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Improving access to finance for young innovative enterprises with growth potential: evidence of impact on firms' output

Part 2. R&D grant schemes: lessons learned from evaluations

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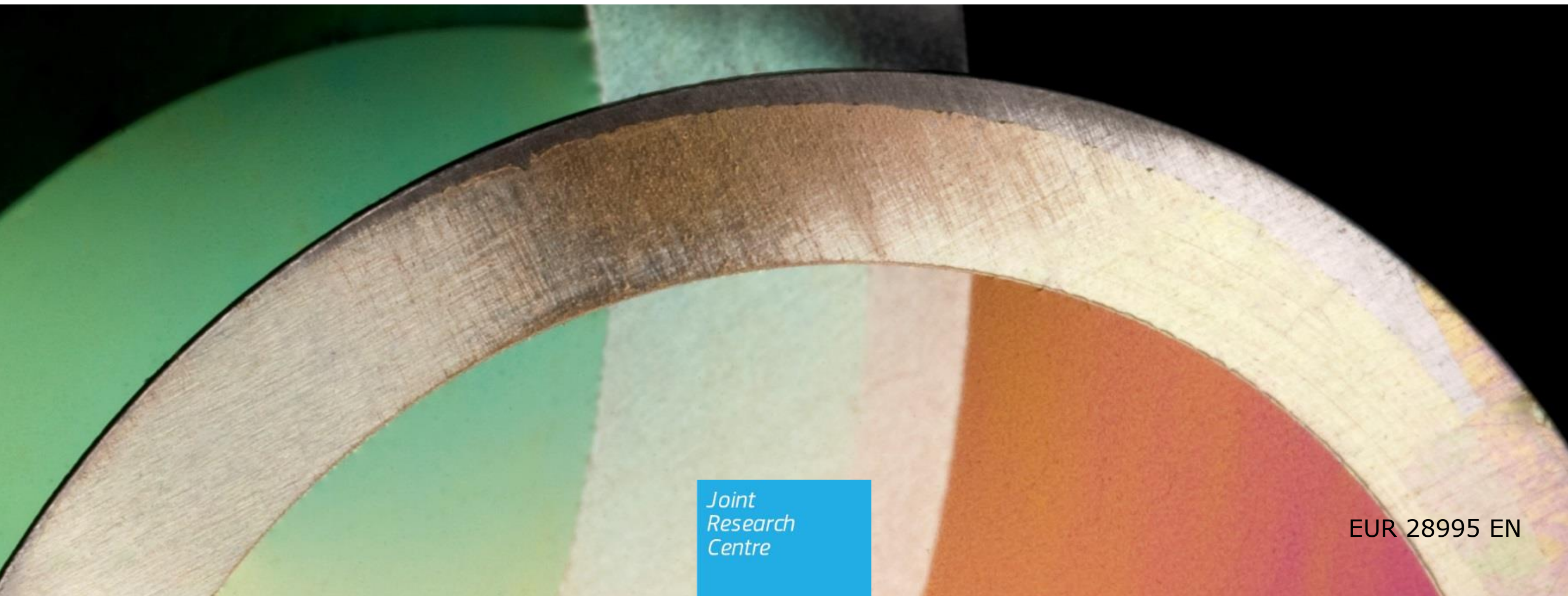

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Title *Improving access to finance for young innovative enterprises with growth potential: evidence of impact on firms' outputs. Part 2*. R&D grant schemes: lessons learned from evaluations

Contents

Foreword

Responding to the lack of in-depth research into the effects of R&D grants for young innovative firms with growth potential, the study 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' output, it contributes to this growing field of research through discussing the complex relationship between the two, comparing different types of R&D Programmes (namely generic R&D grants, and R&D subsidies) and analysing the wider policy implications.

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Executive summary

This policy report explores the role of R&D grant schemes in supporting young innovative firms with growth potential. It uses primarily literature from the Science direct and Scopus databases, and available policy evaluations. The analysis focuses on the impact of R&D grant schemes on companies' outcomes such innovation, employment, and economic and innovative performance, with the intent of providing evidence that could inform current and future R&I policy.

Main findings

R&D grants for young innovative companies with growth perspective:

- **Increase employment**: Evidence shows that between 36-55 percent of beneficiaries report an increase in employment. It is confirmed by the evidence from econometric studies (Girma et al., 2010, and Soderblom et al., 2015).
- **Increase both total sales, and share of innovative sales**. Evidence from both econometric studies and policy evaluations prove that those grants significantly increase total sales and share of innovative sales. The percentage of surveyed beneficiaries reporting an increase in total sales after the grant range between 33% and 92%.
- **The effect on sales growth persists for several years** after the receipt of the grant (Autio and Ranniko, 2016; Soderblom et al., 2015).
- **Increase companies' innovation capacities**. The evidence from policy evaluations shows that between **29-61**% **of beneficiary firms** were engaged in product or service innovation after receiving the grant. Econometric studies provide robust evidence of the positive effect on firm innovation measured by patent applications.
- The **effects for R&D grants for young innovative firms are larger** than the effects of **both generic R&D grants and R&D subsidies**. For generic R&D grants, the effects are higher when the grants induce changes in firm behaviour and when they target particular technologies or sectors.

Policy implications

- **R&D grants** stimulate and prepare the companies **for the growth phase.**
- **Targeted funding** (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.
- **Selection mechanisms** built on milestones or subsequent phases of funding are **still rarely used** although their effects are very positive. This calls for a **greater use of this type of mechanisms**.
- The competitive and attractive R&D grants help companies to **attract follow up funding** (signalling effect especially for equity).
- Financial measures coupled with **complementary services** (e.g. networking, advice) **have a longer lasting effect**.
- **Tax incentives and grants** are **complementary** as regards to their impact on firm's growth and innovation activities given the evidence of higher impact of combined application (tax incentives and grants).

Related and future JRC work

Our future research suggestion is to further investigate the impact of national R&D grants. In particular, a meta-regression analysis would help gaining further insight into the magnitude of the effects of R&D grants. It would be also interesting to analyse 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).

1 Introduction

High growth innovative enterprise (HGIE) ([1]) are in the center of attention of policy makers in the recent years in response to the evidence of their positive impact on job creation and productivity growth in the economy (see Henrekson and Johansson, 2010, among others). They also contribute to knowledge diffusion by creating and implementing new technologies and products as well as by interacting with other firms (see Audretsch, 2005). Nevertheless, these companies experience difficulties in accessing finance when investing in their innovation activities.

Notably, scholars such as Hall (2009), Hall and Lerner (2010) have suggested several rationales for supporting innovative firms with growth potential. First, it is very likely that small, young and potentially high-risk firms are excluded from bank loans due to lack of collateral. In particular, to scale up those firms need to invest in R&D activities, which are rarely collateralised. In most cases, there are information asymmetries between innovative firms aspiring to be high-growth firms and external financiers given that R&D investments are characterised by highly uncertain returns and costly monitoring. This is especially true for potential entrepreneurs or entrepreneurs without a well-established reputation. Furthermore, although some firms might be able to finance their profitable projects internally, the presence of R&D spillovers may force them to reduce their R&D expenses. That is, since the firms making these investments are unlikely to capture the entire surplus (e.g. the profits associated to new innovations may accrue to competitors who rapidly introduce imitations), they will tend to invest below the social optimal level of R&D. Based on these arguments, governments regularly support innovative firms with growth potential in their knowledge development and diffusion, but little is known about the effects of government R&D funding for such companies.

The aim of this report ([2]) is to expand the existing knowledge on the effects of government-R&D funding by thoroughly reviewing the literature on R&D programmes and policy evaluations, with primary attention to young innovative firms with growth potential. More precisely, with recourse to the most relevant and recent literature (both academic and policy-oriented), this report investigates the impact of R&D grants targeting young innovative firms with growth potential and assesses their impact based on three indicators of HGIE performance – employment, turnover and innovation.

After a brief discussion of the conceptual background of this study, Section 2 considers the rationale for this report and presents the research questions. Section 3 provides a discussion of our methodological approach and Section 4 presents and elaborates on the results of academic literature and policy evaluations. Section 5 presents the results distinguishing between generic R&D grants and R&D subsidies and compares them to the evidence for R&D grants for young innovative firms with growth potential. Section 6 provides evidence of the effects of R&D grants specifically targeting young innovative firms with growth potential vis-a-vis tax incentives. Section 7 draws lessons from both policy evaluations and econometric studies. Concluding remarks and policy implications are presented in sections 8 and 9, respectively.

[1] The term 'high-growth innovative firms' is problematic when applied to something that may well be far from united or static. Yet, through lack of a better term, we refer to the 'innovative firms with growth potential' here to depict what we hope to show is a heterogeneous, transient and dynamic - and yet recognisable - presence of innovative firms aspiring for high-growth.

[2] This report is part of a larger project exploring modalities for access to finance for high growth innovative enterprises and scale-up companies carried out jointly by the JRC's Unit for Finance, Innovation and Growth, and the Units for Territorial Development and Digital Economy. The results of this report will complement the results from the first JRC study by Gampfer et al. (2016) on HGIE policies, and the study by Szkuta et al. (2018) which evaluates the impact of public equity on innovative firms with growth potential. The first report focuses on all publicly-funded instruments that are available in the policy mix to nurture the emergence of the high growth innovative companies, the second report focuses on public equity, while this report focuses on publicly-supported R&D grant programmes.

2 A gap in the existing high-growth firm literature

High-growth firms are increasingly a target for government interventions (European Commission, 2010). This is especially true for Europe which is lagging behind the US in the number of fast growing highly innovative enterprises (the so-called scale-ups) (see Holzl and Janger, 2013). In Europe, the policy debate has been centred on a re-think of the innovation policy and a shift toward breakthrough and market-creating innovation. The tendency has been to focus on new sources and forms of R&I funding to enhance EU level support for young innovative companies with growth potential ([3]).

Policies targeting high-growth innovative firms have been the subject of debate and re-examination. Coad et al. (2014) provide a useful review of the literature and policy in this domain suggesting that the policies should be oriented to the identification of barriers to firm growth dynamics (one being the access to finance), rather than on the high-growth innovative firms themselves. Bos and Stam (2014) corroborate this argument suggesting that a focus on "Removing the barriers to growth of new firms in industries of their own choice, i.e. horizontal industrial policy, is a no-regret policy that is likely to enhance job creation in general" (*Ibid*: 165). Indeed, high-growth firms' policies are increasingly perceived as a way to stimulate future economic development. Yet, as Huber et al. (2014) argue, rather than increasing entry rates (i.e. share of companies entering an industry), high-growth innovative policies should aim at expanding start-up firm size in order to increase the share of high-growth firms.

From a policy perspective, indeed, it is difficult to target high-growth innovative firms directly because of difficulties in establishing the target beneficiaries ex-ante (see Storey, 1994; Holzl, 2009; among others) as growth can be only measured ex post and their growth pattern is highly non-linear. The OECD defines a high-growth enterprise as one with "average annualised growth in turnover or employees greater than 20% a year, over a three-year period, and with ten or more employees at the beginning of the observation period" (Eurostat-OECD, 2007).

The aim of this policy paper is to examine the effectiveness of R&D grants on the output of young innovative firms with growth potential, i.e. those companies that have the potential to experience high growth. Most of the existing literature on financial constraints mostly does not consider high-growth innovative firms explicitly and concentrates on financial constraints faced by small and medium firms (SMEs). We believe that a better understanding of the impact of national R&D programmes aimed at young innovative enterprises with high growth potential is important to improve our understanding of the consequences of such policies and to design better policies.

2.1 Research Context

There is a vast theoretical literature exploring the factors behind the financial constraints faced by innovative firms in financing their R&D activities. Scholars have focused mainly on two key factors: information asymmetries (Akerlof, 1970), and moral hazard problems (Jensen and Meckling, 1976). The basic theoretical framework is that of Akerlof (1970) that models the firm choice of accessing external finance, assuming that firms have better information about the returns on their R&D investment than potential investors. He suggests that entrepreneurs need to compensate their investors with a higher rate of return upon their R&I investment (which constitute the so-called lemon's premium ([4])) as they are not able to distinguish between bad and good R&I projects. He also predicts the disappearance of the market for R&D projects when the asymmetric problem becomes substantial. An alternative explanation for the existence of financial

[3] See, for instance, the SME Instrument of Horizon 2020 modelled after the US SBIR programme and other recent initiatives that try to alleviate the financial constraints of these companies through the supply of venture capital, such as a pan-European venture capital fund of funds within the Start-up and Scale up Initiative.

[4] Akerlof, G. (1970)

constraints is suggested by Jensen and Meckling (1976). In their model, managers play a key role in firms' R&D investment decisions. They may under- or overinvest in R&D spending for two main reasons: first, managers' incentives may be involved in the firm value maximisation problem ([5]). In doing so, managers may deviate from their goal of shareholder value maximisation. Secondly, managers may avoid risky innovation projects because their remuneration may be linked to the success of their R&D projects. According to Hall (2009), it is the combination of asymmetric-information and agency costs that makes it difficult for innovative firms, especially start-ups, to decide whether or not to invest in innovative activities.

In what follows, we investigate the extent to which innovative firms are financially constrained. An extensive body of empirical literature analyses whether innovative firms are affected by the presence of "liquidity constraints". Using data from the UK, Canepa and Stoneman (2008) point out that high-technology firms and smaller firms are more likely to encounter financial constraints than their counterparts. This is confirmed by Magri (2009) indicating that cash-flow sensitivity is higher among small innovative firms in Italy. With reference to German firms, Czarnitzki and Kraft (2009) find that more leveraged firms innovate less when they are strongly controlled by managers. Drawing on US data, Himmelberg and Petersen (1994) find that small owner-managed firms in R&D intensive environments suffer most from financing constraints. More importantly, they show that being a member of a business group or being a main shareholder of a large corporation may provide collateral for a small firm's investment.

