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Improving access to finance for young innovative enterprises with growth potential: Evidence of impact of R&D grant schemes on firms' outputs

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Abstract

Responding to the lack of in-depth research into the effects of R&D grants for scale-ups, this article examines how they impact upon firms' employment, firm economic and innovative performance, and firm innovative activities. Drawing on both policy evaluations and empirical literature relating to R&D programmes and firms' outputs, it contributes by discussing and comparing different types of R&D programmes and analyzing the wider policy implications. Overall, positive outcomes are found on employment, total sales and share of innovative sales (effects which can persist for several years), and companies' innovation capacities. Moreover, the effects for R&D grants for scale-ups are larger than the effects of both generic R&D grants and R&D subsidies. In terms of policy implications, R&D grants stimulate and prepare companies for growth and targeted funding (technology focused) delivers better results for disruptive innovations, whereas generic grants for small and medium-sized enterprises are better suited for knowledge diffusion. Despite the positive effects of milestone-based selection mechanisms and phased funding, they are still under-used. Competitive R&D grants help companies to attract follow up (especially equity) funding. When coupled with complementary services (e.g. networking, advice), there is a longer lasting effect. Lastly, tax incentives and grants are complementary as regards to their impact on firm growth and innovation activities.

Key words: R&I policy, policy design, implementation, evaluation.

1. Introduction

High-growth firms are increasingly a target for government interventions (European Commission, 2016). This is especially true in Europe which lags behind the USA in the number of fast growing highly innovative enterprises (so-called scale-ups). In response to this large scale-up gap, the current policy debate has focused on new sources and forms of R&I funding to enhance EU level support for scale-ups.[1]

Several studies (e.g. Hall 2009, Hall and Lerner 2010) note that high potential young innovative firms experience greater difficulties in accessing finance than other firms. This is because small, young, and potentially high-risk firms are likely to be excluded from bank loans due to lack of collateral and thus unable to scale up (Canepa and Stoneman 2008; Magri 2009, among others). In most cases, information asymmetries exist between innovative firms aspiring to be high-growth firms and external financiers given that R&D investments are characterized by highly uncertain returns and costly monitoring. This is especially true for potential entrepreneurs or entrepreneurs without a well-established reputation (Audretsch, Bönte and Mahagaonkar 2012). Furthermore, although some firms might be able to finance their profitable projects internally, the presence of R&D spill-overs may force them to reduce R&D expenses: since the firms making these investments are unlikely to capture the entire surplus (e.g. the profits associated with new innovations may accrue to competitors who rapidly introduce imitations), they will tend to invest below the social optimal level of R&D.

This article aims to expand existing knowledge on the effects of R&D grants targeting young innovative firms with growth potential,[2] by comprehensively reviewing the literature on R&D programmes and policy evaluations. It distinguishes three types of R&D programmes, and investigates the impact of each type of programme with respect to employment, turnover, and innovation. The effects of both generic R&D grants and R&D subsidies are used as a benchmark for comparison of the effects of R&D grants for scale-ups. To complement this picture, we also use evidence regarding the impact of R&D grants versus tax incentives.

The paper is organized as follows. Section 2 provides a discussion of our methodological approach and Section 3 presents and elaborates on the results of academic literature and policy evaluations. Section 4 presents the results, distinguishing between generic R&D grants and R&D subsidies and compares them to the evidence for R&D grants for scale-ups. Section 5 provides evidence of the effects of R&D grants specifically targeting these firms vis-a-vis tax incentives. Section 6 draws lessons from both policy evaluations and econometric studies. Concluding remarks and policy implications are presented in Sections 7 and 8, respectively.

2. Methodological framework

Our research approach draws on policy evaluation studies, and academic literature. In the former, the main methods are online surveys, project administrative data analysis and qualitative interviews with beneficiaries and other actors. In the academic literature, the outcomes of policies are tested using different econometric techniques such as ordinary least squares regression analysis (OLS) and instrumental variables (IV) analysis.

(1) Sample papers: selection criteria

Policy evaluation studies were explored through contacts with national experts and the use of the SIPER database.[3] Academic articles were found through the Scopus and Science direct databases between March and September 2017. Keywords used included 'R&D' 'grants', 'subsidies', 'support', 'SMEs', 'young', 'innovative firms', 'high-growth firms', 'young innovative firms', and 'growth potential'. Our research identified more than 200 academic articles whose titles and abstracts were then screened. Direct grants for R&I projects were selected only if their objective is to help innovative firms grow faster. Moreover, studies were included only where the median firm age is under 10 years.[4] This resulted in a short list of 48 econometric studies; several papers were excluded because the programme targeted larger firms or small and medium-sized enterprises (SMEs) in general. Another group of papers was excluded because they evaluated mixed programmes where the effect of R&D grants alone was not assessed. This resulted in a final list of 13 econometric papers.

(2) Selection criteria for generic R&D grants and R&D subsidies

Generic R&D grants were defined as R&D grants targeting all companies (SMEs and larger enterprises), in all sectors, while R&D subsidies include a mix of R&D programmes (grants, loans, and tax incentives), without distinguishing between policy instruments when reporting effects. Our search resulted in more than 500 studies in the first sample.

2.1 Definition of beneficiaries by grant type

The primary objective of this research is to investigate differences in types of R&D grants and to link these to firms' performance. Its strength lies in distinguishing between 'beneficiaries of R&D grants for scale-ups' and 'beneficiaries of generic R&D grants and subsidies' based on age of the firm. While grants for scale-ups are targeted at young firms, the generic R&D grants and R&D subsidies target are well-established firms. In addition, this research highlights that scale-up firms are more likely to be engaged in high-risk projects (see eligibility criteria in Tables 1 and 2 in the Annex[5]), establish strategic R&D relationships with external partners and their managers and are committed to create new opportunities for change or expansion (see Section 3). The beneficiaries of generic R&D grants and R&D subsidies are both SMEs or large firms. While large firms can be characterized by the presence of large R&D laboratories, high internal expertise and close and consistent relationships with regular partners, small firms rely on external partners to identify technological and market opportunities and their R&D personnel and are in general not sufficiently flexible to customize their innovation to market requirements (see Figure 1).

2.2 Research limitations

The term 'high-growth innovative firms' is problematic because it is hard to establish the target beneficiaries *ex ante* (see Storey 1994; Holzl 2009; among others) as growth can be only measured *ex post* and growth patterns are highly non-linear. Thus the group of 'high-growth innovative firms' referred to in this report depicts a heterogeneous, dynamic and yet recognizable group of young innovative companies with growth potential. A number of policy evaluations and academic studies identify young innovative companies using parameters such as age, and minimum level of R&D intensity.[6] The analysis in this report presents the heterogeneity of policy options applied in Member States. Another limitation is the use of different output indicators which make it difficult to compare the impact of policy measures.

