POLICY BRIEF

Brief No. 3/2021

Do innovation subsidies generally work?

Impact evaluations are particularly useful and important for policy areas where achieving succes can neither be readily presumed nor outcomes can easily be verified. Innovation policy is a prime example of this, as innovation is a complex phenomenon, filled with risk and uncertainty, and is challenging to measure.

Do innovation subsidies generally work by creating significant additional innovations in the long run?

The InnoPact project has sought the state-of-art in impact evaluation for innovation policy by connecting ex-post and ex-ante impact assesments, as well as drawing on strong quantitative and qualitative methods. This Policy Brief reports the results from a large scale quantitative ex-post study, spanning 24 years (1995-2018), on the impact of one of the most important pillars of Finnish innovation policy: the public RDI subsidies provided to Finnish businesses by Business Finland (Tekes in the past).

There is significant evidence that, on average, receiving financial innovation support raises the probability that a firm introduces a significant innovation

For our study, we built a large and uniquely detailed dataset with enterprise, RDI subsidy, and innovation information containing more than 2.5 million firm-year observations. We examined the association between various forms of subsidy 'treatments' (i.e. loans and grants) and firms' innovation output compared to a large, matching control group of companies that did not receive RDI subsidies, using statistical inference.

We found that:

- On average, only a small fraction of firms in the total population of Finnish enterprises innovate significantly (0.10%) or get innovation support (0.67% to 0.92%); True innovation is infrequent.
- There is significant evidence that, on average, receiving a subsidy is associated with a higher probability that a company introduces a significant innovation to the market (i.e. the average marginal effect of receiving support is positive)
- Our estimated marginal effects indicate that receiving financial RDI support by Finnish companies is associated with a raised probability to innovate during the next three years by 3.7 – 6.5 percentage points relative to the matching control group, with the high-tech sector reaching even slightly higher.
- The type of support matters too: While for grants, the average marginal effect (AME) is 3.68 percentage points, for grants in combination with loans this amounts to 6.52 percentage points (in line with prior research). The AME for loans is 5.15 percentage points.
- Small and young companies -the most 'risky' subsidy target groups- display a somewhat lower additionality effect size than small and more mature companies but still at a meaningful and positive level.
- Average impact effects vary with time: During the 1995-2006 period the general AME was 5.58 pct. points, while in the subsequent 2007-2015 period it dropped down to 3.41. We also found significant variation in the AME's between the government periods.

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The aim of Innovation and Growth Research funded by Business Finland is to find solutions to the global challenges of the Finnish economy and society.

Introduction

There are good arguments for policy intervention in the form of public RDI subsidies for private companies, but thorough evaluation research is needed to determine when they work.

The main justification for government support in the form of subsidies for research, development and innovation (RDI) activities of private companies is that the regular market mechanisms for the allocation of capital to these activities do not always offer enough incentives for private capital to invest in these activities. This is because significant innovation is – due to its novel nature – generally a risky endeavour, frequently also performed by 'riskier' young and small venture companies and strongly dependent on the development of new knowledge and know-how, the returns to which are not always easy to capture entirely by the investors. Therefore, as a whole economy, we may risk having lower levels of innovation, competitiveness and resulting national welfare from not sufficiently investing in RDI activies without public RDI subsidies covering the shortcomings of purely market-based allocation of capital.

It is clearly crucial that we need to research and evaluate the effects of RDI subsidies in an era that is characterized by tough economic circumstances, global corporate R&D races and technology shifts. We already know from existing research that, for the most part, public subsidies at least do not crowd out private RDI investments, but is that sufficient to be sure that RDI subsidies indeed lead to more innovations that are ultimately introduced to the market and make companies generate new business and be more competitive? Did national RDI subsidies that have been provided to Finnish companies in the past lead to more non-trivial innovations? Foreign studies on the effects of direct subsidies have sometimes left an ambiguous image (Veugelers 2021).

While most RDI subsidy evaluations have a limited scope in terms of the studied time-period or instrument/program, we set out to study the general impact of subsidies across a large number of publicly funded research, development and innovation projects by Finnish firms and over a long period of time, spanning many funding instruments and various policy- and economic conditions to answer the big-picture question:

Do RDI-subsidies significantly increase subsidised companies' probability of launching a significant innovation during the three-year period after receiving a subsidy?

Data

Large numbers of RDI subsidies have been provided in Finland for a very long time, but so far we have limited knowledge as to whether they have generally worked by creating more innovations or not.