There are few studies investigating the relevance of patents for the external financing of innovative and young entrepreneurs. Audretsch et al. (2012) suggest that a nascent entrepreneur that possesses patents as well as prototypes has a higher probability of obtaining equity finance from business angels and venture capitalists. However, the authors emphasize that the signalling force of patent matters to investors only if the nascent entrepreneurs are in the early stage of the start-up process rather than in the planning stage. Scholars such as Bottazzi et al. (2008) and Hall (2009) have argued that specialised financial intermediaries, such as venture capital organisations, can address credit market imperfections by scrutinizing firms ex-ante and engaging in ex-post monitoring. In particular, Hall (2009) argues that specialised venture capitalists supply informed monitoring of early stage technology start-ups and perform coaching (including monitoring, support, and control) and scout functions which contribute to their development.

Finally, Hallak et al. (2017) find that young companies are more financially constrained than mature ones. When focusing on financially constrained start-up and young companies, the authors find that they are nearly 25% less likely to be high-growth companies than other start-ups.

There is a general tendency to associate young innovative companies with growth potential with venture capital supply. Yet, when looking at the full 'funding escalator' (Nesta, 2009) those companies make use of different public and private sources of finance. There is a need to look at the wide spectrum of instruments that support the emergence and scale up of those companies and this reports looks more closely at use of grants aimed at growth and export.

R&D grants are a source of upfront finance (as opposed to tax incentives) do not involve partial loss of control as in case of equity and are potentially more available than a bank loan given the lack of a tangible collateral and the presence of information asymmetries.

[5] In the literature, economists have used the usual tools of profit maximization to model the firm decision as a choice made by firm owners and shareholders who decide to invest in R&D if the return from R&D investment is higher than the cost of R&D capital. Their decision, however, may be distorted by managers who want to maximize their own benefits.

2.2 Research Rationale, Aims and Questions

As noted in Cunningham et al. (2013) the R&D grant support for SMEs has become increasingly targeted at specific sectors (high and medium technology) and types of SMEs – young companies, start-ups, scale-ups, therefore anticipating specific needs of those beneficiaries.

In our study the R&D programmes are classified into three main categories: R&D grants for young innovative enterprises with growth potential; R&D grants targeted at all firms and all sectors (we use the term generic R&D grants from now on) and R&D subsidies.

a) **R&D grants for young innovative firms with growth potential**: are grants for market expansion, internationalisation, i.e. specifically targeting growth; R&D grants for (innovative) SMEs or young innovative companies with growth potential financing part or the totality of the research project costs to bring it to the market. Our strategy for the identification of such grants is that the firm growth potential status be included in the eligibility criteria and in the scope of R&D programme. Most of such R&D grants are awarded on a competitive basis and are covering future R&D costs of a specific project and/or costs of proof of concept and or market and prototyping. These grants may be delivered with additional services – coaching, advice, and training.

b) **Generic R&D grants**: are R&D grants targeted at all firms/all SMEs in all sectors;

c) **R&D subsidies**: refer not only to R&D grants, but also encompasses other R&D measures such as subsidized loans, and R&D tax incentives.

Most of empirical works focuses on the effects of generic R&D grants and R&D subsidies, with limited research on the effects of R&D grants for high-growth potential young innovative firms. We use the effects of both generic R&D grants and R&D subsidies as a benchmark for comparison relative to the effects of R&D grants for young innovative firms with growth potential. To complement this picture, we also use the evidence regarding the impact of R&D grants versus tax incentives.

Research Questions

The aim of this study and its rationale is thus to provide **a more rigorous impact evaluation of R&D policies targeting young innovative firms with growth potential through an examination** of existing **policy evaluations** and **academic literature**. This study examines specific R&D grants for young innovative firms with growth potential as well as generic R&D grants, and R&D subsidies including various types of financial products such as subsidized loans, and R&D tax incentives. The specific research questions we attempt at tackling are: what are the effects of R&D grants on employment, firm economic and innovative performance, and innovation when the objective of R&D programmes is to help innovative firms grow faster? And, how do these R&D grants that specifically target young innovative firms with growth potential compare in term of employment, firm economic and innovative performance, and innovative activities with generic R&D grants and R&D subsidies commonly used as external funding to support both SMEs and large enterprises?

3 Methodological Framework

3.1 Research Design

Our research approach is based on two different sources of information: policy evaluation studies (using mostly a qualitative approach), and academic literature (using mostly econometric methods). In policy evaluation studies, the main methods are online surveys, project administrative data analysis and qualitative interviews with beneficiaries and other actors assessing the impact of the grant of firm's outputs. In 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. We use both policy evaluation reports and academic contributions to identify the types of R&D grants studied and assess their impact on output additionality (e.g. in terms of revenue, employment growth, patenting activity and innovative sales).

3.2 Research Method

(a) *Identification of R&D grants for young innovative firms with growth potential, selection criteria*

Our research approach focuses on R&D grants for young innovative firms with growth potential and their effects using available results from both policy evaluation studies and econometric studies.

Policy evaluation studies were explored through contacts with national experts in each country, and the use of the SIPER database. The academic articles on government-funded R&D programmes targeting innovative firms with growth potential were found through the Scopus and Science direct databases between March and September 2017. Keywords in the search 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. Titles and abstracts of these studies were screened. We focus on direct grants for R&I projects only if their objective is to help innovative firms grow faster. Moreover, we only included studies where the median firm age is under 10 years old ([6]). The application of this inclusion criteria resulted in a short list of 48 econometric studies. Several papers were excluded because the programme targeted larger firms or SMEs in general. Another group of papers were excluded because they evaluated mixed programmes where no isolated effect of R&D grants only was assessed. This resulted in a final list of 13 econometric papers.

Table 1A in the Annex 2 list all the policy evaluation studies used, while Table 1B in the same Annex provides a representative list of the most relevant econometric studies carried out since 2000. Both tables show the authorship, the country in which the study was performed, the name of the policy initiative, the agency funding, the aim of the programme evaluated, the eligibility criteria and the selection process and method.

Thus, in our analysis, the target group of high-growth innovative firms comprises young innovative SMEs i.e. SMEs mostly active in highly innovative sectors (such as aerospace, agricultural technologies, and automotive) and technologies (big data, satellites, and robotics) that are seen as important future economic sectors. We further focus our attention on those R&D programmes for young innovative firms with growth potential, whose main purpose is to facilitate access to finance.

([6]) As a universal definition of young innovative firms with growth potential does not exist, we use an upper cut-off of 10 years old. The descriptive statistics in Table 1A in the Annex 1 show that beneficiary firms are not older than 10 years (median age) and are firms with less than 49 employees (median size).

In order to gauge the effectiveness of each HGIE policy measure, we analyse the policy evaluation studies along the "output additionality" dimension, rather than the "input" or "behavioural additionality" ([7]). The "output additionality" approach addresses the effects of policies on the output of firms, as measured by innovation activities, employment growth and firm performance (in terms of output, sales –including sales of new products and foreign sales/exports - value added and revenues).

(b) *Identification of generic R&D grants and R&D subsidies, selection criteria*

The study compares R&D grants for young innovative firms with growth potential to both generic R&D grants and R&D subsidies. We screened the academic literature related to R&D using the Scopus and Science direct databases between March and September 2017. The examples of key search terms are "R&D", "programmes", "subsidies", and "grant". We have studied the effects of both generic R&D grants and mixed R&D programmes:

- Generic R&D grants being R&D programmes grants targeting all companies, i.e. both SMEs and larger enterprises.
- R&D subsidies are all R&D programmes (grants, loans and tax incentives). Those studies do not distinguish between instruments when reporting effects.

Our search resulted in more than 500 studies in the first sample.

Subsequently the titles and abstracts of these studies were screened. Whenever the paper adhered to above mentioned criteria having the scope on output additionality, it was included. We also paid attention to the research design and the econometric methods used in these studies; in particular, we looked at the validity, reliability, and the interpretative and representational 'power' of these studies. We included studies that used regression analysis, instrumental variables methods as well as quasi-experimental designs.

3.3 Research Limitations

We are fully aware that the term "high-growth innovative firms" is problematic so we refer to the group of "high-growth innovative firms" in this report to depict a heterogeneous, dynamic and yet recognisable group of young innovative companies with a growth potential. A number of policy evaluations and academic studies identify what constitute young innovative companies based on parameters such as age criteria, and minimum level of R&D intensity ([8]). The analysis in this report presents the heterogeneity of policy options applied in Member States.

Another limitation of the analysis is the use of different output indicators which make it difficult to compare the impact of policy measure.

Finally, limitations still remain in identifying the impact of R&D grant on firm's output. Most of evaluations do not control for multiple simultaneous treatment effects, i.e. firms receiving funding from different sources (e.g. tax credits combined with grants)([9]). Therefore the attribution of causality is problematic.

[7] See Table 4A in the Annex 4 for a brief discussion of the project additionality. The evidence comes from the policy evaluations. Unfortunately, the issue has not been investigated in the selected econometric studies.
[8] See Czarnitzki and Delanote (2012) for an in-depth discussion of young innovative companies.
[9] See Guerzoni and Raiteri (2015) for an overview of the issue of 'hidden treatment'.

4 Results

We reviewed seven policy evaluations and 13 econometric analyses of R&D grant impact on young innovative firms with growth potential. 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 US). One empirical study uses data from China. Also, most of the econometric studies use longitudinal data and the predominant estimation method is the two-stage regression approach, with a selection equation and an outcome equation.

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

i) **employment** in terms of the (change in) number of employees or hours worked within the supported innovative firms with growth potential;

ii) **firm performance & productivity** (where firm performance is mainly measured in terms of output, sales (including sales of new products), value added, revenues; whereas productivity is measured as labour productivity or Total Factor Productivity, TFP); and

iii) **innovation** measured in terms of product and/or process innovation as well as in terms of patent application.

The sample of studies has been constructed according to the type of output additionality analysed. Table 1 summarises the evidence on the effects of R&D grants targeting young innovative firms with growth potential on the variables of interest.

A half of the selected studies (11) find that R&D grants are related to increases in employment among innovative enterprises with growth potential. More than half of the studies (14 over 20) find that R&D grants increase economic and innovation performance of innovative enterprises with growth potential, and 35% of the empirical studies (7) find that such R&D grants foster firm engagement in innovation processes.

Table 1. Evidence sources

	All sources	**Academic articles**	**Policy evaluation reports**
Employment	11	5	6
Economic and Innovation performance	14	8	6
Innovation	7	3	4
Total	**20**	**13**	**7**

In the next subsection we discuss the results from these studies distinguishing among three important outcomes: 1) impact on firm employment, 2) firm economic and innovative performance, and 3) firm innovative activities.

4.1 Impact on firm employment

4.1.1 Policy evaluations

The evaluation of the Spanish Centre for the Development of Industrial Technology (CDTI, 2015) finds that **40% of R&I projects subsidised in 2014 generated new**

jobs. In Ireland, the "Impact assessment of Enterprise Ireland Propel Programme" (Forfas, 2012) finds that almost **1/5 (18%) of surveyed beneficiaries** experienced employment growth which can be attributed to the participation in the programme, whereas over **two-thirds (68%) expected employment growth** over the next 12 months. When managers in the "Evolve" initiative for creative industries implemented over the period 2008-2013 in Austria were interviewed, they reported increases in the number of employees in **36% of the funded projects** (Radauer and Dudenbostel, 2014). **Thirty four percent** of surveyed beneficiaries of the Finnish Young Innovative Companies Programme (NIY Programme) **reported increased employment** by more than 100% since their initial engagement in the NIY Programme. Results from the Academia plus Business (AplusB) grants study conducted with a longer time frame showed that nine years after admission to the AplusB Center, the **surviving AplusB cases have almost twice as many employees as the surviving companies of the control group**. The descriptive statistics of the survival rates show a substantial dissimilarity between the AplusB group and control group data. The AplusB group report a higher survival rate compared to the control group (87% and 59% respectively) (Ploder et al., 2015). For the SMART scheme ([10]) in UK, the SQW report (2015) show that **about 55% of the SMART-awarded firms have experienced a positive employment change as a result of the Smart award**, and 85% of them will expect to see a positive employment change in the future. When looking at the impact of the SMART scheme on employment among different type of beneficiaries (Proof of Market beneficiaries, Proof of Concept beneficiaries, and Development of Prototype beneficiaries), the Proof of Market beneficiaries report a higher change in employment as a result of the Smart project, compared to other beneficiaries (both Proof of Concept, and Proof of Development of Prototype beneficiaries). This finding is not surprising given their higher risk, and thus, their higher R&D reward opportunities.

Table 2. Effects of R&D grants on firm employment: Evidence from policy evaluations

Study	Country	Policy initiative	Data	Period	Method	% of firms reporting increases in employment
CDTI (2015)	ES	CDTI projects	1061 projects	2012-2014	Survey	40%
Forfas (2012)	IE	Enterprise Ireland Propel Programme	25 firms	2009-2010	Survey	18% (a higher percentage of firms, 68%, reported increases in employment at t+1)
Radauer and Dudenbostel (2014)	AT	The Initiative for the Creative Industries "evolve"	77 firms	2008-2013	Interviews and online surveys	36%
The Evidence Network (2013)	FI	The NIY Programme	108 companies	2013	Web-based survey	34% of firms reported an increase in employment greater than 100%

[10] The Smart scheme supports R&D activity at three different stages: Proof of Market grants, Proof of concept grants, and Development of Prototype grants. Innovate UK, the UK's innovation agency, appointed SQW Ltd, working with Cambridge Econometrics and BMG Research, to undertake an evaluation of SMART scheme in 2014.