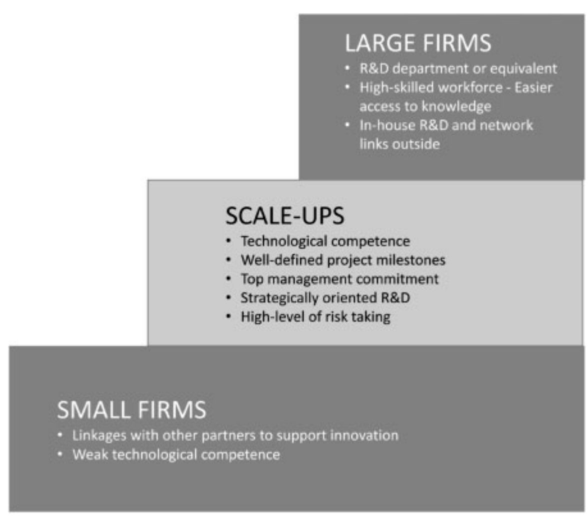

Figure 1. Beneficiary type.

Finally, most evaluations do not control for multiple simultaneous treatment effects on firms' output, i.e. firms receiving funding from different sources (e.g. tax credits combined with grants).[7] Therefore the attribution of causality is problematic.

3. Results

We reviewed seven policy evaluations and 13 econometric analyses of R&D grant impact on scale-ups. The vast majority of studies use data from the EU (Austria, Belgium, Croatia, Finland, Germany, Ireland, Italy, and UK) and other developed countries (Norway and USA). One empirical study used data from China.

The results from our review of the literature are characterized according to three main outcome variables:

1. 'employment' in terms of the (change in) number of employees or hours worked within the supported firms;
2. firm performance & productivity: firm performance is mainly measured in terms of output, sales (including sales of new products), value added, revenues; productivity is measured as labour productivity or Total Factor Productivity;
3. 'innovation' measured in terms of product and/or process innovation as well as patent application.

About half of the selected studies find that R&D grants are related to increases in employment for scale-ups. More than half of the studies find that R&D grants increase economic and innovation performance, and 35% of the empirical studies find that such R&D grants foster firm engagement in innovation processes.

3.1 Impact on firm employment

In Spain 40% of R&I projects subsidized in 2014 generated new jobs (CDTI 2015). In Ireland, 18% of surveyed beneficiaries experienced employment growth which could be attributed to participation in the programme, whilst 68% expected employment growth over the coming 12 months (Forfas 2012). Managers in the 'Evolve' initiative for creative industries in Austria reported increases in the number of employees in 36% of the funded projects (Radauer and Dudenbostel 2014). Similarly, 34% of surveyed beneficiaries of the Finnish Young Innovative Companies (NIY) Programme reported increased employment of over 100% since their initial engagement in the Programme. Results from the Academia plus Business (AplusB) grants study showed that 9 years after admission to the AplusB Center, the surviving AplusB cases have almost twice as many employees as the surviving control group companies.[8] For the UK's SMART scheme, about 55% of SMART-awarded firms experienced a positive employment change and 85% expect to see a positive employment change in the future (SQW report 2015). When looking at the impact of the SMART scheme on employment among three types of beneficiaries,[9] the Proof of Market beneficiaries report a higher change in employment, compared to both other beneficiaries. This finding is not surprising given their higher risk, and thus, their higher R&D reward opportunities.

The findings from articles based on econometric methods are consistent with those from policy evaluations. Using traditional OLS analysis, Girma et al. (2010) find that supported plants employ on average 1.21 employees more after the grant than non-supported plants. Using quantile regressions showed the effects of grants to be stronger for plants at the medium to high-end of the size distribution than for plants at the very low or very high ends.[10]

An analysis of firm level data from Finland (Koski and Pajarinen 2011) shows that R&D subsidies have a significant and positive effect on contemporaneous employment growth among both older incumbents and start-ups, with little apparent effect on the employment growth of gazelles (i.e. the 10% fastest growing firms among start-ups). For those firms, both the presence of possible lagged effects of R&D subsidies and other forms of financing (e.g. equity) may play a larger role in explaining variation in employment among scale-ups.

Using panel data analysis for Italy, Colombo, Giannangeli, and Grilli (2013) find evidence that R&D grants positively influence employment growth of young new technology-based firms (NTBFs) during the 2-year period following the receipt of R&D grants. In contrast, no effect is found for mature NTBFs.

Söderblom et al. (2015), studying VINN NU grant effects in Sweden, find that granted firms on average hire about 14 employees more than non-granted firms and conclude that the award of a VINN NU subsidy acts as a signal increasing firm probability to attract personnel.

Einio (2014), using Finnish data, finds that on average granted firms employ on average 2.33 employees more after the grant than non-granted firms, controlling for other factors.

3.2 R&D grants and impact on firms' economic and innovative performance

In the evaluations, beneficiary firms were asked to report if they had experienced sales growth or sales growth from innovative products as a result of their participation in the programme, and provide a quantification of this growth.

In Spain, in 92% of firms the subsidized projects generated high turnover, but only 13.5% of total sales came from sales of innovative products (CDTI 2015). The study suggests that it may be due to adverse market conditions which have negatively affected R&D commercialization strategies. In Ireland, 41% of surveyed beneficiaries had already experienced sales growth as a result of public support, while a further 54% increase was expected over the next 12 months (Forfas 2012). For the Austrian 'Evolve' initiative for the Creative Industries, Radauer and Dudenbostel (2014) find that about 30% of the projects reported increases in sales. In Finland, 61% of firms saw an increase of 100% or more in their annual revenues since their first engagement in the NIY Programme. In Denmark, about 58% of respondents reported increased market penetration (IRIS Group 2015). For the UK SMART scheme, 33% of beneficiary firms experienced a change in sales in the current year, and 88% expected to experience a change in sales in the future as a result of the SMART project (SQW 2015). A higher proportion of Development of Prototype award beneficiaries reported a change in turnover in the current year (48% vs 24%) when compared to beneficiaries of Proof of Market awards. The proportion of Development of Prototype award beneficiaries expecting a change in turnover in the future was also higher (93% vs 79%). Thus, most of the sales effects of SMART awards over 2012 and 2013 remained to be realized. The evaluation also shows that 74% of all beneficiaries expect to increase their export activity as a result of the award, reflecting the R&D knowledge-based nature of these firms. Looking at academic studies, Guo, Guo, and Jiang (2016) find that the Chinese Innofund programme significantly increases the sales from new products (by 7.88%) and the firms' exports volumes (by 2.41%). Likewise, when looking at the impact of the amount of funding, firms that receive a larger Innofund grant generate higher sales from new products and exports. Whilst unsurprising, this suggests that the firms considered the amount of money to be adequate and appropriate. Even after controlling for endogeneity of participation, the study finds that the firms generate more sales from new products after the grant.

Autio and Rannikko (2016) investigated the effects of the Finnish NIY programme and found that it positively influenced the sales growth of high-growth firms. In particular, they found that within a 2-year time span, the difference-in-difference point estimate in growth sales between NIY participants and the control group was 1.20 and 1.30 over a three-year period, implying that the programme has more than doubled the growth rate of treated firms. Furthermore, they found that the growth enhancing impact is mainly due to the contribution made by the NIY programme itself, and not because of the selection effects.

Grilli and Murtinu (2012) provide empirical evidence on the effects that R&D subsidies have on firm total factor productivity growth. The authors find that TFP increases by 25% more than other R&D schemes when Italian NTBFs receive R&D grants on a competitive basis. Gans and Stern (2003) find that the highest performing Small Business Innovation Research (SBIR) funded projects in the USA are active in industries with high rates of venture capital funding.

