Hanna Hottenrott and Cindy Lopes-Bento

Research versus Development: When are R&D Subsidies most Effective?[1]

Hanna Hottenrott
Technical University Munich, ZEW.

Cindy Lopes-Bento
KU Leuven, ZEW.

Subsidies for research and development (R&D) are one of the largest and fastest-growing forms of industrial aid in developed countries (OECD 2015). R&D subsidies are often designed as project-based grants offered and administered by public funding bodies. The economic rationale behind the implementation of such policies is that private sector R&D creates positive externalities to society (Jones and Williams 1998). While the investing firm carries all the risk, the returns from R&D are not only uncertain, but are also hard to fully appropriate. Means of intellectual property protection such as copyrights, patents or trademarks are important, but provide only incomplete protection and are not always applicable. This results in levels of private sector R&D spending that are likely below the social optimum. In addition to appropriation concerns, outcome uncertainty results in financing constraints particularly for smaller firms and firms pursuing a risky R&D agenda (Czarnitzki and Hottenrott 2011a, b; Hottenrott and Peters 2012; Hottenrott and Lopes-Bento 2014).

From a public policy point of view, the major objectives of R&D subsidies are to compensate firms for the social returns to their R&D investments and to ease financial market frictions that increase the private costs of financing R&D (David et al. 2000). Grant-based public funding schemes therefore aim at incentivizing R&D projects by covering parts of the project cost thereby reducing the need for other external financing or even facilitating it through the grants' signaling effect to lenders and investors (Hottenrott et al. 2018).

R&D GRANTS AS AN INNOVATION POLICY TOOL

Direct subsidies differ from fiscal incentives for R&D in two main ways. First, grants are awarded ex-ante, thereby allowing firms to receive funding for a planned, but not yet pursued project while tax credits reward R&D activities ex-post. Second, grants allow the funder to target specific technology areas (e.g. renewable energy technologies) that promise high social returns or focus on specific geographical regions. Since direct grant programs are costly to implement as they require expert review of project proposals as well as the administration of the financial payments, the cost-efficiency of providing R&D grants is still under debate (Takalo et al. 2013).

Estimating causal effects of R&D grants on the firms' own-financed R&D efforts is often difficult due to limited data availability (i.e. on the funding amounts and R&D expenditures) and due to the selectivity that is inherent to these programs: firms with more ambitious R&D plans are more likely to apply for grants and more successful in the funding competition. Even if the grantee has higher R&D spending in the future, it is not clear whether this is due to the grant and whether the firm would have spent more, even in the absence of public support. Dimos and Pugh (2016) critically review the evaluation literature and conclude that while full crowding out, i.e. full displacement of own-financed R&D by public grants, can be ruled out, there is little evidence on the ability of grants to trigger additional R&D, on average. One explanation for this observation may be found in the heterogeneity of treatment effects. For instance, grants may make a bigger difference to the R&D budget in smaller or younger firms. Likewise, grants my be more effective if they encourage collaborative R&D which increases the returns on investment (Hottenrott and Lopes-Bento 2014).

In addition, it seems crucial to distinguish between the types of projects that are supported because R&D subsidies affect two related, but distinct activities: research ('R') and development ('D'). Research activities are quite different from development activities as research typically produces tacit knowledge and intangible results (Usher 1964). Moreover, basic research typically involves early-stage activities with a wider set of possible applications and hence higher knowledge spillovers and a potential for greater social returns (Akcigit et al. 2016). Research is furthermore characterized by a greater outcome uncertainty and a larger distance to the market when compared to product or process development. As the development trajectory is often more focused and builds on earlier (successful) research investments, it is less prone to unintended knowledge spillovers when compared to research. In addition, because development projects are closer to the actual implementation of an invention or of the introduction of a new product to the market, firms will typically protect their "close-to-the-market" inventions through formal IP strategies (Cassiman and Veugelers 2002). Therefore, appropriability tends to be stronger for development investments when compared to research investments. These basic features of research activities also result in financial constraints for research which are more binding than for development projects (Czarnitzki et al. 2011). The often cited market failure arguments are therefore more applicable to the R-component of R&D, resulting in an underprovision associated with research that is more severe than that for development.