We compiled the data for our study from several comprehensive datasets. The first dataset was provided by Business Finland, containing all detailed, project-level R&D subsidy data from Tekes/Business Finland between January 1984 and the end of 2019, spanning 83.246 subsidized projects by both public and private entities during this 36-year period. This data allowed us to distinguish subsidies in the form of grants, subsidized loans, as well as combinations of the two. We then matched this data to two register databases from Statistics Finland: the Finnish Business Register, containing basic administrative information of all organizations for the period 1988-2018, and the Financial Statement database covering the period 1986-2018, so that we obtained detailed administrative and financial records for the population of registered companies. Our third data source is the database of Finnish innovations[1] (SFINNO). This is a unique and independent innovation database which has been compiled by the Technical Research Center of Finland, VTT, since the 1990s. This data set currently contains information about 4327 individual innovations that have been successfully introduced by enterprises domiciled in Finland between 1985 and the end of 2019. We used this dataset to determine if and when a Finnish company introduced a significant innovation. What makes this innovation data suitable and distinct is that it is based on a data collection method known as the "literature-based innovation

output" (LBIO) method (Coombs et al. 1996), where researchers have first identified relevant, independent, technical and trade periodicals across industries, which are then systematically surveyed to identify and collect information about innovations and the associated innovative firms. This allows us to avoid relying on self-reported information from companies that may be biased and provides us with a more conservative measure of innovation output as it focuses on more "significant" innovations within their respective industrial contexts. These characteristics of our innovation data provide us with a conservative measure of innovation output which helps safeguarding us from over-estimating effect sizes for the association between subsidies and innovation.

Our analysis is based on a large-scale combination of long-term, detailed business, subsidy, and innovation data which allows us to make conservative estimates by keeping strict criteria of what constitutes an 'innovation'.

After matching and cleaning all data sources, we had a full and analyzable dataset with 237 505 subsidized and unsubsidized unique firms, and 2375 significant, commercialized innovations covering the years 1994-2018, totaling more than 2.5 million firm-year observations available for our analysis.

After matching all subsidized firms with a highly similar control group of non-subsidized firms, to correct for selection effects, we estimate the general effects of RDI subsidies on companies' probability to commercialize a significant innovation during the three years after getting the subsidy, while controlling for a number of other factors using a pooled cross-sectional design. We distinguish all combinations of subsidies in the form of grants and loans of at least 30 thousand euros in size (adjusted for inflation).

Results

First, we like to highlight that on average, only very small shares of firms in the total population of Finnish enterprises innovate (0.10%) or get innovation support (0.67% to 0.92%).

We present our estimation results as average marginal effects in terms of the difference between receiving no treatment and receiving a subsidy (i.e. a grant, loan or combination thereof). This is expressed as the difference in probability to introduce a significant innovation to the market during the three years following the receipt of a subsidy. Note that if we would take a longer, less conservative window of observation, our impact results would be higher.

RDI subsidies appear to have significantly increased the Finnish innovation output by raising the probability that supported companies' successfully launch a significant innovation. Subsidies in general (of various types and size) raise the probability that a firm will commercialize a significant innovation successfully by 4.5 percentage points (that is, about one additional innovation per 22 independent subsidy events, notwithstanding variation in support size).

Grants, which are generally distributed to earlier-stage R&D projects, on average have a marginal effect of 3.7 percentage points (about one innovation in 27 independent funding events) on recipient-firms' probability to commercialize a significant innovation.

Loan recipients, on the other hand, have an average marginal increase in probability to commercialize a significant innovation of 5.1 percentage points. This amounts roughly to one additional innovation in 20 funding events. Loans are usually distributed closer to the commercialization stage, which explains their greater degree of association with innovation.

Some companies have received both grants and loans; We found that this 'hybrid' subsidy treatment increases the probability to innovate during the next three years with 6.5 percentage points (i.e. about one innovation in 15 funding events).

Table 1 provides us with a sectoral perspective on subsidy effectiveness. We can see that, on average, companies from different key sectors respond positively to RDI subsidies in terms of showing higher probabilities to launch significant innovations relative to their non-supported peers. As one would expect, we can also observe sectoral variations in average marginal effects.

Table 1: Marginal effect sizes of support on probability to launch significant innovations after three years for different sectors

MANUFACTURING SECTOR	+ 5,8 PERCENTAGE POINTS
HIGH-TECH SECTOR	+ 7,1 PERCENTAGE POINTS
LOW-TECH SECTOR	+ 4,6 PERCENTAGE POINTS
KNOWLEDGE-INTENSIVE SERVICES	+ 3,7 PERCENTAGE POINTS