Using data on firm applicants to Tekes, Einio (2014) finds that granted firms report higher sales growth than non-granted firms. When controlling for population density, the coefficient of R&D grants becomes larger indicating that firms located in regions where there are high levels of regional R&D support report higher sales growth.

A study from Söderblom et al. (2015) use Swedish VINN NU grants data to show that on average receiving the grant increases firm sales by 11% more than without the grant. A similar result is found by Howell (2015) and Gicheva and Link (2016). Howell (2015), using data on the Department of Energy's SBIR in the USA, finds that Phase 1 SBIR grants increase the firms' probability of commercialization by 11% on average. Gicheva and Link (2016) report that a further increase in SBIR funding improves the firm's probability of technology commercialisation by 18%.

3.3 R&D grants and impact on firms' innovative activities

In the available evidence, firms were asked to report whether they have been engaged in product/service innovation as a result of their participation in the R&D programme. Innovative activities are measured by innovation dummy variables, and patents.

In Ireland, about 29% of companies had engaged in new product development as a result of support provided with a further 61% expecting to develop and introduce a new product or service over the next 12 months (Forfas 2012). In Austria, Radauer and Dudenbostel (2014) find that 61% of projects funded by 'Evolve' have led to new or substantially improved products. According to the Smart scheme report (SQW 2015), a higher percentage of Development of Prototype beneficiaries as compared to Proof of Market and Concept respondents report a new or significantly improved product/service to the market (41% vs 25% and 28%), but the proportion of Proof of Market and Concept respondents stating that they expect to introduce new service/product in the future is higher (56% and 64% vs 53%).

Guo, Guo, and Jiang (2016), using data for China, find that firms generate both more total patents and invention patents[11] after obtaining Innofund grants. The growth rate of newly granted patents of all types for supported firms after the grant is 13.2% higher than that of non-supported firms. Additionally, the growth rate of newly granted invention patents for Innofund-backed firms after the grant is 8.6% higher than that of non-Innofund-backed firms. When using the amount of funding as an explanatory variable, the authors find that, after gaining funding of RMB 1 m, the growth of newly granted patents of all types generated by supported firms is 20% higher than that of non-supported firms. For the case of new invention patents, a funding of RMB 1 m results in 10% higher growth for Innofund-backed firms compared with non-Innofund firms. These latter findings indicate that a 1 m RMB increase in Innofund support increases the probability of firms being innovative (at 20% for newly granted patents of all types, and at 10% for new invention patents).

Bronzini and Piselli (2016) examine the regional R&D grants effect on innovation in a group of NTBFs in Emilia-Romagna. They find that the impact of R&D grants is greater for smaller firms,[12] whereas large firms increase patent applications by around 1.2 times the mean for large untreated firms. This seems to support the arguments that small firms find it harder than large firms to finance innovation activity due to greater informational asymmetries and adverse selection problems.[13] Looking at patent applications, for the whole sample, in relative terms the effect of treatment is about 1.4 times the average for untreated firms.

Widmann (2016) finds that Austrian Research Promotion Agency (FFG) research grants increase the propensity to file a patent application with the European Patent Office within 4 years following the provision of a grant by 10.8% for subsidized firms. Furthermore, this effect is stronger for established firms above the median age (5 years). More precisely, results show that the effect of funding is 17% for established firms compared to 3.63% for younger firms, possibly due to the higher participation of established firms in high-risk projects compared to young firms.

4. A comparative analysis

This section[14] examines the effects of generic R&D grants on employment, firm economic and innovative performance, and innovation; the effects of R&D subsidies on the same set of outcome variables and how these compare with the effects of R&D grants for scale-ups.

4.1 Results: generic R&D grants

4.1.1 *Impact on firm employment*

Only two studies investigate to which extent generic R&D grants stimulate employment. Czarnitzki and Lopes-Bento (2013) found a significant difference of 9.57% between the control group and the subsided group, and that this effect does not change over time. Focusing on R&D grant schemes for SMEs they find that smaller firms benefit more in terms of R&D employment from R&D grant schemes than larger firms. When estimating the microeconomic impact of generic R&D grants, they find that on average the grant creates five additional R&D jobs.

Bedu and Vanderstocken (2015) find that the R&D employment growth rate in subsided firms is on average between 46.5% and 48.9%, compared to growth rates for non-subsidized firms ranging from 10.5% and 18%. The non-R&D workforce in subsidized firms increases between 73.1% and 83.5%, a substantial rate of growth compared to their non-subsidized counterparts (between 5.6% and 23.4%).

In brief, the evidence collected on generic R&D grants shows that their effects on employment tend to be larger for SMEs than large firms.[15] The scarcity of empirical studies suggests a need for more rigorous evaluation of existing and new R&D programmes.

4.1.2 *Generic R&D grants and impact on firms' economic and innovative performance*

Liu and Rammer (2016) find that ZIM-funded firms (the German Federal Government's Central Innovation Programmes for SMEs) increase the share of innovative sales (from new-to-firm product innovation) by 1.8% for year of funding (t) and 2.3% after 2 years ($t+1$) over that of non-ZIM-funded firms. In contrast, the Technology Programmes-funded firms (which support SMEs, large firms, and universities) increase the share of innovative sales (from new-to-firm product innovation) by 1.7% for year t and 3.2% points for year $t+1$. Furthermore, for Technology Programmes, the effects on innovative sales' share (from new-to-market product innovation) are 2.7% in year t and 2.6% in year $t+1$, whereas these are not statically significant for the ZIM financial scheme. These findings indicate that Technology Programmes perform better than central innovation funding in terms of new-to-market innovation, and future new-to-firm innovation.

Other scholars suggests that generic R&D grants have positive effects on firms' shares of innovative sales when coupled with firm human capital endowment[16] and collaborations with partners. Using firm data from Belgium, Hottenrott and Lopes-Bento (2014) find no difference between the effects of subsidy-induced R&D and privately induced R&D. However, the coefficient of publicly induced R&D becomes larger when it interacts with collaboration dummy variables, suggesting that R&D grants have a positive effect on sales share from market novelties when the recipient firm collaborates with international partners. This positive effect does not appear when the collaboration dummy variables interact with private R&D. Radas et al. (2015) using data for Croatia confirm that R&D grants modify the behaviour of beneficiary firms. They find that firms receiving R&D grants are more likely to collaborate with research institutions than firms that did not receive the grant. In addition, they find that while the coefficient of direct grants on firm shares of innovative sales is statistically significant, the coefficient of direct grants on the number of innovations is not significant, suggesting that public support helps firms to introduce improvements to existing products rather than entirely new goods and services.