[1] This article is based on the paper "Direct and Cross-Scheme Effects in a Research and Development Subsidy Program" by Hanna Hottenrott, Cindy Lopes-Bento and Reinhilde Veugelers published in Research Policy 46 (6), 2017, 1118–1132.

TARGETED GRANT-BASED SUBSIDY PROGRAMS

If research and development have different characteristics affecting the gap between private and social returns and invoke different degrees of financial constraints, an optimal subsidy policy should be tailored to address these different characteristics. If the arguments raised above apply, grants supporting research project should have a stronger incentivizing effect than grants focusing on later stages of product or process development. On the other hand, firms may find it easier to raise funding for development projects for instance through bank loans, resulting in more available funds and hence higher own-financed development investments. If funding for research is indeed constrained, firms may find it too hard to raise sufficient own funding to complement the government-funded part in the project. In that case, we would expect input additionality to be higher for development than for research grants, as the latter may lack financing for the privately funded part of the project.

At the same time, research and development are interdependent activities. Product and process development often depends on the outcome of research activities. Firms may need to do (basic) research in order to understand how to solve problems of a more applied nature and be more effective in development activities. Subsidy schemes focusing on research or development are therefore also likely to affect the returns to the respective other activity.

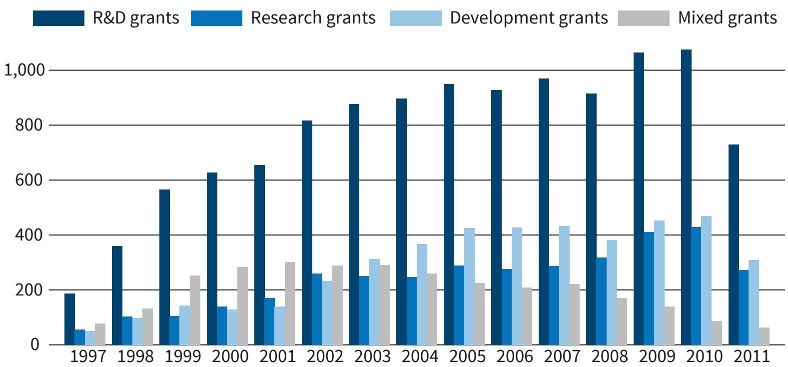
Based on detailed data on R&D grants from a Belgian funding agency (Vlaio, Vlaanderen Agentshap Innoveren & Ondernemen, formerly IWT) of the population of publicly co-financed projects over the period 2000 to 2011 (ICAROS database) and on information on firms' research and development activities (OECD R&D survey), we can investigate the effects of targeted research and development grants on both research and development spending. The policy program explicitly provides different schemes for research projects, development projects and for mixed R&D projects. This allows measuring the effects from the different types of grants, but also to test for any cross-scheme effects from research grants on development spending and vice versa.

Unlike in the case of public "top-down R&D programs" such as thematic calls for project proposals issued by the government or public procurement, for these R&D subsidies, the project idea and the planning is initiated by the applying company and not by the government itself. The program is therefore characterized by a bottom-up approach, which leaves the project choice and timing to the applicant.

Figure 1 shows the distribution of ongoing grants within the different schemes over time. During the earlier years of the observed period mainly mixed-scheme projects had been co-funded, while in later years the funding agency shifted to primarily targeted programs for research or development. Note that in the funding program the subsidy rate, i.e. the share in project cost borne by the funding agency, differs by grant type and firm characteristics. The base rate can increase depending on firm characteristics (smaller firms may receive a higher share in total project funding) and depending on whether the project is being conducted in collaboration with other firms or a university. Figure 2 shows Kernel density plots of the subsidy rates by

