert WG (2002) Stock volatility in the new millennium: How Wacky is Nasdaq? J Monet Econ 49(1):3–26. https://doi.org/10.1016/S0304-3932(01)00099-X
- Söderblom A, Samuelsson M, Wiklund J, Sandberg R (2015) Inside the black box of outcome additionality: effects of early-stage government subsidies on resource accumulation and new venture performance. Res Policy 44(8):1501–1512. https://doi.org/10.1016/j.respol.2015.05.009
- Whited T, Roberts M (2013) Endogeneity in empirical corporate finance. In: Constantinides GM, Harris M, Stulz RM (eds) Handbook of the Economics of Finance, vol. 2A, 2nd edn. Elsevier Science, North-Holland, pp 493–572
- Wooldridge JM (2010) Econometric analysis of cross section and panel data, 2nd edn. The MIT Press, Cambridge
- Zhao B, Ziedonis R (2020) State governments as financiers of technology startups: evidence from Michigan's R&D loan program. Res Policy 49(4):103926. https://doi.org/10.1016/j.respol.2020.103926

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.