Using Irish Innovation Panel data, Hewitt-Dundas and Roper (2010) find that public support for product development led to an increase in the plants' share of new and improved product sales by about 30%, while it led to a slightly lower increase (17%) in the share of new products in plants' sales in Northern Ireland.[17]

To compare these findings to the evidence from R&D grants for scale-ups, we focus on those econometric studies having similar specifications, similar time periods, and same dependent variables. Hottenrott and Lopes-Bento (2014), using data on Flemish IWT R&D grants between 2002 and 2008, find that a 1% increase in subsidy-triggered R&D raises the sales' share in market novelties by 0.525% on average. In contrast, Söderblom et al. (2015), estimating the effect of VINN NU grants between 2002 and 2008, find that the grant raises annual sales by 11.2% points on average. Einio (2014), using R&D subsidy data from Tekes for the period 2000–2005, finds that the sales growth of supported firms is higher than that of non-granted firms. Guo, Guo, and Jiang (2016), using data on the Innofund grant for the period 1999–2007, find that supported firms are over 59% more likely to report higher sales from new products than non-supported firms. Finally, Liu and Rammer (2016) report a 2.1 factor difference in means for the Technology Programme on innovative sales share from new-to-market product innovation. The matching estimates reported by Autio and Rannikko (2016) suggest that the NIY Programme has more than doubled the growth rate of treated firms.

Thus, the impact of R&D grants for scale-ups on firm economic and innovative performance are higher than generic R&D grants. The latter can positively affect performance if they are: better targeted to firm R&D activities, i.e. e.g. targeting specific technologies (Liu and Rammer 2016, among others) and if they stimulate firm collaboration (Hottenrott and Lopes-Bento 2014; Radas et al. 2015).

A limitation of the selected studies is that although most of the empirical studies take into account firm collaboration, very few of them control for partner type and mode of collaboration.

4.1.3 *Generic R&D grants and impact on firms' innovative activities*

Only a few studies investigate this area. In Germany, 59.5% of the ZIM projects report market product innovation in 2014 and 2015 (Depner, Baharian and Vollborth 2017). In Northern Ireland, public support for product development increases the probability of reporting new or improved products by 1.2%. For Ireland, the regression estimated reports positive coefficient but it is not statistically significant (Hewitt-Dundas and Roper 2010). Finally, Czarnitzki and Licht (2006) estimate the impact of German R&D grants on patent applications for, distinguishing between patent application induced by public funding and that financed by firms' internal resources. They find that government-induced R&D and privately financed R&D have the same effects on the firm's propensity to apply for at least one patent.

When comparing these findings to the evidence from R&D grants for scale-ups, we find that while the estimate obtained by Hewitt-Dundas and Roper (2010) is 1.2%, Guo, Guo, and Jiang (2016), using Innofund Programme data for the period 1999–2007, report Innofund-backed firms to be 13.2% more likely to innovate than non-Innofund-backed firms.

4.2 Results: R&D subsidies

This section analyses the effect of R&D subsidies on firm employment, performance, and innovation. R&D subsidies comprise grants, loans, loan guarantees and R&D tax incentives.[18]

4.2.1 *R&D subsidies and impact on firm employment*

Falk (2005) finds that a 1% increase in the amount of Austrian FFF-R&D subsidies increased firm scientific R&D staff by 0.04%, after controlling for firm characteristics. When the sample is split into firm size categories, the coefficient of R&D subsidies is a little larger (0.07%) for small firms (fewer than 25 employees) than for medium and larger firms (0.02% although not statistically significant). Afcha and Garcia-Quevedo (2014) investigate the impact of R&D subsidies on firm R&D employment in Spain. Firm size had no effect on the recruitment of graduates and PhD holders In France, Dortet-Bernadet and Sicsic (2017) find that R&D support leads to an increase in the number of highly skilled jobs of 1,160 fte in 2010 compared to 2003, i.e. the reference year. However, as the authors argue, compared with the amount received, especially from 2008 onwards, the effect of R&D subsidies is small.

In conclusion, R&D programmes for SMEs show small positive effects, especially for those subsidies promoting R&D and high-technology projects that require qualified personnel. Concerning generic R&D subsidies, an important implication is that the effectiveness of R&D programmes aimed at increasing firm innovation engagement may depend on human capital.

4.2.2 *R&D subsidies and impact on firms' economic and innovative performance*

Using data from the Irish Innovation Panel, Hewitt-Dundas and Roper (2010) find that receiving public support for new product development increases innovative sales from new products by 4.9%, and increases innovative sales from new and improved products by 6.4%, controlling for other factors. They also find that public subsidies influence firm share of innovative sales by increasing the quality or novelty of innovation output, firm human capital endowment, and firm's ability to establish cooperative relationships.

Garcia and Mohnen (2010), using Austrian CIS data, find that national government R&D support has a higher impact on firms' share of sales from new-to-market product innovation (3.4%) than on firms' share of sales from new-to-firm product innovation (2.5%). They conclude that true innovators have higher payoff in terms of innovative sales from R&D subsidies than imitators.

When focusing on subsidies that provide R&D support to recipients in high tech sectors, the estimates of the effects become larger. In Switzerland, Arvanitis, Donze' and Sydow (2010) find that subsidized-firms increase their innovative sales from significantly improved or modified products by 12% over non-subsidized firms, and their innovative sales from new-to-firm and new-to market innovation by 10%. Moreover, they find that the larger the subsidy (in relative terms), the larger its impact.

In a study investigating the effects of R&D subsidies on the share of innovative sales by young innovative companies (YICs[19]), Schneider and Veugelers (2010) find that although YICs show a higher innovative performance than other firms, the effect on their innovative performance is not statistically significant, suggesting that YICs tend to be financially more R&D self-sufficient than other firms. Furthermore, when using instrumental variables estimation, the estimate of R&D subsidies becomes negative. The authors argue that in Germany the system of allocating subsidies is not effective in dealing with the specific nature and problems of YICs.

Overall, it appears that the effects of R&D grants for scale-ups are higher than those of R&D subsidies, but the latter are shown to be effective only if the grants acknowledge the difference between economic activity sectors and concentrate on high-tech sectors, and if they interact with firm absorptive capacity.

4.2.3 *R&D subsidies and impact on firms' innovative activities*

Most econometric studies examine the question of whether national or European R&D support has a greater impact on innovation than regional R&D support (see Albors-Garrigos and Rodriguez-Barrera 2011; Herrera and Ibarra 2010; Marzucchi and Montresor 2013; Becker, Roper and Love 2016; Czarnitzki and Lopes-Bento 2014; Huergo and Moreno 2014).

Becker, Roper and Love (2016), using Spanish survey data, find that regional support seems most influential for product (22%), organizational (33%), management (~38%), and marketing innovation (45%), whereas national innovation support is associated with a higher probability of product or service innovation (~37%). Only national and EU support prove important in positively affecting new-to-the market innovation (26% and 37%, respectively). This seems to be confirmed by Czarnitzki and Lopes-Bento (2014) who found that firms that received national funding patent more than firms without subsidy, and that the effects tend to be greater if firms had also received European grants. Moreover, they found that national and European funding are also relevant in affecting the number of forward citations, suggesting that nationally funded firms (or in combination with EU funds) are not only appropriate targets but are also capable of generating valuable technology.