Figure 1

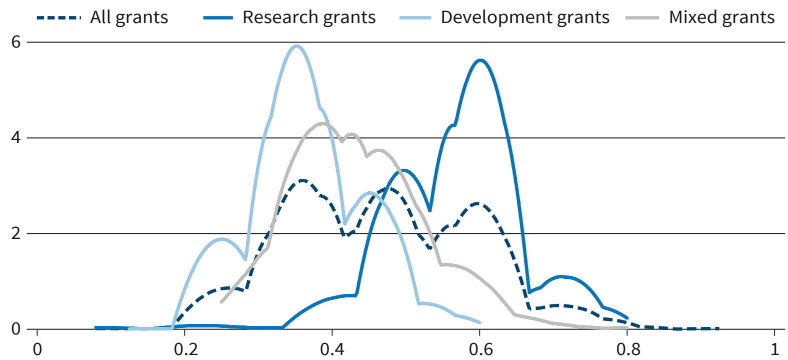
Grants by Type



Source: ICAROS data base (own calculations). © ifo Institute

Figure 2

Subsidy Rates
Kernel density estimates by grant type



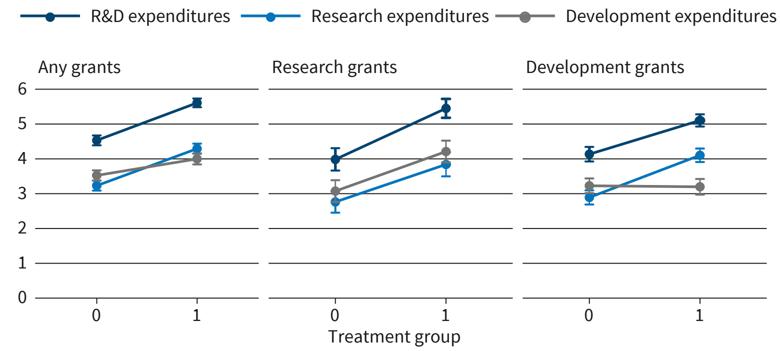
Source: ICAROS data base (own calculations). © ifo Institute project type. As can be seen, the subsidy rate tends to be higher for research projects (mean = 57 percent) than for development projects (mean = 37 percent). Mixed projects' subsidy rates are between the two (mean = 44 percent).

R and D expenditures are obtained from the Belgian part of the OECD/Eurostat R&D survey. Guidelines for the surveyed firms described in detail how to attribute spending to research and development activities based on the Frascati Manual. The survey also contains information on other firm characteristics that can be used for constructing control variables such as the number of R&D employees, group and ownership structure, subsidies from other sources and R&D collaborations. We complemented the survey data covering the years 2000-2011 with patent statistics issued by the European Patent Office (EPO) and balance sheet information from the Bel-First data base.

Figure 3

Estimated Treatment Effects

After matching, differences between groups (in logged expenditures in T€)



Source: Hottenrott et al. (2017).

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The sample comprises firms that receive at least one grant during the period under review as well as firms that never received a grant. We calculate net expenditures as firms' annual total spending on R and D less the annualized subsidy amount received in a year (if any). The minimum funding amount over the entire project duration is EUR 100,000 and the grant amount is capped at EUR 3 million per project. The average payment received is EUR 259,000 (median = EUR 111,000). Amounts are highest for mixed grants and lowest for research grants. The average project length is two years with a slightly lower mean for research projects and a higher one for mixed projects.

In Hottenrott et al. (2017), we estimated the direct average treatment effects and the cross-scheme average treatment effects using a nearest-neighbor propensity score matching procedure. The matching accounts for selection effects that explain the difference in R&D between subsidized and unsubsidized firms in addition to the treatment effect. By making firms in the subsidized group and in the unsubsidized group comparable in terms of a large set of observable characteristics, the ex-post difference between both groups can be attributed to the treatment. The estimation sample covers 12,138 firm-year observations from 1,994 different firms and about 15 percent of these firm-year observations have benefited from some type of subsidy within the three thematic schemes.