Ploder et al. (2015)	AT	APlusB programme	–	2007-2014	Interviews and data analysis with control group compariso n	The number of employees in granted firms is more than twice that of employees in non-granted firms as a result of the APlusB programme
SQW (2015)	UK	SMART scheme	513 SMEs	2012-2013	Survey	55% of the SMART awarded firms have experienced a positive change in employment, and 85% of them will expect in the future

4.1.2 Academic studies

The findings from policy evaluations are consistent with articles based on econometric methods ([11]). Girma et al. (2010) investigated the impact of grants for start-ups using traditional OLS analysis. Regression results indicate that **a supported plant employs on average 1.21 employees more** after the grant than a non-supported plant. In addition, using quantile regressions, the authors found that the effects of grants appear to be stronger for plants at the medium to high-end of the size distribution (between the 50^{th} and 75^{th} quantiles) than for plants at the very low or high ends. The results are confirmed when using a matching procedure to deal with the issue of selection bias in grant receipt.

A study by Koski and Pajarinen (2011) using firm level data from Finland show that R&D subsidies have **a significant and positive effect on contemporaneous employment growth** among both older incumbents (i.e. all firms that are over five years old at a given year) and start-ups (i.e. firms that are up to five years old), while it does not seem to have much effect on the employment growth of gazelles (i.e. 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 young innovative firms with growth potential.

Using panel data analysis (i.e FE-IV estimator) for Italy between 1994 and 2003, Colombo et al. (2013) find evidence of R&D grants positively influencing **employment growth of young** (i.e. firms that are 5 years old or younger at the time of receipt of the grant) **new technology-based firms** (NTBFs) during the two year period following the receipt of R&D grants. In contrast, **no effect** is found for **mature NTBFs**.

Soderblom et al. (2015) study VINN NU grant effects in Sweden and find that firms awarded the grant also attract more employees. The OLS estimated coefficient indicates that **granted firms on average hire about 14 employees more than non-granted firms**. The authors conclude that the award of a VINN NU subsidy acts as a signal increasing firm probability to attract personnel.

Einio (2014), using data on government R&D funding in Finland, find that on average **granted firms employ on average 2.33 employees more after the grant than non-granted firms** , controlling for other factors.

[11] See Annex 4 for a discussion of the interpretation of the coefficients.

Table 3. Effects of R&D grants on firm employment: Evidence from academic studies

Study	Country	Data	Period	Method	Main finding
Girma et al. (2010)	Ireland	4853 plants	1972-2000	OLS and Quantile regression	1.21 more than non-recipient start-ups
Koski and Pajarinen (2011)	Finland	– Start-ups, gazelles, and incumbents	2003-2008	Two-stage least squares random effects model and the differences-in difference method	Positive effect of R&D grants on start-ups and incumbents' employment growth
Colombo et al. (2013)	Italy	536 New technology-based firms	1994-2003	GMM-IVFE	Positive effect of R&D grants on young NTBFs employment growth
Soderblom et al. (2015)	Sweden	1102 firms	2002-2008	OLS regression	Awarded firms attract 14 employees more than non-awarded firms
Einio (2014)	Finland	1800 firms	2000-2005	Fixed Effect panel data model, and IV estimation	Positive and large effect on employment. 2.3 more than non-granted firms

4.2 Impact on firms' economic and innovative performance

This section explores the relationship between R&D grants and firms' economic and innovative performance. In the evaluations the beneficiary firms were asked to report whether they have 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.

4.2.1 Policy evaluations

The results of the evaluation of the CDTI grants (2015) in Spain shows that in **92% of firms the subsidised projects generated high turnover**, but only 13.5% of total sales comes from sales of innovative products. The study suggests that it may be due to the adverse market conditions which may have negatively affected R&D commercialisation strategy. In Ireland, a study by Forfas (2012) finds that **41% of surveyed beneficiaries had already experienced sales growth** as a result of granted public support granted, while a further 54% sales growth was expected over the next twelve months. When considering the Austrian "Evolve" initiative for the Creative Industries, Radauer and Dubenbostel (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, IRIS Group has carried out a survey questionnaire among 122 firms over the period 2010-mid-2014. Firms were asked to assess the contribution of the Market Development Fund in increasing the commercial potential of their product (i.e. market expansion). About **58% of the respondents reported increased market penetration**. For the SMART scheme in UK, a report by SQW (2015) show that **33% of**

beneficiary firms have experienced a change in sale in the current year, and 88% of them expect to experience a change in sales in the future as a result of the SMART-awarded project. When considering the composition of beneficiaries in term of type of grant, a higher percentage of beneficiaries of Development of Prototype award as compared to beneficiaries of Proof of Market reports a change in turnover in the current year (48% vs 24%), but the proportion of beneficiaries of Development of Prototype award expecting a change in turnover in the future is also higher (93% vs 79%). Thus, most of the sales effects of SMART awards over 2012 and 2013 remain to be realised. The SMART report also shows that **74% of SMART beneficiaries expect to increase their export activity as a result of the award**; this reflects the R&D knowledge based nature of these firms.

Table 4. Effect of R&D grants on firm economic and innovative performance: Evidence from policy evaluations

Study	Country	Policy initiative	Data	Period	Method	Increase in sales
CDTI (2015)	ES	CDTI projects	1061 projects	2012-2014	Survey	92%
Forfas (2012)	IE	Propel Programme	25 firms	2009-2010	Survey	41%
Radauer and Dubenbostel (2014)	AT	The Initiative for the Creative Industries "evolve"	77 firms	2008-2013	Interviews and online surveys	30%
The Evidence Network (2013)	FI	The NIY Programme	108 companies	2013	Web-based survey	61%
IRIS group (2015)	DK	Market Maturation Fund	122 firms	2010-2012	Survey	58%
SQW (2015)	UK	SMART scheme	482 SMEs	2012-2013	Survey and difference-in-difference analysis	33%

4.2.2 Academic studies

Guo et al. (2016) investigate the effect of the **Chinese Innofund programme** on innovation outputs (measured by sales from new products, exports, and newly granted patents) in a panel data analysis between 1998 and 2007. The results show that the R&D support **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**, the estimated coefficients are statistically significant and positive suggesting that firms that receive a larger Innofund grant generate higher sales from new products and exports. This finding is not surprising; however it conveys the idea that the amount of money was considered by firms adequate and appropriate. Even after controlling for endogeneity of participation in Innofund, the study finds that the firms generate more sales from new products after the grant.

Autio and Rannikko (2016) investigate the effects of the NIY programme in Finland on sales growth by measured by the log difference of sales between the year before the firm applied to the NIY programme and the total realised sales during the three subsequent years. As a result the initiative positively influence sales growth of high-growth firms. In particular, the authors find that within the time span of two years, the difference-in-difference point estimate in growth sales between NIY participants and the control group is 1.20 and 1.30 over a three-year period, implying that **the NIY programme has more than doubled the growth rate of treated firms**. Furthermore, they find that the growth enhancing impact is mainly due to the contribution made by the NIY programme itself, and not because of the selection effects (i.e. there is no difference in pre-treatment growth between treated and untreated groups).

Grilli and Murtinu (2012), using data on Italian new-technology based firms (NTBFs), provide empirical evidence on the effects that R&D subsidies have on firm total factor productivity growth (distinguishing between R&D grants and other subsidies - mainly fiscal contributions). The authors find that only R&D policy schemes contribute to TFP growth. In particular, they find that **TFP increases by 25 per cent** more than other R&D schemes **when Italian NTBFs receive R&D grants** on a competitive basis.

Gans and Stern (2003) find that highest performing Small Business Innovation Research (SBIR) funded projects in US are active in industries with high rates of venture capital funding. The size elasticity is 0.653, implying a 0.65 percent increase in revenue for one percent increase in venture capital funding.

Einio (2014) provides evidence on the influence of R&D support programmes on firm sales' growth in Finland and investigate the extent to which government funding varies across regions. Using data on firm applicants to Tekes during the period 2000 and 2006, the author 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 Soderblom et al. (2015) use VINN NU grants data from Sweden to show that **on average receiving the grant increases firm sales by 11 percent more** without the grant. Similar result is found by Howell (2015) and Gicheva et al. (2016). Howell (2015), using data on the Department of Energy's SBIR in the US finds that **Phase 1 SBIR increase the firms' probability of commercialisation by 11 percentage points on average**. Gicheva et al. (2016) report that **a further increase in SBIR funding** lead to an **increase by 18 percent firm's probability of technology commercialisation**.

Table 5. Effect of R&D grants on firm economic and innovative performance: Evidence from academic studies

Study	Country	Policy initiative	Data	Period	Method	Main finding
Guo et al. (2016)	China	Innofund Programme	2638 firms	1999-2007	Fixed Effect panel data model, logit regression and IV estimation	Innofund support increases sales from new products by 7.88% and export volume by 2.41%
Autio and Rannikko (2016)	Finland	NIY Programme	160 new technology based firms with growth orientation	2008-2012	Matching estimator	The NIY programmehas more than doubled the growth rate of treated firms.

Grilli and Murtinu (2012)	Italy	R&D schemes	247 new technology based firms	1994-2003	GMM estimator	The impact of R&D grants on the TFP growth of NTBFs of positive and of considerable economic magnitude (i.e. 25%)
Soderblom et al. (2015)	Sweden	The Programme VINN NU (Win Now)	1102 firms	2002-2008	OLS estimations	VINN Nu subsidy is positively and significantly relate to performance (the estimated coefficient is 0.112)
Gans and Stern (2003)	US	SBIR Programme	71 small firms (36 employees on average)	1990-1998	OLS regressions	Positive and significant effect of SBIR Programme. The highest performing SBIR-funded projects tend to be related with those industrial segments with high rates of venture capital funding
Einio (2014)	Finland	R&D projects	1800 firms	2000-2005	Fixed Effect panel data model, and IV estimation	Positive and significant effects of R&D support Programme on sales (the IV estimate of the treatment effect on sales is very large, i.e. 0.912)
Howell (2015)	US	SBIR Programme	7436 high-tech firms	1983-2013	OLS; negative binomial	A phase 1 grant increases a firm's probability of commercialization by 11 percentage points
Gicheva and Link (2016)	US	SBIR Programme	1878 firms	2005	Two-stage selection probit model	The probability of commercialization is nearly 18% points higher for granted firms.

4.3 Impact on firms' innovative activities

This section examines the relationship between R&D grants and 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 ([12]), and patents.

4.3.1 Policy evaluations

In Ireland, a Forfas (2012) evaluation study on "Propel Programme" finds that **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 twelve months. In Austria, Radauer and Dudenbostel (2014) find that **61% of projects funded by "Evolve"** have led to **new or substantially improved products**. As observed by SQW (2015), Smart scheme was undoubtedly fundamental in the development of new or improved products or services. According to the 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

[12] According to the OSLO Manual (2005), innovation is defined as '…the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practises, workplace organisation or external relations' (OECD, 2005: 46).

Market and Concept respondents stating that they expect to introduce new service/product in the future is higher (56% and 64% vs 53%).

Table 6. Effect of R&D grants on firms' innovative activities: Evidence from policy evaluations

Study	Country	Policy initiative	Data	Period	Method	Product innovation
Forfas (2012)	IE	Propel Programme	25 firms	2009-2010	Survey	29%
Radauer and Dudenbostel (2014)	AT	The Initiative for the Creative Industries "evolve"	77 firms	2008-2013	Interviews and online surveys	61%
IRIS group (2015)	DK	Market Maturation Fund	122 projects	2010-2012	Survey	58%
SQW (2015)	UK	SMART scheme	482 SMEs	2012-2013	Survey and difference-in-difference analysis	41% of Development of Prototype beneficiaries have introduced a new product/service

4.3.2 Academic studies

Guo et al. (2016), using data for China, find that firms generate both more total patents and invention patents ([13]) after obtaining Innofund grants. The **growth rate of newly granted patents of all types** for Innofund-backed firms after the grant is **13.2% higher** than that of non-Innofund-backed 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 winning a funding of 1 million RMB, the growth of newly granted patents of all types generated by Innofund-backed firms is 20% higher than that of non-Innofund-backed firms. For the case of newly invention patents, a funding of 1 million RMB results in 10% higher growth for Innofund-backed firms compared with non-Innofund firms. These latter findings indicate that a 1 million 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 newly invention patents).

Bronzini and Piselli (2016) examine the regional R&D grants effect on innovation in a group of technology-based firms in a northern region of Italy (Emilia-Romagna). When splitting the sample by firm size, they find that the **impact of R&D grants is greater for smaller firms**, i.e. small firms increase the number of patent applications by almost twice the mean application rate of small untreated firms, whereas large firms increase patent applications by around 1.2 times the mean for large untreated firms. This finding seems to support the arguments that small firms find it harder than large firms to

[13] In China there are three types of patents, namely, invention, utility, and design patents. Utility patents are generally granted to technical solutions related to shapes or structures, whereas design patents are normally granted to shapes and patterns with patentable aesthetic appeals. Invention patents are granted to the methods and products; they are the most technologically innovative and thus require more R&D efforts than the other types.

finance innovation activity due to more acute informational asymmetries and adverse selection problems ([14]). For the whole sample, they find that in relative terms **the effect of treatment is about 1.4 times the average for untreated firms** in terms of patent applications.