Studies, such as Huergo and Moreno (2014), Albors-Garrigos and Rodriguez-Barrera (2011), and Herrera and Ibarra (2010), find that national R&D policies targeted at particular technologies and sectors, and which interact with firm absorptive capacity, are effective in increasing the likelihood that firms will introduce innovation. Huergo and Moreno (2014) analyzed the impact of two Spanish financial schemes on the probability of firms reporting product and process innovation and found that a higher probability is related to participation in the CDTI loan programme (as opposed to the national subsidy system). Although the latter significantly affects the likelihood of firms to report process innovation, the influence of the CDTI loan programme is higher. This effect may be due to the detailed knowledge of the CDTI regarding the firm innovation process. Albors-Garrigos and Rodriguez-Barrera (2011) studied the effect of national and regional R&D support on innovation using a non-linear model. They found both regional and national subsidies to be relevant in low-tech firms' innovation, whereas national subsidies have more impact in a high-tech sample. They conclude that national policies supporting firm innovation would improve performance when firms increase their R&D intensity, their cooperative skills and are open to external partners and innovation sources. Herrera and Ibarra (2010) confirm the hypothesis that subsidies are more effective in increasing the likelihood of a firm innovating when they are closely linked to firm absorptive capacity.

Two econometric studies (Czarnitzki and Hussinger 2004; Hujer and Radic 2005) use microdata to study the effect of R&D subsidies on innovation in a sample of German SMEs. Hujer and Radic (2005) look at the effect of R&D subsidies on degrees of product innovation and find that there are positive effects on new product/service for SMEs only, indicating that R&D subsidies lead to new and radical innovation among SMEs.

One econometric study examines the effects of tax credits and R&D grants, compared to tax credits alone, on innovation. Using a matching method, Berube and Mohnen (2009) find that in firms that used tax credits and grants, the proportion of those making a world-first innovation is 25.29%, versus 17.24% of those using tax credits only. The proportions are larger when considering the other outcome variable (dummy for more than two product innovations): 67.7% of firms that used both policy instruments compared to 50.86% of firms that used only tax credits. This suggests that firms innovate more if they received both R&D grants and tax credits than if they received tax credits only.

We now discuss how these empirical findings are different from those from R&D grants for scale-ups. Czarnitzki and Lopes-Bento (2014), using German innovation survey data (1992–2006), find that firms that received national funding are more likely, by 4.6%, to file a patent than firms without a subsidy and the effect is greater if firms also received European grants (7%). Guo, Guo, and Jiang (2016), using Innofund programme data (1999–2007), find that Innofund-backed firms are 13.2% more likely to generate new patent than non-Innofund-backed firms. However, Aiello et al. (2017), using Italian data for the period 2001–2009, find that R&D support increases the probability of patenting by firms by 4%, while Widmann (2016), using data for the Basis Programme in Austria (2002–2005), finds that government research grants increase firm propensity to file a patent by 10%.

The literature has several limitations. Few studies report how effects change over time or do not control for multiple treatment effects, e.g. tax credits combined with grants.[20] Furthermore, few studies investigate the relevance of the policy measures in macroeconomic terms and there is little evidence of the effect of soft measures that can be delivered as part of or in addition to the subsidies (networking, learning effects, cooperation, etc.) due to the lack of appropriate measures for these largely intangible inputs.

5. A comparison of impacts of R&D grants for scale-ups versus R&D tax incentives

Our analysis regarding firm employment, economic and innovative performance, draws solely on econometric studies comparing the estimates of the impact of R&D grants versus tax incentives, although there are few empirical examples. Colombo, Grilli and Murtinu (2011) compared the effects of R&D grants and tax incentive on employment. Analyzing panel data (between 1994 and 2003), they show that the introduction of grants has the effect of increasing (after 2 years) the employment growth of the NTBFs by 56% for young firms, whereas tax incentives are negatively related to employment growth. When testing the statistical validity of average treatment effects of both types of subsidies, grants exert a statistically greater average treatment effect than tax incentives on the employment growth of young NTBFs during the 2-year period following receipt of the subsidies, whereas no such effect is found for more established NTBFs. However, the evidence is limited to the Italian context.

Grilli and Murtinu (2012) discuss the effects of R&D grants and tax incentives on the total factor productivity of Italian NTBFs. They find that when Italian NTBFs receive R&D grants on a competitive basis it increases by 25% more than when using other schemes, whereas the effect of tax credits was not significant. Radas et al. (2015), using data on matching grants for Croatian SMEs, find that the matching estimate for tax incentives and subsidies (13.82) is only slightly larger than the matching estimate for subsidies alone (13.31), suggesting that the addition of tax incentives does not bring significant benefits compared to subsidies alone.

Two studies link the effects of R&D grants and tax incentives on firm innovation and show their combination to be more effective in increasing firm innovation. Using R&D survey data, Falk (2009) finds that firms funded through taxation are 14% more likely to report radical innovations than their non-R&D subsidized counterparts. Firms funded through direct support are 17% more likely to report successful radical innovation. All else being equal, firms subsidized through both tax and direct funding are 24% more likely to report radical innovation than non-R&D subsidized firms. Using the 2005 Survey of Innovation from Statistics Canada, Berube and Mohnen (2009) looked at the effects of tax credits and grants on innovation, in terms of the nature of innovations, the number of new or significantly improved products, and the economic success of newly introduced products. When focusing on the nature of innovation, the authors find that 25.29% of the firms that used both instruments made a world-first innovation during the 3 years considered, compared to 17.24% among those that used only tax credits. For new or significantly improved products, 80.47% of the firms that used both instruments made at least one innovation during the period considered, compared with 71.8% of the firms that used tax credits only. Some, 60.79% of firms that claimed tax credits and received grants reported having at least some commercial success from newly introduced products, whereas only 52.49% of the firms that claimed tax credits alone reported the same. Similarly, 52.8% of the firms using both instruments, compared with 38.8% of the firms using tax credits only, declared a percentage of revenue above 3% due to first-to-market innovations.

In summary, the literature studying and comparing the results of R&D subsidies and tax incentives is limited, particularly for their effects on firm employment, innovation, and economic and innovative performance. Nevertheless, our review suggests that tax incentives are not a substitute but play a complementary role to R&D grants and such a combination can positively affect firms' ability to develop new products (see Berube and Mohnen, 2009; Falk, 2009). Others, such as Grilli and Murtinu (2012) and Radas et al. (2015) instead suggest the pre-eminence of R&D grants in increasing firm performance, especially for high-technology R&D projects. They argue that the funds released by tax incentives are likely to be inadequate for more ambitious R&D projects, particularly since they require the firm to invest upfront.

6. Implications for policy design and implementation

6.1 Policy evaluations: lessons learned

The evidence reviewed provides some general lessons on the design and implementation of financial support for innovative ventures with growth potential. As stressed in the OECD report (2013) and Cunningham, Gok, and Laredo (2013), the outcomes of a given programme are heavily dependent both on its design and its subsequent implementation.

R&D grants may target different populations—specific sectors, technologies or regions, types of firms (young, R&D intensive, etc.), and barriers (financial constraints). In our sample, the targets are high-tech companies and 'growth ready'.

Only the Finnish YIC programme applied a milestone approach, i.e. a gradual selection of companies being ready to grow or being able to continue to grow, although the US SBIR programme and the European Commission Horizon 2020 SME Instrument divide funding into phases that move the company closer to the market, adapting the funding to each phase. However, the Finnish programme selection process was adapted to company specifics (KPIs), thus offering very targeted support.