Source: authors' own calculations for the subsidy period 1995 – 2015

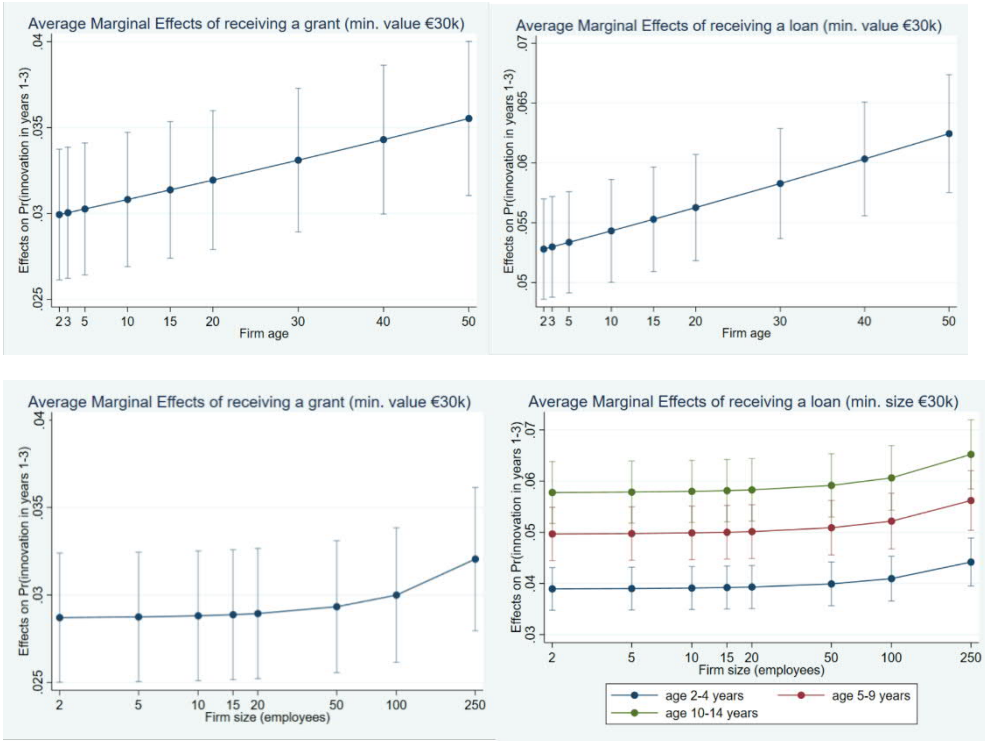
In Figure 2 we can examine these effects in more detail for some interesting potential policy target groups of companies of different sizes and ages. We restrict ourselves here to young firms (and up to 50 years old for context) and micro companies and SME's. Because of the higher risk profiles of young and small innovative firms, we were interested to see if there are also positive and significant subsidy impacts detectable for small and young innovative companies.

Generally, in all four panels of Figure 2, we can see that there are only very small variations in subsidy effect sizes (plotted on the Y-axes) when we vary our model results by firm age and firm size. While somewhat below the most general effects reported above, it is encouraging to see that both loans and grants appear to have highly similar impact effects for the youngest and smallest companies compared to their larger and older counterparts. Due to their limited asset-base, short financial histories and frequent indebtedness these companies often have a harder time obtaining external capital to finance innovation through normal market mechanisms.

In the lower right panel, we look at how the effect of loans vary by firm size over different ages groups. We observe that small, young companies -the most 'risky' subsidy target group- display a somewhat lower additionality effect size than small and more mature companies but still at a meaningful and positive level. This difference is not unexpected, because more established firms have a set of additional advantages over the smallest and youngest firms, and have already withstood evolutionary pressures form their environment in their past.

Thus we conclude that, by and large, RDI subsidies from Tekes/Business Finland have succeeded in creating additional, significant innovation output by Finnish companies. Again, had we chosen a longer observational window for impact, the presented effects would increase.

Figure 2. Marginal effect sizes of grants and loans on probability to launch significant innovations after three years by company age and size.



Note: Y-axes show percentage point increases in companies' probability to successfully launch a significant innovation. Vertical lines indicate the 95% confidence intervals. Source: author's own calculations.

Implications for innovation policy

We started our brief by citing the reasons for providing public subsidies for innovation activity in the private sector. However, there are also possible reasons why RDI subsidies as a policy intervention may not work as intended. For example, it could be that public subsidies just simply 'crowd-out' private investments which would have been made without innovation policy support. In this case, the total innovation output of private companies would not change, but part of the cost burden would fall on the tax-payer. Also, if it is indeed difficult for private investors to predict a positive rate of return for innovation projects, it is also possible that the public sector is not able to select and deploy RDI subsidies to projects in a way that, on balance, creates more positive innovation outcomes as well. Our positive and significant results show that these challenges have not outweighted the positive effects of policy intervention in the form of RDI subsidies.

These positive results also extend to small and young firms with naturally higher risk profiles. We view this as encouraging, given their complementary and dynamic role in economic and industrial growth and renewal.