Widmann (2016) finds that the research grant introduced by the Austrian Research Promotion Agency (FFG) increases the **propensity to file a patent application** with the European Patent Office within four years following the provision of a grant by **10.8 percentage points** (statistically significant at the 5% level) for subsidized firms. Furthermore, when splitting the sample by firm age (by less than five years and more than five years), he finds that this effect is stronger for established firms above the median age (five years). More precisely, results show that the effect of funding is 17 percentage points for established firms (statistically significant at the 1% level) whereas it is 3.63 percentage points for younger firms (not statistically significant). Such finding may be explained by the higher participation of established firms in high-risk projects compared to young firms.

Table 7. Effect of grants on firms' innovative activities: Evidence from academic studies

Study	Country	Policy initiative	Data	Period	Method	Main finding
Widmann (2016)	AT	Basis Programme m	1936 firms	2002-2005	IV variable approach	Government research grant increases the propensity to file a patent application with the European Patent Office within 4 years by 10 percentage points. Stronger effects for established firms.
Guo et al. (2016)	China	Innofund Programme	2638 firms	1999-2007	Fixed Effect panel data model, logit regression and IV estimation	The growth rate of newly granted patents for Innofund-backed firms after the grant is 13.2% higher than that of non-Innofund-backed firms. The growth rate of newly granted invention patents is 8.6% higher for Innofund-backed firms than that of non-Innofund-backed firms.
Bronzini and Piselli (2016)	IT	R&D grants	1246 high-tech firms	2000-2005	Regression Discontinuity Design	Positive effect of R&D grants on the number of patents (i.e. the effect of the treatment is about 1.4 times the average for untreated firms). The effect is significantly greater for smaller firms (sales are below the median) than for larger enterprises. Positive effect of the Programme on firm's probability of applying for a patent, especially for smaller firms.

[14] Another possible reason for this finding (suggested by our reviewer) is that small firms with small-scale R&D projects may benefit more from R&D grants than larger firms with large-scale R&D projects.

5 A comparative analysis

This section addresses the question: what are the effects of generic R&D grants on employment, firm economic and innovative performance, and innovation? What are the effects of R&D subsidies on the same set of outcome variables? And how do they compare with the effects of R&D grants for innovative firms with growth potential?

Drawing on the large empirical body of literature relating R&D programmes and firm output, we classify the R&D programmes existing in the literature in two main categories different from R&D grants for young innovative firms with growth potential.

a) Generic R&D grants: R&D grants for all firms –including SMEs- operating in all economic sectors

b) R&D subsidies: R&D grants combined with other financial support such as subsidized loans, fiscal credit, and guarantees.

In the next two sections (5.1 and 5.2) we present the results from the literature review, distinguishing between studies related to generic R&D grants and those related to R&D subsidies. In each section we discuss the effects of each type of R&D programmes and how they compare with those stemming from R&D grants for young innovative firms with growth potential. It is worth noting here that this section draws solely on the results from academic studies.

5.1 Results: generic R&D grants

5.1.1 Impact on firm employment

How relevant are generic R&D grants to increase firm employment? The evidence is limited as only two studies investigate to which extent generic R&D grants stimulate employment ([15]).

Czarnitzki and Lopes-Bento (2013) examine the effect of R&D grant schemes on firm R&D employment intensity (measured as the ratio of R&D employment to total employment) in Flanders. They find that there is a significant difference between the control group and the subsided group, which amount to 9.57% points, and that this effect does not change over time (from 2004 to 2008). When focusing on R&D grant schemes for SMEs (the KOM Programme ([16])) they find that **smaller firms benefit more in terms of R&D employment from R&D grant schemes than larger firms**, i.e. this treatment effect is larger for SMEs (10.19%). When estimating the microeconomic impact of generic R&D grants, they find that **on average the grant creates five additional R&D jobs** (the projects are 2,012 in total).

Bedu and Vanderstocken (2015) use regional data on R&D grants for SMEs ([17]) to show 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 the 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%).

[15] Given the lack of research on firm employment, in this section we move beyond the 'output additionality' to examine the "behavioural additionality". While the 'output additionality' provides the empirical evidence of the impact of R&D programmes on firm output, the behavioural additionality' examines "how" and "why" the participation in R&D projects has produced the desired effects.

[16] The "KMO programma" is a special program for SMEs. The maximum project cost a firm can submit under this program is €200,000. Of these total project costs, the maximum subsidy rate is of 35% for a medium-sized company, and an extra 10% for a small-sized company. If an SME collaborates with a public research institute or an international partner, it can submit a proposal of a maximum of €250,000. If it collaborates with another firm (nationally), it can get 10% top-up in the subsidy rate.

[17] The main scope of the measure is to promote the development of firms, with a particular focus on SMEs. The main selection criteria of this measure are: the size of the firm, the content of R&D projects, and the collaborative dimension of the project.

In brief, the evidence collected on generic R&D grants shows that the **effects of generic R&D grants on employment tend to be larger for SMEs than large firms** ([18]).

Given the scarcity of empirical studies, an important policy implication is the need for more rigorous evaluation of existing and new R&D programmes.

Table 8. Effects of generic R&D grants on firm employment: Evidence from academic studies

Study	Country	Programme	Data	Period	Method	Main finding
Czarnitzki and Bento (2013)	Belgium (Flanders)	Matching R&D grant schemes from the agency for Innovation and Technology in Flanders (IWT)	4761 firms	2002-2008	Matching method	The treatment effect is larger for SMEs (10.19%) compared to the whole sample (9.57%).
Bedu and Vanderstocken (2015)	France (Aquitaine)	Regional R&D grants for SMEs	253 SMEs	2005-2010	Matching method	The R&D employment growth rate is on average between 46.5% and 48.9% in subsided firms compared to subsided firms (10.5% and 18%)

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5.1.2 Impact on firms' economic and innovative performance

Analysing the effects of generic R&D grants on innovative and economic performance, Liu and Rammer (2016) find that ZIM-funded firms (the Central Innovation Programmes for SMEs run by the German Federal Government) increase the share of innovative sales (from new-to-firm product innovation) by 1.8 percentage points for year t (i.e. in the year of the funding) and 2.3 percentage points for year t+1 (i.e. after two years) than non-ZIM-funded firms. In contrast, the Technology Programmes-funded firms (Technology Programmes support SMEs, large firms, and universities) increases the share of innovative sales (from new-to-firm product innovation) by 1.7 percentage points for year t and 3.2 percentage points for year t+1. Furthermore, for Technology Programmes, the effects on innovative sales' share (from new-to-market product innovation) are 2.7 percentage points in year t and 2.6 percentage points in year t+1, whereas these are not statically significant for ZIM financial scheme. These findings clearly suggest that Technology (i.e. cutting-edge novelty) Programmes perform better than central innovation funding in terms of new-to-market innovation, and new-to-firm innovation in the future.

Other scholars suggests that **generic R&D grants have a positive effects on firm shares of innovative sales** when they are coupled both with firm specific characteristics such as firm **human capital** (i.e. **absorptive capacity** ([19])) and **collaborations with partners**. Using firm data from Belgium, Hottenrott and Lopes-Bento (2014) find that the effects of subsidy-induced R&D and the privately-induced R&D are the same. However, the coefficient of publicly induced R&D becomes larger

[18] Please note that the estimates of generic R&D grants are not directly comparable with those of R&D grants for innovative firms with growth potential because they are obtained using different econometric techniques.
[19] Firm absorptive capacity can be thought of as good proxy of firms' knowledge base, and firms' ability to absorb R&D from other firms. In most empirical works firm absorptive capacity is measured by firm human capital endowment (see Cohen and Klepper, 1992, and Klepper, 1997; among others).

when it interacts with collaboration dummy variables (both national, and international collaboration), suggesting that R&D grants have a positive effect on sales share form 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 ([20]) modify the behaviour of those firms which benefited from them. More precisely, they find that firms receiving R&D grants are more likely to collaborate with research institutions than firms that did not receive the grant. This finding is rather interesting as it implies that R&D grants interact with other strategies and capabilities of firms.

In addition, Radas et al. (2015) find that while the coefficient of direct grants on firm shares of innovative sales is statistically significant (i.e. on average funded-firms increase their percentage of sales from innovation by 11 percentage points than firms that were not funded), the coefficient of direct grants on the number of innovations is not significant, suggesting that public support help firms to introduce improvements to existing products rather than entirely new goods and services. Using the Irish Innovation Panel over the period 1994-2004, 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 ([21]).

To compare these findings to the evidence from R&D grants for young innovative firms with growth potential, we focus on those econometric studies having similar specification, similar period time, and same dependent variable ([22]).

Hottenrott and Lopes-Bento (2014), using data on R&D grants (from the Flemish agency for innovation and technology, IWT) for the period 2002-2008, finds that a one percent increase in subsidy-triggered R&D raises, on average, by 0.525 percent the sales' share in market novelties. In contrast, Soderblom et al. (2015), estimating the effect of VINN NU grants for the period 2002-2008, find that winning the grant raises annual sales by 11.2 percentage points on average. Einio (2014), using R&D subsidy data provided by Tekes for the period 2000-2005, finds that the sales' growth of firms that have received the R&D support is higher than that of non-granted firms. Guo et al. (2016), using data on Innofund grant for the period 1999-2007, find that Innofund-backed firms are over 59 percentages more likely to report higher sales from new products than non-Innofound-backed firms.

Finally, Liu and Rammer (2016) report a 2.1 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, when looking at the impact of generic R&D grants on firm economic and innovative performance, the **effects of R&D grants for young innovative firms are higher than generic R&D grants**. The latter can be also be relevant for their performance if they satisfy the following criteria: (1) better targeted to firm R&D activities, i.e. e.g. targeting specific technologies (Liu and Rammer, 2016; among others) and (2) they stimulate firm collaboration (Hottenrott and Lopes-Bento, 2014; Radas et al., 2015). In other words, **generic R&D grants can have a larger effect if they induce changes in firm behaviour (collaboration) and enhance firm ability to innovate** (absorptive capacity).

[20] These are matching grants aimed at SMEs. Funding is based on the quality and creativity of proposed industry project.

[21] For Ireland, the regressions estimated report positive coefficients but they are not statistically significant.

[22] It is not completely obvious how to compare the estimates of generic R&D schemes with those of R&D grants for innovative firms with growth potential, because the estimates are affected by econometric techniques, dataset used in the analyses, country and period of time considered. Furthermore, the econometric analyses use different dependent variables. One way of alleviating this problem is to compare results from similar regression models covering similar time period. This assumes that firms operate in the same economy and occupy similar points in their innovation journeys or trajectories.

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

Table 9. Effects of generic R&D grants on firms' economic and innovative performance: Evidence from academic studies

Study	Country	Programme	Data	Period	Method	Main finding
Liu and Rammer (2016)	Germany	Central Innovation Programmes for SMEs (ZIM)	Innovative SMEs	2008-2012	Matching estimator	Small and positive effects of national government R&D funding
Hottenrott and Lopes-Bento (2014)	Belgium	Matching grants for SMEs in conducting R&D projects and encourage firms to collaborate	1593 firms	2002-2008	Tobit	Positive effects of R&D grants on sales share from market novelties
Radas et al. (2015)	Croatia	R&D matching grants	700 SMEs	2005-2010	Propensity matching	The effect of grants on innovative sales for funded-firms tend to be greater than non-funded firms (by 11 percentage points)
Hewitt-Dundas and Roper (2010)	Ireland	Research and Technical Innovation (RTI) scheme	Plant: 1156	1994-2004	IV Tobit	Public support for product development increases the share of new products in plants' sales by 17 percent

5.1.3 Impact on firms' innovative activities

There are very few contributions investigating the effect of generic R&D grants and firms' innovative activities.

In Germany, Depner et al. (2017) observe that 59.5% of the ZIM projects report market product innovation in 2014 and 2015.

Table 10. Effects of generic R&D grants on firms' innovative activities: Evidence from policy evaluations

Study	Country	Programme	Data	Period	Method	Product innovation

Depner et al. (2017)	DE	The Central Innovation Programme for SMEs (ZIM)	108 companies	2013	Web-based survey	59.50%

Hewitt-Dundas and Roper (2010) find that public support for product development increases the probability of reporting new or improved products by 1.2 percent in Northern Ireland. For Ireland, the regression estimated reports positive coefficient but it is not statistically significant.

Czarnitzki and Litch (2006) estimate the impact of R&D grants on patent application for German firms, distinguishing between patent application induced by public funding and that financed by the firms' own 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.

Table 11. Effects of generic R&D grants on firms' innovative activities: Evidence from academic studies

Study	**Country**	**Programme**	**Data**	**Period**	**Method**	**Product/Process innovation**
Hewitt-Dundas and Roper (2010)	Ireland	Grants for R&D and innovation activity (RTDI scheme)	Plant: 1156	1994-2004	IV probit	Positive effect on product innovation
Czarnitzki and Licht (2006)	Germany	R&D grants	735 beneficiaries	1994-2000	Probit regression	Positive effects of public funding on firm patent application, although smaller than privately financed R&D.

When comparing these findings to the evidence from R&D grants for young innovative firms with growth potential, we find that while the IV probit estimates obtained by Hewitt-Dundas and Roper (2010) is 1.2 percent, Guo et al. (2016), using Innofund Programme data for the period 1999-2007, find that Innofund-backed firms are 13.2 percentage points more likely to innovate than non-Innofund-backed firms.

5.2 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 ([23]).