Evidence from the evaluations of the US SBIR programme and other literature (Cunningham, Gok, and Laredo 2013) stresses the signalling effect of grants as a significant contributor to the ability of a company to attract further funding—i.e. having already attracted a grant can act as a positive signal both for private investors (such as venture capital, in the case of the SBIR grants) and distributors of public funding. For companies that lack a long track record of sales, profitability or patents, grant history can provide more credibility to private investors.

Policy evaluations also highlight the added-value of complementary services and many grants include advice, training, coaching, and networking (Autio and Rannikko 2016; see also Cunningham, Gok and Laredo 2013 for a detailed analysis). The venture capital literature (Hellmann and Puri 2002; Ueda 2004) also stresses that part of the rationale for the choice of venture capital over debt is explained by the added-value of services accompanying the funding (coaching, managerial advice, and networking opportunities). Thus, the involvement of skilled managers and advisors in the implementation of grant programmes may amplify their effects. Table 1 summarizes the differences in policy design of both R&D grants for scale-ups and generic R&D grants.[21]

6.2 Academic studies: lessons learned

Most of the econometric studies reviewed in this article, controlling for a set of variables, investigate the effects that R&D grants have on the economic and innovative performance and innovation for innovative enterprises with growth potential. We discuss these variables in turn:

1. Grant history. Do past R&D grants (e.g. lagged values of R&D grants) affect firm performance? Most empirical studies control for past receipt of publicly supported R&D projects (see, for instance, Czarnitzki and Licht 2006). The main hypothesis behind these studies is that such firms display a higher economic and innovative performance, after controlling for other factors.
2. Amount of R&D grants. Are performance outcomes of innovative firms with growth potential affected by the amount of R&D grants? This is tested by regressing firm performance against the usual set of independent variables, including the amount of R&D grant together with other control variables (see Koski and Pajarinen 2011; Gicheva and Link (2016); Guo, Guo, and Jiang 2016).
3. Time lag of dependent variables. Extending the time frame over which the outcome variables are measured, provides results that become stronger with time. For example, Widmann (2016) finds the highest point estimate 3 and 4 years after the funding application; after year 4, the estimated treatment effect disappears/declines. Several studies (e.g. Söderblom et al. (2015) and Colombo, Giannangeli, and Grilli (2013)) use lagged values in order to avoid simultaneity between the dependent variables and the covariates.
4. Financial constraints. Effects are tested by including indicators of financial constraints within the firm among the set of regressors. The expectation is that financial constraints are greater for scale-ups. The presence of financial constraints is ascertained using control factors such as the amount of fixed assets and equity assets (see Koski and Pajarinen 2011; Söderblom et al. 2015; among others).
5. Funding indicators. Empirical studies use different public innovation funding schemes at different levels of disaggregation: regional, national and European (EU Commission and multilateral programmes). These indicators are intended to capture how different types of funding affect firm performance. However, as a measure of innovation funding the data has limitations as survey participants may not differentiate between different sources of funding (e.g. co-managed regional funding and structural funds).
6. Characteristics of R&D grants. An interesting piece of information concerns the type of R&D grants shared across firms. This information allows the verification of firm performance resulting from collaborative links between firms, and between firms and universities. Data for R&I collaboration and national and international collaboration are included in the econometric specifications used to test such hypotheses.

The research methods used to derive measures of impact from our selected studies are (i) descriptive statistics from survey data, (ii) microeconometric models (e.g. regression analysis), and (iii) counterfactual impact evaluation. Many policy evaluation studies use survey data. Although these capture the widest possible range of information regarding beneficiaries, using self-reported data may

Table 1. Summary of R&D grants' design

Description	Advantages	Challenges
R&D grants for scale-ups		
• Phased approach, often linked to performance • Mostly delivered with additional services (training, mentoring, and advice) • Small cohorts of firms Eligibility criteria more detailed and focused cf. generic grants (e.g. specific sectors, project managers' experience, company age)	• Phased approach allows distribution of funding based on results—not project proposals alone • Added-value services help entrepreneurs to deliver project to market	• Phased approach requires clear milestones to enable monitoring of the process • Problems with picking winners if eligibility criteria very stringent
Generic grants		
• Single grant • Financial support rarely linked with additional servicesLarger cohorts of firms • Eligibility criteria more generic: R&D intensity, company's size, no age limits	• Simple administrative rules • Risk more equally distributed due to larger cohorts	• Risk of funding mostly new-to-the-firm innovation and/or issues with commercialization given the lack of support during project development

cause biases in the estimations. Academic studies using micro-econometric approaches produce more robust results than descriptive statistics; however, measurement errors in explanatory variables and latent variables such as firm managerial skills may affect the estimation of the effects of R&D programmes. Other studies estimated the effects of R&D funding using counterfactual approaches to attempt to identify the causal effect of the support instrument. While this methodology is a well-developed and robust technique, it is not easy to implement and depends on the evaluator's ability to identify the appropriate control group (e.g. non-beneficiary companies may be in receipt of funding from another programme, which the evaluation analysis may not capture).

Examples of limitation of our reviewed econometric models here include:

- Survey data. Firms are asked to report whether they engaged in R&D and have experienced or expect to report a positive turnover change. Using self-reporting data, some errors, optimism bias and uncertainty in variables may emerge which may cause biases in the estimations.
- Skewed distribution of the effect. Policy makers are especially concerned with changes in employment/sales distributions; however, large subsidized firms tend to experience growth, while employment at the lower decile is unchanged. As Edler et al. (2016) argue, there are few studies (González, Jaumandreu and Pazo' 2005; Lee, 2011) that report evidence on how R&D programmes affect such distributions. In our selection, this issue is addressed only by Girma et al. (2010). However, it is less clear how the employment effects change according to age and size distributions.
- Unobservables related to R&D funding (e.g. networking, learning effects). Few studies investigate the influence of R&D programmes on firm behaviour. Scholars such as Edler et al. (2016) have highlighted the change in behaviour among firms benefiting from R&D policy (e.g. increase collaboration; changes to organizational routines and other firm capabilities). While firm behaviour is difficult to capture, omitting such unobservables can lead to understatement of the effects of R&D programmes.
- Biased sample. The greatest effect of R&D programmes should be exhibited by firms that do not undertake R&D activities on a regular basis. Unfortunately, this type of firm is hard to isolate in empirical studies. Thus, samples tend to be biased in favour of more continuous R&D performers.

Table 2 provides a summary of the difficulties, which arise from our reviewed econometric models.

Table 2. Different research methodologies used

Research methodologies	Weaknesses
Survey data analysis	Self-reported data causes biases in the estimation
Microeconometrics	Measurement errors; unobservables related to R&D funding; biased sample; modelling distributions
Counterfactual Impact Evaluation	Selection bias

7. Conclusions

Two main findings arise from our review of studies on the effectiveness of targeted R&D grants on employment:

There is robust empirical evidence for the positive impact of R&D grants for scale-ups on employment (Girma et al. 2010; Koski and Pajarinen 2011; Einio 2014). Policy evaluations report between 36% and 50% of the surveyed beneficiaries obtaining an increase in employment attributable to the grant. The AplusB and NIY Programmes, in particular, resulted in granted firms employing more than twice as many employees as non-granted firms. The average increase ranges from 7 to 16 employees per granted firm—consistent with the average increase (12) in the econometric study by Girma et al. (2010).