The probability to receive a subsidy from any of the three schemes is higher when a firm has had past research, past development, or past mixed grants. Mixed-grant receipt is more likely when the firm had a research grant in the past. The probability of receiving a development grant after having had a research grant is larger than the probability of receiving a research grant after having had development grant previously. The patent stock per employee as well as R&D collaboration have a positive and significant impact on all grant receipts. Older firms are less likely to receive grants, irrespective of the type of scheme. Finally, larger firms are more likely to obtain mixed grants and are also more likely to hold multiple grants from different schemes in the same year.

After the matching, the respective treatment groups and the control group are balanced in terms of all control variables and the propensity scores. Figure 3 illustrates the differences in logged outcome variables (net R&D expenditures, net Research expenditures, and net Development expenditures) for firms participating in the subsidy scheme and the control group. The results show that R&D grants of any type result in a higher R and D expenditures in the recipient firms (treatment group = 1) compared to the control sample (treatment group = 0). Research grants show positive within scheme effects as well as positive cross-scheme effects. That is firms with research grants invest more in both research and development than similar control firms. For development grants, however, there is no positive within scheme effect of development grants on development expenditures. Considering cross-scheme effects, we find that development grants trigger addition research expenditures. The treatment effects of research grants and development grants are in fact quite similar when we look at net research expenditures. These results are robust to alternative estimation strategies.

Further analyses in Hottenrott et al. (2017) show that mixed grants lead to more research, but not to more development expenditures and that the overall achieved R&D additionality increased as the funding agency moved from mixed schemes towards targeted schemes over time.

POLICY IMPLICATIONS

Studies on R&D subsidies as an innovation policy tool provided ambiguous conclusions regarding their usefulness for triggering additional R&D in the private sector (Dimos and Pugh 2016). However, previous research did not provide any insights regarding possible differences in the responsiveness of research versus development activities to this policy instrument. With higher outgoing spillovers, higher risk and constrained access to external financing, gaps between social and private returns are larger for research than for development projects. Research subsidies may therefore yield higher additionality effects than development subsidies. At the same time, research and development are complementary activities, with investment in one activity increasing the productivity of the other. Targeted schemes are therefore likely to generate cross-scheme effects, with research grants having knock-on effects on development expenditures and vice versa. The analysis of a policy design that explicitly distinguishes between research projects, development projects and mixed R&D projects shows that when decomposing the type of grant and the type of investment, research grants indeed yield higher average direct effects than development grants. In the assessment of these targeted grants, however, we have to consider that there are significant cross-scheme effects from research grants on development expenditures and from development grants on research expenditures. These results, pointing to higher direct additionality from research grants compared to development grants, are consistent with theory suggesting higher market failures associated with (basic) research (Akcigit et al. 2016). They are moreover consistent with the view that research and development are complementary activities each increasing the productivity of the other (Cassiman et al. 2002). The lower within scheme effectiveness of development grants compared to research grants could be explained by companies shifting their budget from a less financially constrained activity (development) to a more financially constrained activity (research). Typically, information asymmetries between firms and the funding agency prevent full control of the funding agency over the use of funds in the recipient firms.

The detailed results in Hottenrott et al. (2017) further show that mixed grants, which support both research and development activities, turn out to trigger additional research, but not additional development activities.

One important policy implication that arises from this analysis is that re-directing the amounts spent on development subsidies towards research projects may lead to a better budget utilization of public resources for R&D supporting programs. Despite the positive cross-effects from development grants on research spending, the average return to funding research projects is higher than the returns to supporting the development stage. This suggests a higher priority for subsidy programs targeting projects that involve (basic) research activities. Furthermore, funding agencies can expect that their research subsidies will not only invoke additional research with potentially higher social returns, but also additional development activities. In other words, the results show that the impact of the R&D policy increased under the targeted schemes compared to the mixed grant scheme design.

However, for publicly co-funded research projects the outcome uncertainty is higher than for development projects, making it a potentially less attractive policy tool when evaluating output additionality rather than input additionality. Moreover, it would be highly desirable to investigate the full cost-benefit trade-off of targeted R and D subsidy programs in a setting that allows to monitor the internal processes in the funding agency in addition to firms' investments.

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