5.2.1 Impact on firm employment

Falk (2005) examines additionality effects stemming from the **R&D subsidies** funded by the Austrian Industrial Research Promotion Fund (FFF)[24] between 1995 and 2002. When

[23] See Edler et al. (2016) for an overview of major instruments of direct government funding.

[24] The support of the FFF (i.e. Austria's most important source of finance for R&D projects carried out by business enterprises) comprises non-repayable grants, loans and guarantees for bank loans.

regressing the logarithm of scientific R&D personnel on the logarithm of R&D subsidies, the author finds that a one-percent increase in the amount of R&D subsidies granted increase firm scientific R&D staff by 0.04%. That is, firms supported by FFF-R&D subsidies show little variation in their demand for high-skilled R&D employment, after controlling for firm characteristics. When splitting the sample by firm size categories, the coefficient of R&D subsidies is a little larger (0.07%) for small firms (with less than 25 employees) than for medium and larger firms (0.02 but not statistically significant). Afcha and Garcia-Quevedo (2014) investigate the impact of R&D subsidies (distinguishing from national and regional authorities) on firm R&D employment in Spain. When splitting the sample in SMEs and larger firms, the authors find that R&D subsidies lead to the recruitment of graduates and PhD holders in both types of firm. Dortet-Bernadet and Sicsic (2014), investigating the impact of R&D subsidies (both direct and indirect such as R&D tax credit) on French micro firms in R&D intensive sectors, find that R&D support leads to an increase in the number of highly skilled jobs of 1,160 equivalent jobs 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, we find **small positive effect of R&D programmes for SMEs**, especially for those subsidies promoting R&D and high-technology projects that require qualified personnel (Afcha and Garcia-Quevedo, 2014).

As far as generic R&D subsidies are concerned, an important implication of our findings is that the effectiveness of R&D programmes aiming at increasing firm innovation engagement may depend on human capital (see Afcha and Garcia-Quevedo, 2015).

Table 12. Effects of R&D subsidies on firm employment: Evidence from academic studies

Study	Country	Programme	Data	Period	Method	Main finding
Falk (2005)	Austria	R&D grants	1064 firms	1995-2002	Fixed effect model	The effect is larger in small firms (0.07%) compared to medium and larger firms (0.02)
Dortet-Bernadet and Sicsic (2016)	France	Support to R&D (including and Research Tax credit CIR, and JEI)	2261 small firms	2003-2010	Matching	1,160 additional jobs in 2010 compared to 2003
Afcha and Garcia-Quevedo (2014)	Spain	R&D support from regional, and national authorities	12283 firms	2006-2011	Matching method	Positive effect of national subsidies on R&D employment both in SMEs and larger firms

5.2.2 Impact on firms' economic and innovative performance

Roper and Hewitt-Dundas (2016) find that receiving public support ([25]) for new product development increases innovative sales from new products by 4.9 percent, while it increases innovative sales from new and improved products by 6.4 percent, controlling for other factors. In addition, they 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 ([26]).

Garcia and Mohnen (2010), using CIS data from Austria, 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 firm share of sales from new to firm product innovation (2.5%)[27]. 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. Arvanitis et al. (2010), for instance, investigate the effect of CTI policy (Technology policy[28] in Switzerland) on high-tech firm innovative performance. They find that subsidized-firms increase their percentage of innovative sales from significantly improved or modified products by 12 percentage points than non-subsidized firms, and their innovative sales from new-to-firm and new-to market innovation by 10 percentage points. Moreover, they find that the larger the subsidy (in relative terms), the larger its impact.

One study investigating the effects that R&D subsidies (both from German and EU government) have on young innovative companies (YICs)' ([29]) share of innovative sales is by Schneider and Veugelers (2010). Their findings indicate that although YICs show a higher innovative performance than other firms, the effect of R&D subsidies 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 (IV) estimation, the estimate of R&D subsidies becomes negatives for YICs. The authors argue that in case of Germany the **system of allocating subsidies is not effective in dealing with the specific nature and problems of YICs**.

All in all, when looking at the impact of R&D subsidies on firm economic and innovative performance, the **effects of R&D grants for young innovative firms are higher** than those of R&D subsidies, but the latter are shown to be effective only if the grants acknowledge the difference of sector of economic activities and concentrate on high-tech sectors, and if they interact with firm absorptive capacity.

Table 13. Effects of R&D subsidies on firms' economic and innovative performance: Evidence from

[25] Roper and Hewitt-Dundas (2016) use data from the Irish Innovation Panel (IIP) for a sample of Irish manufacturing plants over the period 1991-2011. Respondents were asked: "Have you received government support for product development over the last three years?" and "Have you received government support for R&D not linked to any specific product development?".

[26] The authors identify four possible effects of public subsidies: the effect of subsidies on innovation inputs (the so-called legacy input additionality); the effects of subsidies on firm's human capital endowment (the so-called congenial additionality); the effects of subsidies on innovation output (the so-called legacy output additionality); the effects of subsidies on firm network and technical skills (the so-called legacy inter-organisational and experiential additionality).

[27] They also find that EU support for innovation (EU 4th and 5th Framework Programmes for R&D) does not significantly affect the variables of interest.

[28] The Commission of Technology and Innovation (CTI), the most important government agency for the promotion of innovation in Switzerland, supports R&D co-operation projects from scientific fields (machinery and apparatus construction as well as information technology) by funding the public partner (a university or a public research institution) in such cooperation, the private partner being an enterprise that agrees to contribute to this project at its own expense by at least the amount of funds offered by the CTI (private contribution of at least 50%).

[29] In this study, YICs are defined as firms with less than 6 years old, less than 250 employees and at least 15% of their revenues on R&D.

academic studies

Study	Country	Programme	Data	Period	Method	Main finding
Roper and Hewitt-Dundas (2016)	Ireland	support for NPD (new product development)	Plant: 3254	1991-2011	Tobit model	Public support from new product development increases innovative sales from new and improved product by 6.4 percent
Garcia and Mohnen (2010)	Austria	Public support for innovation (both R&D grants and R&D tax credit) from national and EU governments	1287 firms	1998-2000	System of simultaneous equations with limited dependent variables (Probit and Tobit model)	National government support increase firm share of sales from new to market product innovation, and firm share of sales from new to firm product innovation by 3.4% and 2.5% respectively
Schneider and Veugelers (2010)	Germany	National, regional and EU funding (R&D subsidies and tax incentives)	1715 firms	2002-2004	OLS, Tobit, IV methods	Positive effect of R&D subsidies for all firms, expect for YICs
Arvanitis et al. (2010)	Switzerland	CTI subsidy	1195 firms	2000-2002	Matching	Positive effects on innovation performance

5.2.3 Impact on firms' innovative activities

Most econometric studies have examined the question of whether national or European R&D support has larger impact on innovation than regional R&D support (see Becker et al., 2014; Marzucchi and Montresor, 2012; Huergo and Moreno, 2014; Albors-Garrigos and Barrera, 2011; Herrera and Ibarra, 2010; Czarnitski and Lopes-Bento, 2014).

Becker et al. (2014) using survey data from the Spanish National Innovation panel (PITEC) find that regional support seems most influential for product (22%), organisational (33%), management (about 38%) and marketing innovation (45%), whereas national innovation support is associated with a higher probability of product or service innovation (about 37%). They also find that only national and EU support prove important in positively affecting new-to-the market innovation (26% and 37% respectively). This finding seems to be confirmed by Czarnitzki and Lopes-Bento (2014).

They find that firms that received national funding sources patent more than firms without subsidy, and such effects tend to be larger if firms had received European grants in addition. Moreover, they find that national and European funding are also relevant in affecting the number of forward citations, suggesting that funded firms (only national or in combination with EU funds) are not only "the right" targets but are also capable to generate valuable technology ([30]).

Various studies such as Huergo and Moreno (2014), Albors-Garrigos and Barrera (2011), and Herrera and Ibarra (2010) find that national R&D policies are effective in increasing the firm likelihood of introducing innovation when they are targeted to particular technologies and sectors, and when they interact with firm absorptive capacity. Huergo and Moreno (2014) analyse the impact of two financial schemes, broadly CDTI (Centre for the Development of Industrial Technology) loan programme and national subsidy programme, on firm probability of reporting product and process innovation. They find that a higher probability of reporting product innovation (1.8%) is related to the participation in CDTI loan programme (as opposed to the national subsidy system). The national subsidy significantly affects firm likelihood to report process innovation (0.3%), but the influence of the CDTI loan programme is higher compared to the national subsidy (0.7%). This picture that favours the CDTI loan over the national subsidy may lean on detailed knowledge of the CDTI regarding the firm innovation process. Albors-Garrigos and Barrera (2011) study the effect of national and regional R&D support on innovation using a non-linear model. They find the relevance of both regional and nation subsidies in low-tech firms' innovation, whereas national subsidies perform better than regional subsidies in high-tech sample. The authors conclude that national policies aiming at supporting firm innovation would produce the effect of increasing their performance when the firm increase their R&D intensity, their cooperative skills and are open to external partners and innovation sources. Herrera and Ibarra (2010) confirm this hypothesis that is subsidies are more effective in increasing the likelihood of a firm to innovate when they are closely linked to firm absorptive capacity. More precisely, they find that R&D subsidies have a significant effect on large firms' propensity for patenting both in the year when they receive the subsidy and in the following year, whereas SMEs need more time to report a positive effect of the subsidies received. The authors use this evidence to argue that the previous R&D experience is the most important variable to gain access to R&D subsidies.

Two econometric studies (Czarnitzki and Hussinger, 2004; Hujer and Radic, 2005) use micro data to study the effect of R&D subsidies on innovation in a sample of SMEs in Germany. Hujer and Radic (2005) look at the effect of R&D subsidies (including tax incentives) on different degree of product innovation (new product/service, and improvements of existing products/services). They find that R&D subsidies have positive effects on new product/service for SMEs only, indicating that R&D subsidies lead to new radical innovation among SMEs.

One econometric study addresses the question: what are the effects of tax credits and R&D grants compared to tax credits only on innovation? Using a matching method, Berube and Mohnen (2009) find that in the sample of firms that used tax credits and grants, the proportion of those which have made a world-first innovation is 25.29%, against only 17.24% of those that used tax credits only. The proportions are larger when considering the other outcome variable (i.e. dummy for more than two product innovations): 67.7% of firms that used both policy instruments, against 50.86% of firms used only tax credit. Such finding suggests that firms make better innovation if they received R&D grants and tax credit than if they received tax credit only. The next chapter will examine further this important issue.

We now discuss how these empirical findings are different from those from R&D grants

[30] Forward citations are typically interpreted as proxy for the importance, the quality, or the significance of a patented invention. Empirical studies such as Hall et al. (2005) and Jaffe et al. (2000) show that forward citations are highly correlated with the private value of the patented inventions, and reflect the economic and technological importance as perceived by the inventors themselves.

for innovative firms with growth potential.

Czarnitzki and Lopes-Bento (2014), using German innovation survey data for the period 1992-2006, find that firms that received funding from national support are 4.6 percentage points more likely to file a patent than firms without subsidy, and such effect tend to be larger if firms had got European grants in addition (7%). Over the same time period (1999-2007), Guo et al. (2016), using Innofund programme data for the period 1999-2007, find that Innofund-backed firms are 13.2 percentage points more likely to generate new patent than non-Innofund-backed firms.

Yet, Aiello et al. (2016), using Italian data for the period 2001-2009, finds that R&D support increase firm probability of patenting by 4 percentage points. In contrast, Widman (2016), using data for Basis Programme in Austria for the period 2002-2005, find that government research grants increases firm propensity to file a patent by 10 percentage points.

The extant literature is limited in a number of respects. Few of these studies report how the effect change over time or do not control for multiple treatment effects, i.e. firms receiving funding from different sources (e.g. tax credits combined with grants) ([31]). Furthermore, few studies investigate the relevance of those policy measures in macroeconomic terms. There is also little evidence of the effect soft measures that can be delivered with the subsidies or in addition to it (networking, learning effects, cooperation, etc.) because of the unavailability of appropriate measures for mostly intangible inputs.

Table 14. Effects of R&D subsidies on firms' innovative activities: Evidence from academic studies

Study	Country	Programme	Data	Period	Method	Main finding
Huergo and Moreno (2014)	Spain	R&D subsidies vs soft loans	4300 firms	2002-2005	Probit model	Positive effect on product and process innovation, especially when subsidies are better R&D oriented.
Czarnitzki and Hussinger (2004)	Germany	R&D grants from the German Federal Government	3799 firms	1992-2000	Matching and system of equations	Positive effects on patents, especially for SMEs
Becker et al. (2014)	Spain	R&D support from regional, national, and EU authorities	Innovative firms (SMEs and large firms)	2004-2012	two-stage estimation model	National and EU support in positively affecting new-to-the market innovation (26% and 37% respectively)
Albors-Garrigos and Barrera (2011)	Spain	R&D support from regional, national, and EU authorities	3000 innovative firms	2005	Logistic regression	National subsidies perform better than regional subsidies in high-tech sample
Herrera and Ibarra (2010)	Spain	R&D support from regional, national, and EU authorities	1718 Innovative firms	1999-2001	Matching	Positive effect of subsidies, especially for larger firms

[31] A clear exception is Czarnitzki and Lopes-Bento (2013).