Targeted R&D grants are more effective over the medium to long term (Koski and Pajarinen 2011; Forfas 2012; Colombo, Giannangeli, and Grilli 2013; Ploder et al. 2015). It is very likely that firms that received R&D grants will experience an increase in employment in the long run. However, the evidence precludes any conclusions on the estimated time lag. Colombo, Giannangeli, and Grilli (2013) show that R&D grants do not influence the employment growth of young NTBFs until 2 years after the receipt of the grant. A 2-year time lag (the normal duration of a small R&D project) is confirmed by Forfas (2012).

The results on the effect of R&D grants for scale-ups on innovative and economic performance show that they can increase sales and the share of innovative sales: a majority of funded firms (between 41% and 92%) increase their sales after the grant. Studies such as Grilli and Murtinu (2012), Söderblom et al (2015), and Autio and Rannikko (2016) show positive effects on firm TFP and sales growth, but suggest that such positive effects may take from 2 to 4 years to appear.

There is evidence for growth-boosting effects, i.e. firms continue to grow for several years following receipt of the subsidy (Söderblom et al. 2015; Autio and Rannikko 2016), possibly because the receipt of a prestigious and highly competitive government subsidy provides an indication of quality, facilitating access to other types of funding (e.g. equity finance).

R&D grants for scale-ups are more beneficial in helping firms to develop new capabilities and knowledge and are an efficient stimulus for R&D/innovation when firms interact with other organizations (universities or firms) to introduce new capabilities and knowledge (see Autio and Rannikko 2016; Gicheva and Link 2016).

The main result from our studies on the effects on innovation is that the descriptive statistics from policy evaluations show that between 29% and 61% of granted firms were engaged in product or service innovation after receiving public support. Econometric studies show that, after controlling for other variables, R&D grants increase firm propensity to file a patent application. The time elapsed between grant receipt and innovation is at least 4 years according to Widmann (2016).

The results of the comparative analysis show that the effects of R&D grants for scale-ups on firms' share of innovative sales, employment, and innovative activities are generally higher than the effects of both generic R&D grants and R&D subsidies. Finally, we find very limited evidence on the effects of tax incentives compared to R&D grants for scale-ups on employment, firm innovative performance, and innovation. Nevertheless, the available empirical studies show that although tax incentives have little impact on increasing firm innovative performance, their combination with

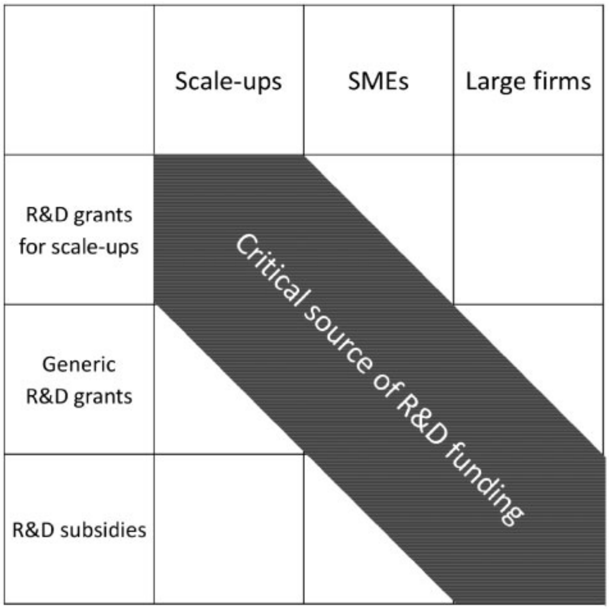

Figure 2. Relative importance to scale-ups of different type of R&D grants based on a review of 20 policy and econometric studies.

R&D grants is more effective in increasing firm innovation than when using only one instrument. The relative importance of different type of R&D grants to each type of beneficiaries is summarized in Figure 2.

8. Policy implications

Several policy implications relate to the conditions under which R&D grants for scale-ups can yield positive results. However, these are derived from a limited number of studies and, in many cases the evaluations fail to disentangle the effects of the policy mix and to quantify the effects of specific policy interventions, especially in countries where tax incentives are used for the majority of R&D active firms and are coupled with several other support measures. For these reasons the following should be treated with caution.

- R&D grants motivate companies to innovate, stimulating and preparing them for the growth phase.
- Targeted funding (with a technology focus) delivers better results for disruptive innovations, whereas generic grants for SMEs are better suited for knowledge diffusion as they mostly deliver new-to-the-firm rather than new-to-the-market results. Thus, there is an offset between the investment in the general innovativeness of small firms and specific, more targeted and riskier instruments for those motivated to grow.
- Programme selection mechanisms built on milestones or result-dependant subsequent phases of funding are rarely used, even though the effects for grants using such mechanisms on firms' employment and economic performance are very positive. This calls for increased use of this type of approach.
- R&D grants for scale-ups designed in an attractive and competitive way help companies to obtain follow-up funding (this signalling effect is especially evident for equity).
- Financial measures bring better results when accompanied by soft instruments (e.g., support for firms' organizational capacity for growth) (see Autio and Rannikko 2016). This may have a longer lasting effect than the funding itself (due to behavioural additionality). There is evidence for the added-value of complementary services—thus, networking helps to connect to new knowledge through external actors (e.g., investors, test users, academia). It would be useful to further investigate the effects of coaching and advisory services associated with some government-funded R&D programmes (Forfas 2012; and Ploder et al. 2015).
- Similarly, the high growth literature (for instance, Hellmann et al. 2016, among others) strongly underlines the importance of networks. The potentially dissimilar effects between collaborative grants and single recipient grants should be studied in order to see the effects of collaboration on the innovativeness of the outcomes.
- Tax incentives and grants are complementary as regards to their impact on firm growth and innovation activities. They should not be regarded as policy options but rather as a set of tools in the policy box.

8.1 Limitations and suggestions for future research

We have sought to shed further light on the impact of R&D grants for scale-ups, in particular, on their output additionality effects. However, this study is not without some limitations. Firstly, methodological differences in the evidence base, such as different time periods, econometric and other methods, and data caveats, preclude a deeper comparative analysis of the impacts. More insight into programme design and implementation features (perhaps obtained from combining descriptive statistics with econometric methods) may result in more robust, comparable empirical evidence. There is thus a need to improve the quality of policy evaluations. Secondly, the differentiation between SME policy, (focused on SME growth), R&D policy (focused on innovative companies), start-up and scale-up policies (focused on growth of innovative SMEs) is often fuzzy in terms of the specified programme objectives.

Potential avenues for future research include further investigation of the impact of R&D grants (at a national scale); in particular, a meta-regression analysis would help gain further insight into the magnitude of their effects. It would be also useful to examine if national R&I policies have a lasting effect on firm behaviour (e.g. increase of R&D personnel; setting up of R&D collaborative agreements, etc.). Finally, the signalling effect of grants on the success in obtaining further sources of funding in Europe forms an important issue for exploration.