To understand the meaning of our empirical results, it is useful to put them into practical context with the information that we have. Namely, these 'small' average and general incremental effects get repeated over time in practice. It is therefore statistically plausible that, if an innovation subsidy event raises the probability to successfully introduce an innovation by about 5%, we could expect that on average and in the long term, about one in twenty such subsidy events would produce an

additional significant innovation which we cannot expect to have occurred otherwise, due to market failures. This is, conservatively, independent of any potential additional learning or spillover effects. To put this into context: the long-term Business Finland/Tekes funding activity as represented in our full dataset comprised more than 69.000 such funding events in the Finnish economy over a 34-year timespan (on average more than 2000 RDI projects annually). Thus, our seemingly modest average marginal results draw attention to the potentially quite dramatic importance of consistent innovation subsidy policy on the level of industries and the national economy.

Innovation-policy should be considered a long-run tool and we like to draw attention to the relationship between innovation subsidy policy and national economic competitiveness over long time horizons, keeping in mind that innovation constitutes both technological learning and competitive market-offerings.

However, governments currently face the challenges of slow or negative economic growth and increasingly high budget deficits. They are therefore facing the double pressure to find ways to stimulate growth and increase competitiveness, but simultaneously a heightened accountability for effective use of public funds to do so. R&D subsidies aimed at boosting innovation are very much a part of this, and our study has provided some conservative empirical evidence supporting the existence of direct (first-order) innovation output additionality effects in the Finnish context. It should be noted, however, that we base our conclusions on a fairly simplistic 'black box' model of impact with limited information content regarding the 'when and how's'.

It is a challenge to get a deeper understanding of how long-term innovation policy impacts operate. To be sure, short-term impact evaluations do have their place and purpose, but are subject to more narrow boundary conditions, leading to variability of results. They cannot fully do justice to understanding expected policy effects on long-term growth, -employment, and -competitiveness in the global economic landscape, which requires more in-depth research to still be carried out to open up the 'black box'.

Proposals for action

- Successful innovation policy in the form of direct financial support appears to require consistency, or 'staying-power' to properly manifest its broader societal impact. Maintaining a long-term view is important.
- Further research is still needed to understand any variations taking place underneath a long-term general effect. To better understand the current impact performance results, we advocate comparative cross-national analyses using similar innovation output measurement (most notably Sweden).
- Innovation policy 'impact' is complex and multi-faceted. However, impact assessments using statistical inference have been dominated by economists to date. This limits the range of considered impacts and impact-mechanisms. We would advocate more quantitative, data-driven multi-perspective impact research, drawing on other relevant but underutilized academic fields such as organization science, entrepreneurship, strategic management, human resource management, data-science, international business, geography and the like. Evaluation always entails connecting the theoretical with the empirical, and as such rigorous modeling from various relevant academic fields can greatly enrich policy-maker's understanding of the various innovation policy impacts.
- "Learning-by-evaluation-and-development" is in our view a good direction to develop evidence-based innovation policy in Finland. In general, this can be

best achieved by involving evaluators early on in the process of designing policy changes to ensure that they can be properly studied. Relatedly;

- We recommend investments in collecting and storing more analyzable data: robust evaluation requires information about: selection criteria of any policy treatment, both recipients and rejected applications, as well as the ex-ante specified and operationalized conjectured instrument targets/objectives (i.e. information prospectively on the likely/theoretical outcomes of proposed programs). Relatedly and importantly, regarding the conjectured policy intervention outcomes, information on the current state of **all** applicants to any instrument should ideally be collected and stored for two [or more] periods: a) at the time of application for the instrument; [optionally: b) at the time during the implementation of the instrument/program]; c) at a suitable time after the instrument/program ended and outcomes can be reasonably expected. This approach would render costly experiments such as randomized controlled trials largely unnecessary; It is challenging to design practical experiments that can simultaneously overcome the obstacle of statistical power, and due to the path-dependent learning nature of RDI activity they may have lasting competitive effects, raising questions of unfair advantage to the extent that similarly assessed project proposals get paired for the experiment. Alternatively, fully randomized designs reduce findings to pure monetary effects, which does not reflect policy-formulation and implementation reality, as we touched on in the previous section in this brief. Experimenting with variation in selection policies, however, may facilitate evaluation-based learning that can be useful in formulating more effective policies in the future.

- The detailed information on the nature of innovation, the innovation processes, and innovation output additionality should ideally be linked to conjectured productivity outcomes so as to improve our understanding why innovation inputs do not lead anymore to productivity growth as used to be the case (Peters et al. 2018). Generally, 'novelty' and 'productivity' may very well be antagonistic, and therefore we need to better understand the competitive roles that publicly supported innovations play for companies.

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Footnote: [1] See https://cris.vtt.fi/en/equipments/sfinno-database-of-finnish-innovations-3