Czarnitzki and Lopes-Bento (2014)	Germany	R&D support from regional, national, and EU authorities	6106 firms	1992-2006	Matching	Positive effects on both patent and number of forward citations, especially when national grants are combined with EU grants
Hujer and Radic (2005)	Germany	R&D grants, wage subsidies, and tax incentives	2714 plants	1997-2000	Matching	Positive effects of R&D subsidies on new products/services for SMEs
Berube and Mohnen (2009)	Canada	R&D grants + Tax credits	2785 manufacturing plants	2002-2004	Matching	Positive effect on innovation when firms receive both R&D grants and tax credit
Aiello et al. (2016)	Italy	Three policy measures: 1) R&D grants; 2) R&D tax incentives; 3) R&D grants +R&D tax incentives	3788 SMEs	2001-2009	Probit model	R&D policy increases firm probability of patenting by 4%

6 A comparison of impacts of R&D grants for young innovative firms with growth potential versus R&D tax incentives

This section focuses on the effects of tax incentives on firm employment, economic and innovative performance, and firm innovation activities. We discuss whether and for what reason the R&D grants may be preferred to a tax incentive in case of young innovative companies. The analysis draws solely on econometric studies comparing the estimates of the impact of R&D grants versus tax incentives.

There are few empirical examples of work on the comparison of the effects of R&D grants versus tax incentives on employment, economic and innovative performance and innovation. Colombo et al. (2012) examines the difference in effects between R&D grants and tax incentive on employment. Using panel data analysis (i.e FE-IV estimator) between 1994 and 2003, the study shows that the introduction of grants has the effect of increasing, (2 year after the treatment) the new technology-based firms employment growth by 56 percent for young firms, whereas tax incentives are negatively related to employment growth for young firms. When testing the statistical validity of average treatment effects of both types of subsidies, selective subsidies (i.e. grants) exert a statistically greater average treatment effect than automatic subsidies (i.e. tax incentives) on the employment growth of young new technology-based firms during the 2-year period following the receipt of the subsidies, whereas no such effect is found for more established new technology-based firms. However, the evidence remains limited to the specific Italian context.

Table 15. Effect of R&D grants vs tax incentive on firm employment: Evidence from academic studies

	Country	Programme	Data	Period	Method	Employment growth rate
Colombo et al. (2012)	IT	Grants vs tax incentives to support new technology-based firms.	428 firms	1994-2003	FE-IV	Grants are more beneficial than tax incentives for young firms

Grilli and Murtinu (2012) discuss the effects of R&D grants and tax incentives on TFP of Italian new-technology based firms. They find that the total factor productivity increases by 25 per cent more than when using other schemes when Italian NTBFs receive R&D grants on a competitive basis, 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 subsidy only (13.31), suggesting that the addition of tax incentives does not bring significant benefit if compared to subsidies alone.

Table 16. Effect of R&D grants vs tax incentive on firm performance: Evidence from academic studies

Study	Country	Programme	Data	Period	Method	Total factor productivity growth
Grilli and Murtinu (2012)	IT	Grants vs tax incentive	247 new technology-based firms	1994-2003	GMM-system	Only R&D grants contribute to increase firm' TFP growth
Radas et al.	Croatia	Grants vs tax	700 SMEs	2005-2010	Matching	Tax incentives does

(2015)		incentives				not bring significant benefit if compared to subsidies alone.

Two studies (Falk, 2009; and Berube and Mohnen, 2009) link the effects of R&D grants and tax incentives and firm innovation. They show that the combination of R&D grants and tax incentives are more effective in increasing firm innovation. Using R&D survey data, Falk (2009) investigates how the probability of successful innovation changes when firms use tax incentive rather than direct grants. He finds that firms funded through taxation are 14 percentage points more likely to report radical innovations than their non-R&D subsidized counterparts. Firms funded through direct support are 17 percentage points more likely to report successful radical innovation. All else being equal, subsidized firms through both tax and direct funding are 24 percentage points more likely to report radical innovation than non-R&D subsidized firms. Using the 2005 Survey of Innovation from Statistics in Canada, Berube and Mohnen (2009) study the effects of tax credits and grants on innovation, in terms of 1) the nature of innovations, 2) the number of new or significantly improved products, and 3) the economic success of newly introduced products (measured by the percentage of revenue from first-to-market or already-on-the-market innovation). 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 three years considered, against only 17.24% among those that used tax credits only. When considering the number of new or significantly improved products, 80.47% of the firms that used both instruments made at least one innovation during the period considered, while 71.8% did so among the firms that used tax credit only. When looking at the economic success of newly introduced products, 60.79% of firms that claimed tax credits and received grants reported having at least some commercial success, whereas only 52.49% of the firms that claimed only tax credits reported the same. Very similar results are obtained when testing the dataset for the specification concerning firm percentage of revenue from first-to-market innovation: 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.

Table 17. Effect of R&D grants vs tax incentive on firms' innovative activities: Evidence from academic studies

Study	Country	Programme	Data	Period	Method	Innovation
Falk (2009)	AT	Tax vs direct research funding	4517 firms	2005-2007	Qualitative models	14% vs 17%
Berube and Mohnen (2009)	Canada	R&D grants and tax incentives vs R&D tax incentives only	2785 plants	2002-2004	Matching	25.29% vs 17.24% 80.47% vs 71.8% 60.79% vs 52.49%

To summarise, the **literature studying and comparing the results of R&D subsidies and tax incentives is limited** and even more when analysing their effects on firm employment, innovation, and economic and innovative performance. Still, the literature review suggests that **tax incentives are not a substitute but play a complementary role to R&D grants and such combination can positively affect firm's ability to develop new products**. The studies of Falk (2009) and Berube and Mohnen (2009) corroborate the idea that R&D grants and tax incentives are complementary. Other scholars such as Grilli and Murtinu (2012) and Radas et al.

(2015) have instead suggested the predominance of R&D grants compared to tax incentive in increasing firm performance, especially when R&D projects are of high technological value. They argue that the amount of R&D that can be performed due to tax incentives is likely to be inadequate for more ambitious R&D project given the set-up of a tax incentive that requires from the firm the investment being funded by the company upfront, which may be difficult for a financially constrained companies and tend to cover only costs related to R&I expenses (with different definitions of expenses that may increase the administrative burden of small companies).

7 Lessons learnt on the design and implementations

7.1 Lessons learnt from policy evaluations: key takeaways

The gathered evidence provides us also with more general lessons learnt on the design and implementation of financial support for innovative ventures with growth potential. As already stressed in OECD review, 2011 and Cunningham et al. 2013 the outcomes of a given programme are heavily dependent both on its design and also on its subsequent implementation.

The R&D grants may target different population of firms – specific sectors or technologies applied in the projects, specific types of firms (young, R&D intensive, specific regions, etc.) and problems (e.g. financially constrained). In our sample of evaluations, the targets where **technology/sector (high-tech companies)** and **growth readiness of companies** – more constrained selection criteria and more costly based on the evaluation on managerial skills/expansion plans/etc.

Only one of the evaluations studied, the Finnish Young Innovative Companies programme, applied a **milestone approach**, i.e. **gradual selection of companies being ready to grow or being able to continue to grow. Whereas** US SBIR programme and the European Commission Horizon 2020 SME Instrument divides funding into phases that are moving the company closer to the market and the funding is adapted to each of the phases, the Finnish programme selection process was adapted to companies' specifics (KPIs) offering a very targeted support.

The evidence from the evaluations of the US SBIR programme and other literature (Cunningham et al, 2013) stress the **signalling effect of grants** as a significant contributor to the ability of a company to attract further funding. In other words, being able to attract a grant can act as positive signal both for private investors (SBIR study of the effect of the grants on the possibility to attract venture capital) and evaluators of public funding. For companies that lack a long track record of sales, profitability or a patents, grant history can provide more credibility among private investors. It would be interesting to see if the *prestige* of the grants correlates with the ability to attract further funding.

Policy evaluations also point to the **added value of complementary services** and indeed many grants include advice, training, coaching and networking (Autio and Ranniko, 2016; for instance, see also Cunningham et al. 2013 for a detailed analysis). The venture capital literature (Ueda 2004, Hellman and Puri 2002) also stresses that part of the rationale of the choice of venture capital over debt is explained by the added value of services accompanying the funding (coaching, managerial advice and networking opportunities). Therefore the involvement of skilled managers and advisors in the implementation of grant programmes may amplify the effects of the grant. Table 20 summaries the differences in policy design of both R&D grants for young innovative firms with growth potential and generic R&D grants ([32]).

[32] The policy design for R&D subsidies cannot be drawn as they involve a mix of policy instruments.

Table 18. Summary of R&D grants' design

R&D grants for young innovative firms with growth potential

Description	Advantages	Challenges
R&D grants for young innovative firms with growth potential		
• Phased approach to funding, often linked to performance • Funding is mostly delivered together with additional services (training, mentoring, advice) • Small cohorts of firms • Eligibility criteria more detailed and focused that for generic grants (e.g. specific sectors, experience of project managers, company's age limits)	• Phased approach allows for distribution of the funding based on results and not only on project proposals • Added-value services help the entrepreneurs to deliver the project to the market	• Clear milestones should be set up to monitor the process if phased approach applied • Problems with picking winners if eligibility criteria very stringent
Generic grants		
• Single grant • Financial support rarely linked with additional services • Larger 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 commercialisation given the lack of support during the project development

7.2 Lessons learnt from the academic studies: key takeaways

Most econometric studies investigate the effects that R&D grants for innovative enterprises with growth potential have on their economic and innovative performance and innovation, controlling for a set of variables ranging from: (a) past R&D grants, (b) the amount of R&D grants, (c) lagged values of dependent variables, (d) the presence of financial constraints, (e) funding indicators, and (f) the presence of different type of R&D grants. We discuss these control variables in turn:

a) **Grant history**. The aim is to ascertain whether past R&D grants (e.g. lagged values of R&D grants) affect firm performance. Most empirical studies control for publicly supported R&D projects in the past (see, for instance, Czarnitzki and Litcht, 2006). The main prior hypothesis behind these studies is that firms supported by public R&D grants in the past display a higher economic and innovative performance, after controlling for other factors.
b) **The amount of R&D grants**. Whether performance outcomes of innovative firms with growth potential are affected by the amount of R&D grants 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 Gicheva et al, 2016; Koski and Pajarinen, 2011; Guo et al., 2016).

c) **Time lag of dependent variables**. When extending the time frame over which the outcomes variables are measured, the results are shown to become stronger with time. Widmann (2016), for instance, find evidence that the effects become stronger over time. He finds the highest point estimate for years 3 and 4 after the funding application. After year 4, the estimated treatment effect disappears/declines. In addition, several studies such as Soderblom et al. (2015) and Colombo et al. (2013) use lagged values in order to avoid simultaneity between the dependent variables and the covariates. In the case of venture capital, the effect starts to be positive in the fifth year after the investment (see more in Szkuta et al. 2017).

d) **Financial constraints**. Whether performance indicators for young innovative firms with growth potential are affected by financial constraints is tested by including indicators of financial constraints within the firm among the set of regressors. The expectation is that financial constraints are greater for young innovative firms with growth potential than others. The presence of financial constraints is ascertained using control factors such as the amount of fixed assets and equity assets (see Soderblom et al., 2015; Koski and Pajarinen, 2011; Bronzini and Piselli, 2016; Einio, 2014; Grilli and Murtinu, 2012; Guo et al. 2016).

e) **Funding indicators**. Empirical studies use different public innovation funding schemes at different levels of disaggregation: the regional (State / regional Governments), the national (Federal / National Government) and the European (EU Commission and multilateral Programmes). These indicators of public funding data are meant to capture how different types of funding affect firm performance. However, the data itself has limitations as a measure of innovation funding as firms participating in the survey might not be able to differentiate between different sources of funding (e.g., regional funding and structural funds (co-management)).

f) **Characterististics of R&D grants**. An interesting piece of information concerns the type of R&D grants 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 (a dummy variable assigning a value of one to those firms which assert to collaborate with a research institution) and national and international collaboration (dummies assigning a value of one if firms reported to collaborate with national or/and international partners) are included in the econometric specifications used to test such hypothesis.

7.2.1 Limitations of econometric approaches

In what follows, we briefly discuss some potential problems stemming from the application of econometric methods ([33]). These are:

- **Survey data.** In survey data, firms are asked to report whether they engaged in R&D, whether they have experienced or expect to report a positive turnover change. Using self-reporting data, some errors, optimism bias and uncertainty in variables may emerge and this may cause biases in the estimations.
- **Skewed distribution of the effect**. Policy makers are especially concerned with changes in employment/sales distributions; for example, among subsidized firms, it is mostly the large getting larger, with employment at the lower decile unchanging. As Edler et al. (2016) argue, there are only few studies (Lee, 2011; González et al. 2005) reporting evidence on how R&D Programmes affect such distributions. In our selected studies, this issue is only addressed by Girma et al. (2010). However, it is

[33] Annex 5 discusses in depth the econometric issues emerged from our selected empirical studies.

less clear how the employment effects changes according to age and size distributions.

- **Unobservables related to R&D funding (e.g. networking, learning effects)**. There are few studies investigating 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 organisational routines and other firm capabilities). While firm behaviour is difficult to capture, omitting such unobservables can lead to understating the effects of R&D Programmes.
- **Biased sample**. The greatest effect of R&D Programmes should be observable for firms that do not undertake R&D activities on regular basis. Unfortunately, this type of firms is hard to isolate in empirical studies. Thus, samples used tend to be biased in favour of more or less continuous R&D performers.

8 Conclusions

This study seeks to gather and compare evidence on the impact of R&D grant schemes for innovative enterprises with growth potential. With recourse to both policy evaluation studies and academic literature, it analyses the effects of R&D grants aimed at supporting innovative enterprises with growth potential on a set of output variables: employment, innovation, and firm economic and innovative performance.