Notes

1. See the SME Instrument of Horizon 2020 and other recent initiatives such as a pan-European venture capital fund of funds within the start-up and scale-up initiative.
2. Henceforward, for brevity, referred to as 'scale-ups'.
3. http://si-per.eu/Home/Abouthttp:/si-per.eu/Home/About.
4. An upper cut-off of 10 years old was used. Beneficiary firms are not older than 10 years (median age) and have less than 49 employees (median size).
5. Eligibility criteria in Annex provide in detail the particular type of firms being targeted.
6. See Czarnitzki and Delanote (2012) for an in-depth discussion of young innovative companies.
7. See Guerzoni and Raiteri (2015) for an overview of the issue of 'hidden treatment'.

8. The descriptive statistics of the survival rates show a substantial dissimilarity between the AplusB group and control group data. The former report a higher survival rate compared to the control group (87% and 59%, respectively) (Ploder et al. 2015).
9. The Smart scheme supports R&D activity at three different stages: Proof of Market, Proof of Concept, and Development of Prototype.
10. The results are confirmed when using a matching procedure to deal with the issue of selection bias in grant receipt.
11. In China there are three patent types: invention, utility, and design. Utility patents are generally granted to technical solutions related to shapes or structures, design patents are normally granted to shapes and patterns with patentable aesthetic appeals, and invention patents are granted to the methods and products—they are the most technologically innovative and thus require more R&D efforts than other types.
12. Small firms increase the number of patent applications by almost twice the mean application rate of small untreated firms.
13. Alternatively, small firms with small-scale R&D projects may benefit more from R&D grants than larger firms with large-scale R&D projects.
14. This section draws solely on the results from academic studies.
15. Note that estimates of generic R&D grants are not directly comparable with those of R&D grants for scale-ups because they are obtained using different econometric techniques.
16. In most empirical works, firm human capital endowment measures firm absorptive capacity, i.e. firms' ability to absorb R&D from other firms (see Cohen and Klepper 1992; Klepper 1997; among others).
17. For Ireland, the estimated regressions report positive coefficients but are not statistically significant.
18. See Edler et al. (2016) for an overview of major instruments of direct government funding.
19. Defined as firms less than 6 years old, with less than 250 employees and at least 15% of their revenues on R&D.
20. An exception is Czarnitzki and Lopes-Bento (2013).
21. The policy design for R&D subsidies cannot be reviewed as they involve a mix of policy instruments.

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Annex. List of policy evaluations and academic papers

Table 1. Policy evaluations on R&D grants for innovative firms with growth potential

Study	Country	Name of the policy measure	Funding agency	Objectives of the measure	Eligibility criteria for firms
CDTI (2015)	Spain	R&D projects (PID)	Centre for Technological and Industrial Development (CDTI)	To develop technologies strategic for company growth and consolidation	Research projects with high tech content
Forfas (2012)	Ireland	Enterprise Ireland Propel Programme	Enterprise Ireland	To: (1) increase and accelerate development of technology led start-up companies with scaling potential; and (2) to strengthen industry/college linkages	Significant market opportunity, particularly in international markets
Ploder et al. (2015)	Austria	FFG APlusB Programme	Austrian Research Promotion Agency	To act as bridge-builders between science and businesses and to increase the number of highly innovative and tech-oriented start-ups	Innovative start-up projects, typically technology-oriented
Radauer and Dudenbostel (2014)	Austria	Initiative for the Creative Industries 'evolve'	Federal Ministry for Science, research and economy	To support cultural and creative industries (highly innovative companies with economic potential); to create growth and jobs	Creative industries' innovation projects with high technological content
The Evidence Network (2013)	Finland	Young Innovative Companies (NIY) Programme	Finnish Funding Agency for Innovation and Development	To achieve rapid international growth	Under six years old, employ <50 people, maximum sales turnover of € 10 M, or balance sheet totalling at least €10 M
IRIS Group (2015)	Denmark	Market Maturation Fund	Danish Enterprise Agency	To promote growth and speed up market	Individual companies or consortia
SQW (2015)	UK	Smart scheme	Innovate UK	To nurture small high-growth potential firms to become high-growth mid-sized companies with strong productivity and export success	SMEs in all markets and sectors

Table 2. Academic studies on R&D grants for innovative firms with growth potential

Study	Country	Name of the policy measure	Funding agency	Objectives of the measure	Eligibility criteria for firms
Widmann (2016)	Austria	Basis Programme	Austrian Research Promotion Agency (FFG)	Individual projects of companies of all sizes and industries	Innovation content, technical difficulty of the project, economic exploitation prospects and that the project will intensify research activities
Guo et al. (2016)	China	Innofund Programme	Innofund Administration Center (IAC)	To facilitate and encourage the innovation activities of small & medium technology-based enterprises Commercialization of research	<500 employees; leverage ratio lower than 70%. R&D investments should be >3% of total sales, R&D employees should be >10% of total number of employees
Koski and Pajarinen (2011)	Finland	R&D grants	Finnish Funding Agency for Technology and Innovation (Tekes)	To: increase the number of start-ups; enable financing for changes encountered by SMEs; promote enterprise growth, internationalisation and exports	Firm's potential for rapid (international) growth
Autio and Rannikko (2016)	Finland	NIY Programme	Tekes	Explicitly targets high-potential new firms	Firms <6 years old. employ <50 people with max. sales turnover of 10m and balance sheet of 10m max. Must have recorded >15% R&D expenditure during previous 3 years. Must be domiciled in Finland.
Girma et al. (2010)	Ireland	R&D grants	Enterprise Ireland	Firm growth and internationalisation	Must produce (i) products for sales primarily on world markets, (ii) products of an advanced technological nature and (iii) products for sectors of the Irish market subject to international competition
Bronzini and Piselli (2016)	Italy	R&D grants – 'Regional Programme for Industrial Research, Innovation and Technological Transfer'	Emilia-Romagna region		All firms willing to implement innovative projects in Emilia-Romagna region
Colombo, Giannangeli, and Grilli (2013)	Italy	R&D grants	Italian government	Creation and support of academic start-ups	–
Grilli and Murtinu (2012)	Italy	R&D grants	Italian government	creation and support of academic start-ups	–
Söderblom et al. (2015)	Sweden	The Programme VINN NU	Swedish Governmental Agency for Innovation Systems (VINNOVA)	Creation and support of young innovative firms.	New ventures <1 year of age, in the process of developing a unique and innovative product or service, and are development-oriented and wish to expand Must have a developed idea and proof of concept
Gans and Stern (2003)	US	SBIR Programme	Federal Agencies	To: (i) increase commercialisation, (ii) enhance competitiveness of small firms in technology-intensive industries, and (iii) enhance participation of small firms in the Federal contracting process	US-owned firms with <500 employees in specific industries and technologies
Gicheva and Link (2016)	US	SBIR Programme	Federal Agencies	As above	See above

(continued)

Table 2. Continued

Study	Country	Name of the policy measure	Funding agency	Objectives of the measure	Eligibility criteria for firms
Einio (2014)	Finland	R&D projects	Tekes	To encourage firms to start up new R&D projects and accelerate the completion of ongoing ones	Commercial potential, technological challenge, available resources and the importance of the agency's support to the project's success
Howell (2015)	US	SBIR Programme	Department of Energy	To strengthen the US high-technology sector and support small firms	For-profit, U.S. based, and at least 51% American owned-firms with <500 employees