Two main results arise from our review of the evaluation reports and econometric studies on **the effectiveness of targeted R&D grants on employment**:

1. There is robust empirical evidence of **the positive impact of R&D grants for young innovative companies on employment** (Koski and Pajarinen, 2011; Girma et al., 2010; Einio, 2014). The collected information from policy evaluations can be synthesised into values ranging from 36% and 50% of the surveyed beneficiaries reporting an increase in employment attributed to the grant. In particular, the evidence includes two Programmes (The AplusB Programme and the Young Innovative Companies Programme) resulting in granted firms employing more than twice as many employees as non-granted firms. When considering the average number of employees increase, it ranges from **7 to 16** per granted firms. This result is consistent with the average number of employees (12) in the econometric study by Girma et al. (2010).

2. Those R&D grants **are more effective over the medium to long term** (Colombo et al., 2013; Forfas, 2012; Ploder et al., 2015; and Koski and Pajarinen, 2011). It is very likely that firms that received R&D grants will experience an increase in employment in a long run. However, our evidence does not allow drawing conclusions on the estimated time lag. Colombo et al. (2013) show that R&D grants influence the employment growth of young new technology-based firms only two years after the receipt of the grant. Such two-year time lag is confirmed by Forfas (2012) which would be a normal duration of a small R&D project.

The results on the effect of R&D grants for innovative enterprises with growth potential **on innovative and economic performance** show that:

1. Those **R&D grants increase sales, and share of innovative sales**. A vast majority of funded firms (values between **41% and 92%)** increase their sales after the grant. The literature (Grilli and Murtinu, 2012; Soderblom et al, 2015; Autio and Rannikko, 2016) shows positive effects on firm total factor productivity and sales growth. However, these scholars also suggest that positive effects on TFP and sales' growth take from two to four years to appear.

Interestingly, the venture capital literature points to a **five year time** lag in the **effect on turnover and profitability** as in the short post-investment term firms are going through significant changes in their organisation and processes that may actually have negative impact on their turnover or profitability (Nesta 2009, Cowling et al. 2008).

2. The presence of growth boosting effects, i.e. firms continue to grow for several years following the receipt of the subsidy (Autio and Ranniko, 2016; Soderblom et al., 2015).This might be because the receipt of a prestigious and highly competitive government subsidy provides an important quality signal, allowing to access other types of funding (e.g. equity finance).

3. Those **R&D grants are more beneficial when ? helping firms to develop new capabilities and knowledge**. R&D grants turn to be an efficient stimulus for R&D/innovation when firms interact with other organisations (universities or firms) to introduce new capabilities and knowledge (see Autio and Ranniko, 2016; Gicheva and Link, 2016).

The main result from our studies on the **effects of R&D grants on innovation** is:

1. Increasing product innovation and patent application. 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 **R&D grants increase firm propensity to file a patent application**, after controlling for other variables. The time elapsed between R&D grants and innovation is at least four years according to Widmann, 2016.

The results of comparative analysis show that the **effects of R&D grants for young innovative firms with growth potential** on firm share of innovative sales, employment, and innovative activities **are generally higher** than the **effects of both generic R&D grants and R&D subsidies**.

Table 19. Summary of findings from the comparative analysis

R&D grants for young innovative firms with growth potential	**Generic R&D grants**	**R&D subsidies**
	Effects on employment	
• Granted firms on average hire by about 14 employees more than non-granted firms (Soderblom et al. 2015) • Positive and large effect on employment (Einio, 2014).	• Generic R&D grants effects tend to be larger for SMEs than large firms. Very little evidence.	• Small positive effect of R&D subsidies (Falk, 2005; Dortet-Bernadet and Sicsic, 2014; Afcha and Garciia-Quevedo, 2014)
	Effects on firms' economic and innovative performance	
• Winning the grant raises annual sales by **11.2** percentage points on average (Soderblom et al., 2015). Granted firms report higher sales' growth than non-granted firms on average (Einio, 2014) • Innofund-backed firms are over **59** percentages more likely to report higher sales from new products than non-Innofound-backed firms (Guo et al. 2016)	• A one percent increase in subsidy-triggered R&D raises, on average, by **0.525** percent the sales' share in market novelties (Hottenrott and Lopes-Bento, 2014)	• Impact on firms share of sales from new to market product innovation (**3.4**%) and slightly lower impact on firm share of sales from new to firm product innovation (**2.5**%) Garcia and Mohnen (2010) • **12** percentage points higher increase in the percentage of innovative sales from significantly improved or modified products than non-subsidized firms, and **10 percentage points** their innovative sales from new-to-firm and new-to market innovation (Arvanitis et al., 2010)

Effects on innovative activities		
• Innofund-backed firms are **13.2** percentage points more likely to innovate than non-Innofund-backed firms (Guo et al. 2016) • Government research grants increases firm propensity to file a patent by **10** percentage points (Widman, 2016)	• **1.2** percent increase in the probability of reporting new or improved products by (Hewitt-Dundas and Roper, 2010)	• Firms that received funding from national support are **4.6** percentage points more likely to file a patent than firms without subsidy (Czarnitzki and Lopes-Bento, 2014) • R&D support increase firm probability of patenting by **4** percentage points (Aiello et al. 2016)

Finally, we find very **limited evidence on the effects of tax incentives compared to R&D grants for young innovative firms** with growth potential on employment, and firm innovative performance, and innovation. Still the available empirical studies reviewed show that:

- There is **little impact of tax incentives on increasing firm innovative performance**.
- The **combination of R&D grants and tax incentives** is more effective in increasing firm innovation than using only one instrument.

9 Policy implications

There are several policy implications related to the conditions under which R&D grants for innovative enterprises with growth potential can yield positive results. Although these implications 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 the countries where tax incentives are used for majority of R&D active firms and are coupled with many other support measures. For all the reasons above the implications put forward should be treated with caution.

1. **R&D grants -** by motivating companies to innovate -stimulate and prepare them **for the growth phase.**

2. **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. In other words, 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.

3. **Selection mechanisms** within programmes built on milestones or subsequent phases of the funding depending on the results are **still rarely used.** Even though, the effects for those grants on firms' employment and economic performance are very positive. This calls for a **greater use of this type of mechanisms**.

4. R&D grants for innovative firms with growth potential **designed in an attractive and competitive way** help companies to **attract follow-up funding** (signalling effect is present especially for equity).

5. Financial measures bring better results when accompanied by **soft instruments** e.g., **support the firm organisational capacity for growth** (capacity boosting, see Autio and Rannikko, 2016). Thus may actually **have a longer lasting effect** than the funding itself (behavioural additionality). There is evidence on the **added value of complementary services** – networking helps to connect to new knowledge through external actors (e.g., investors, test users, academia).

It would be important to further investigate the importance of coaching and advice services, related to some government-funded R&D Programmes (Forfas, 2012; and Ploder et al., 2015) on the outcomes of the funded projects.

6. The high growth literature (see, for instance, Helleman et al, 2017 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 importance of collaboration on innovativeness of the outcomes.

7. **Tax incentives and grants** are **complementary** as regards to their impact on firm's growth and innovation activities given the evidence of higher impact of combined application (tax incentives and grants). They should **not be regarded as policy options** but rather as a set of tools in the policy box.

9.1 Limitation and suggestions for future research

Our contribution to the existing literature is to shed some more lights on the impact of R&D grants for supporting innovative firms with growth potential. In particular, we have contributed to the existing knowledge by synthesising available evidence on the output additionality effects of this type of R&D grants.

However, this study is not without some limitations. Firstly, the analysis is limited due to methodological differences in the evidence base because of different time periods, econometric and other methods, and data caveats which do not allow a deeper comparative analysis of the impact of R&D grants. While being more insightful into the design and implementation features, combining them with econometric methods may result in a more robust, comparable empirical evidence. There is a need for improving the quality of evaluations of existing policies.

Secondly, the differentiation between SME policy (focus on growth of SMEs), R&D policy (focus on innovative companies), start-up and scale-up policies (focus on growth of innovative SMEs) is oftentimes fuzzy.

Potential avenues for future research include further investigating the impact of national R&D grants. In particular, a meta-regression analysis would help to gain further insight into the magnitude of the effects of R&D grants. It would be also interesting to analyse if the **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**). Finally, the signalling effect of the grants on equity funding in Europe would be important to explore.

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Annexes

Annex 1. Characteristics of included studies

Table 1A. Characteristics of included studies

Author/year	Sample size	Firm size	Firm age
Widmann (2016)	1936 firms	19 (median)	5 (Median)
Guo et al. (2016)	2638 firms	_	10
Koski and Pajarinen (2011)	Start-ups, gazelles, and incumbents	12 (average)	start-ups (up to 5 years old); gazelles (10% fastest growing firms among start-ups); incumbents (over 5 years old)
Autio and Rannikko (2016)	160 NTBFs with growth orientation	_	6.7 years
Czarnitzki and Licht (2006)	735 beneficiaries	25 (average)	7
Girma et al. (2010)	Plant: 4853	11 (average)	start-ups
Bronzini and Piselli (2016)	1246 high-tech firms	39 (median)	_
Colombo et al. (2012)	536 NTBFs	10	young (0-5)/mature (6-25)
Grilli and Murtinu (2012)	247 NTBFs	77	founded in 1980 or later
Soderblom et al. (2015)	1102 firms	more than 10 employees	targeting new firms that are less than one year at the time of application
Gans and Stern (2003)	71 small firms (36 employees on average)	36 (average)	_
Gicheva and Link (2016)	1878 firms	39 (median)	_
Einio (2014)	1800 firms	49 (median)	10 (median)
Howell (2015)	7436 high-tech firms	_	6 (median age)

Annex 2. List of policy evaluations and academic papers

Table 2A. 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	Selection process and method
CDTI (2015)	Spain	Research and development projects (PID)	Center for Technological and Industrial Development (CDTI)	Business R&D projects (PID) are R&D projects with an applied nature and are based on the development of new technologies. It allows single firms or a group of firms or a consortium, including outsources centres, research institutes, and universities, to apply for financing. The projects funded by CDTI aim at developing technologies strategic for growth and consolidation of the company.	Companies with research projects with a high technological content	–
Forfas (2012)	Ireland	Enterprise Ireland Propel Programme	Enterprise Ireland	The strategic objective of the Enterprise Ireland Propel Programme is to improve the overall economy of Ireland by: 1) increasing the number and accelerating the development of technology led start-up companies with scaling potential; and 2) utilising the infrastructure, capabilities and expertise that exist within the third level sector to strengthen industry/college linkages.	Senior manager with 5 years plus experience; participant proposals should have a significant market opportunity, particularly in international markets, knowledge base business with some potential for intellectual property ownership; a realistic potential for substantial growth; a management team with a strong track record; a realistic expectation that the level of funding required to growth the business can be accessed	Selection is based on short listing and an interview process.
Ploder et al. (2015)	Austria	FFG APlusB Programme	The Austrian Research Promotion Agency	The AplusB centers act as bridge-builders between science (Academia) and business economy (business) with the aim of the chances of success of highly innovative and technology-oriented start increasing ups from different industries significantly.	Innovative start-up projects which are typically technology-oriented, relatively complex or demanding in terms of supervision and support needed	Proof of concept
Radauer and Dudenbostel (2014)	Austria	The Initiative for the Creative Industries "evolve"	Federal Ministry for Sience, research and economy	The initiative "Evolve" aims at supporting cultural and creative industries (considered highly innovative companies with a great economic potential) to create growth and jobs.	Creative industries with innovation projects with a high technological content	–

The Evidence Network (2013)	Finland	The Young Innovative Companies (NIY) Programme	The Finnish Funding Agency for Innovation and Development	The NIY Programme offers support for young innovative companies to achieve rapid international growth. To be eligible, a firm must meet the following conditions: (1) it needs to exhibit good potential for rapid organisational growth in international markets; (2) there must be a comprehensive, high-quality business plan and capacity to implement it; (3) there needs to be evidence about promising business activities and customer references; (4) The firm must possess a competitive advantage with which it is possible to reach an important market position; and (5) the firm must have a committed and competent management team (Tekes, 2013).	The NIY Programme is open for young (under six years old) firms that employee less than 50 people with a maximum sales turnover of Eur 10M, or a balance sheet totalling at least Eur 10M. The firms must also have spent at least 15 percent of all business costs in research and development during the previous three years, and they must be domiciled in Finland	Milestone design and the use of an external evaluation panel.
Iris group (2015)	Denmark	Market Maturation Fund	The Danish Enterprise Agency	The purpose of the market fund is to promote growth, and employment in Denmark by helping companies to overcome market barriers and coming faster on the market with new, high-level products	Private companies can apply individually or in consortia with other companies.	Companies and projects are assessed on the basis of a set of award criteria: novelty, commercial potential, and competencies of the working team
SQW (2015)	UK	Smart scheme	Innovate UK	The purpose of the SMART scheme is to accelerate UK economic growth by nurturing small high-growth potential firms to become high-growth mid-sized companies with strong productivity and export success.	Smart is a competitive fund, available to SMEs in all markets and sectors. Three grant types are available: Proof of Market grants, Proof of Concept grant, and Development of Prototype grants	–

Table 2B. 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	Selection process and method
Widmann (2016)	Austria	BasisProgrammem	The Austrian Research Promotion Agency (FFG)	The basic Programme supports individual projects of companies of all sizes (including Startup,) and industries through funding.	Essential criteria for the funding are the innovation content, the technical difficulty level of the project, the economic exploitation prospects as well as the perspective that the project will intensify research activities	Funded project are selected on the basis of the technical quality of the project and their commercial value
Guo et al. (2016)	China	Innofund Programme	The Innofund Administration Center (IAC) under the Ministry of Science and Technology	The scope of the Innofund Programme is to facilitate and encourage the innovation activities of small and medium technology-based enterprises (SMTEs) and commercialization of research by way of financing, trying to bring along and attract outside financing for corporate R&D investment of SMTEs	A firm is eligible if it has fewer than 500 employees, and has a leverage ratio lower than 70%. The Programme also requires that R&D investments should be more than 3% of the total sales, and the number of R&D employees should be more than 10% of the total number of employees	Funded project are selected on the basis of the quality of the projects; firms with leading products in the market must exhibit good economic performance
Koski and Pajarinen (2011)	Finland	R&D grants	The Finnish Funding Agency for Technology and Innovation (Tekes)	The scope of the funding is to: 1) increase the number of starting enterprises, 2) enable financing for changes encountered by SMEs, and 3) promote enterprise growth, internationalisation and exports	A firm's potential for rapid (international) growth is one pre-requisite for R&D funding targeted to young, innovative companies	–
Autio and Rannikko (2016)	Finland	NIY Programme	The Finnish Funding Agency for Technology and Innovation (Tekes)	NIY is the Finnish policy initiative that explicitly targets high-potential new firms.	The NIY Programme is open for young (under six years old) firms that employ less than 50 people with a maximum sales turnover of 10M and a balance sheet totalling 10M at most. The applicants must also have recorded at least 15% R&D expenditure during the previous three years, and they must be domiciled in Finland.	The NIY Programme applies milestone design and uses an external evaluation panel. Participants need to meet their milestones in order to remain in the Programme. The panel assess participants' growth potential, development needs, and their suitability as an investment target.

Girma et al. (2010)	Ireland	R&D grants	Enterprise Ireland	R&D grants for firms' growth and internationalisation	Projects are eligible in manufacturing industries if they will 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 which are subject to international competition	–
Bronzini and Piselli (2016)	Italy	R&D grants	Emilia-Romagna region	"Regional Programme for Industrial Research, Innovation and Technological Transfer"	All firms that are willing to implement innovative projects in Emilia-Romagna region are eligible	Funded project are selected on the basis of the degree of innovation, the congruence between the project's financial plan and its objectives; past experience and managerial competence
Colombo et al. (2013)	Italy	R&D grants	Italian government	R&D grants targeting new firms in high technology sectors, and aimed at the creation and support of academic start-ups	–	Projects are assessed and ranked on the basis of two main criteria: profitability and social impact of the projects
Grilli and Murtinu (2012)	Italy	R&D grants	Italian government	R&D grants targeting new firms in high technology sectors, and aimed at the creation and support of academic start-ups	–	Projects are assessed and ranked on the basis of two main criteria: profitability and social impact of the projects
Soderblom et al. (2015)	Sweden	The Programme VINN NU (Win Now)	The Swedish Governmental Agency for Innovation Systems (VINNOVA)	This Programme targets new ventures that are less than one year of age at the time of application, that are in the process of developing a unique and innovative product or service, and that are development-oriented and wish to expand.	Recipients must have a developed idea and proof of concept.	In a first step, internal experts screen all applications. In a second step, the external experts evaluate the applications utilizing a standardized form rating them on a scale from one to six.
Gans and Stern (2003)	US	SBIR Programme	Federal Agencies	The goals of the Programme are: i)increase the commercialisation rate of innovations, ii) enhance the competitiveness of small firms in technology-intensive industries, and iii) enhance the participation of small firms in the Federal contracting process	The SBIR defines a small business as a US-owned firm with less than 500 employees	External experts review applications according to three criteria: 1) Strength of the scientific/technical approach, 2) Ability to carry out the project in a cost effective manner, 3) commercialization impact.

Gicheva and Link (2016)	US	SBIR Programme	Federal Agencies	The goals of the Programme are: i)increase the commercialisation rate of innovations, ii) enhance the competitiveness of small firms in technology-intensive industries, and iii) enhance the participation of small firms in the Federal contracting process	The SBIR defines a small business as a US-owned firm with less than 500 employees. Phase I for the assessment of the R&D' scientific and commercial potential; Phase II for the development of the Phase I technology and ideally to bring it to commercialization.	External experts review applications according to three criteria: 1) Strength of the scientific/technical approach, 2) Ability to carry out the project in a cost effective manner, 3) commercialization impact.
Einio (2014)	Finland	R&D projects	The Finnish Funding Agency for Technology and Innovation (Tekes)	To encourage firms to start up new R&D projects and accelerate the completion of ongoing ones.	The main criteria for being selected into the Programme are commercial potential, technological challenge, available resources and the importance of the agency's support to the success of the project.	_
Howell (2015)	US	SBIR Programme	Department of Energy	To strengthen the US high-technology sector and support small firms.	Eligible applicants are for-profit, U.S. based, and at least 51% American owned-firms with fewer than 500 employees.	External experts review applications according to three criteria: 1) Strength of the scientific/technical approach, 2) Ability to carry out the project in a cost effective manner, 3) commercialization impact.

Annex 3. Regression output of the econometric studies used in chapter 4

Table 3A summarizes the information for the interpretation of the coefficients. It reports the definition of the dependent variable, the definition of the explanatory variable, and the estimation method for each econometric study used in chapter 4.

Table 3A. Regression output of the econometric studies (used in chapter 4)

Study	Dependent variable	Explanatory variable	Estimation method	Coefficients
Impact on firm employment				
Girma et al. (2010)	Log of employment	Dummy: Grant	OLS estimation	0.189***
Koski and Pajarinen (2011)	Employment growth	Dummy: Grant	2SLS random effect	0.205*** (Start-ups up to 2 y.)
Koski and Pajarinen (2011)	Employment growth	Dummy: Grant	2SLS random effect	0.047*** (Start-ups up to 5 y.)
Koski and Pajarinen (2011)	Employment growth	Dummy: Grant	2SLS random effect	0.017*** (Incumbents - over 5y.)
Colombo et al. (2013)	Log of employment	Dummy: Grant	FE-IV estimation	0.564***
Soderblom et al. (2015)	Employment	Dummy: Grant	OLS estimation	0.141*
Einio (2014)	Log difference of employment from t-1 to t+1	Dummy: Grant	IV estimation	0.848***
Impact on firms' economic and innovative performance				
Guo et al. (2016)	Log of the values of the sales from new products	Dummy: Grant	FE estimation	0.582***
Guo et al. (2016)	Log of the export volume	Dummy: Grant	FE estimation	0.416***
Autio and Rannikko (2016)	Sales growth	NIY Programme	Difference-in-difference estimation	1.20 (two-years span) 1.30 (three-years span)
Grilli and Murtinu (2012)	Firm Total Factor productivity	Dummy: Grant	GMM estimation	0.25***
Soderblom et al. (2015)	Average annual sales	Dummy: Grant	OLS estimation	0.112*
Gans and Stern (2003)	Log of revenue	SBIR project	OLS estimation	0.653***
Einio (2014)	Log difference of sales from t-1 to t+1	Dummy: Grant	IV estimation	0.912***
Howell (2015)	Achieving Revenue (commercialization)	Dummy: Phase 1 Grant	OLS estimation for binary dep. Var.	0.11***
Gicheva and Link (2016)	Dummy= Phase II project was commercialised as either a product, process, or service	Dummy: additional funding to Phase II award	Probit model	0.180***

Impact on firms' innovative activities				
Widmann (2016)	Patent application	Funding approval	Fuzzy Regression Discontinuity model	0.108**
Guo et al. (2016)	Total number of patent	Dummy: Innofund grant	FE estimation	0.132***
Guo et al. (2016)	Total number of invention patents	Dummy: Innofund grant	FE estimation	0.086**
Bronzini and Piselli (2016)	Patent application	Dummy: Grant	Logit estimation	0.691*** (All firms)
Bronzini and Piselli (2016)	Patent application	Dummy: Grant	Logit estimation	1.114** (Small firms)
Bronzini and Piselli (2016)	Patent application	Dummy: Grant	Logit estimation	0.191 (Large firms)

Notes: In a semi-logarithmic regression, the coefficient β needs to be transformed as exp^{β} to give a proper interpretation of the coefficient.
** and *** significant at 5%, and 1%, respectively.

Annex 4. Project additionality

It is beyond the scope of this study to examine the project additionality. However, our evidence from policy evaluations (i.e. gathered through interviews) can shed light on the importance of R&D grants for young innovative firms with growth potential.

The UK Smart Programme asked beneficiaries and non-beneficiaries to report whether they would have progressed with their project in the absence of a Smart award. Around 40% of surveyed beneficiary firms would have taken forward their project if they had not been successful in their Smart application, by using their own funds, equity finance or other public sector Programmes. 57% of non-beneficiaries carried out the project without a Smart award but facing delays and compromising the quality of the result. 50% of the Austrian AplusB Programmes would have carried out the projects without the AplusB support. Respondents to the Finnish NIY (innovative young firms) Programme survey were asked whether they were able to raise external funding with only 34% being able to do so (as compared to 28% of the firms that applied but were not accepted to the NIY Programme). This shows that for the significant proportion of beneficiaries those grants are the source of finance for their innovative projects. Yet, it has to be stressed that all the evaluations were conducted in countries offering a mature system of direct and indirect R&D measures and mature equity markets. It would be interesting to compare those results for the countries having a more restricted financial offer for young innovative companies.

Table 4A. Project additionality: Evidence from policy evaluations

Study	Country	Policy initiative	Data	Period	Deadweight
The Evidence Network (2013)	FI	The NIY Programme	108 companies	2013	34% of the NIY participating firms
SQW(2015)	UK	Smart Scheme	513 SMEs	2012-2013	40% of surveyed beneficiaries;
Ploder et al. (2015)	AT	ApluB Programme	-	2007-2014	50% of the surveyed firms

Annex 5. Lessons learnt on the econometric approaches

Some econometric issues emerged from our selected empirical studies:

- **Selection bias**. The main problem with the empirical evaluation of the impact of economic and fiscal policy Programmes is that their instruments are typically non-randomly assigned, and, as a result, groups of supported and unsupported firms are not directly comparable. Moreover, participants of a public policy Programme differ from non-participants in some characteristics which are seldom observed by the researcher. For instance, funding bodies usually tend to select those firms that promise high innovation success and possess strong capabilities to transfer innovation into economic performance. It is plausible that firms with higher capabilities provide a project in accordance with funding bodies, which may overestimate the actual effect of R&D grants. In this case, the ordinary least squares approach (OLS) and other methods are likely to yield biased estimates of the causal effect of the Programme. In the empirical literature, several different strategies have been developed to address this potential bias, including difference-in-difference estimators, selection correction models, instrumental variable (IV) estimation and non-parametric matching approaches. The difference-in-difference method requires the existence of observations before and after the treatment (change of subsidy status). The IV estimators and selection models require valid instruments for the treatment variables. Matching is based on the idea that a counterfactual situation for companies that are not treated can be estimated from the sample of companies receiving the subsidies. The matching estimator consists of creating a set of firms that is comparable to the set of firms in the treated sample if firms, conditional on a set of a priori defined characteristics. More recent studies use randomized trials to eliminate selection bias. In randomised experiments the evaluator or Programme administrator randomly allocates firms to either a treatment or a control group. This ensures that we are comparing apples to apples, that is, that the firms of different sectors and size (or other specific characteristics) are otherwise comparable.
- **Measurement errors**. Measurement error in explanatory variables is part of the error term in the regression equation thus creating an endogeneity bias. The measurement error in the explanatory variables causes OLS estimates of the coefficients to be biased and invalidates standard errors, *t* tests, and *F* tests. To address this problem, most empirical studies use the instrument variables (IV) approach. An instrumental variable estimator is used when one has data on an explanatory variable in the regression model but OLS would give inconsistent estimates because the explanatory variable is not distributed independently of the disturbance term. The instrumental variable is used to replace the original explanatory variable in the estimator, this making estimates consistent.
- **Unobservables.** There may be unobservable variables which may affect outcome variables. For instance, the management capability of executives may affect a firm's R&D investment, or a firm may have a greater probability of receiving support when it is located in a city or a county where local governments provide more support to local firms. This issue of unobservable variables can be addressed using an IV instrument variable approach. Guo et al. (2016), for instance, use two interesting instrumental variables (IVs): the total number of firms in high-tech areas of the city where the firm is located[34], and the ratio of total investment in fixed assets made by local governments over the total GDP at the county level. As Guo et al. (2016) argue, both instrument variables are intended to capture the effort level of the local governments in developing the local economy.
- **Modelling distributions**. Many variables, like employment and sales, have continuous distributions. These distributions can change in ways not revealed by an

[34] According to Guo et al. (2016), high-tech zone is a particular type of special economic zone in China where central and local governments seek to attract foreign direct investment and consequently stimulate the local economy.

examination of averages, for example, they can spread out or become more compressed. A useful and powerful econometric tool to study such distributions is the quantile regression. It allows seeing whether participation in a R&D Programmes affects employment distribution as well as average employment, and how it varies conditional on covariates such as firm characteristics (e.g. age and size).

- **Data confidentiality**. A possible reason for the scarce attention from academic literature devotes to this issue is probably the fact that little data is available to provide evidence of the extent that R&D grants impact on performance among high-growth innovative firms. For reasons of anonymity and confidentiality (i.e. the agency does not disclose the identity of successful and unsuccessful applicants to the public), most data on applicants and non-applicants are hard to retrieve.
- **Type I Error and Type II Error**. These tend to occur when there are changes in firm names in different databases and over time. A way to overcome this problem is to refer to legal person codes.

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