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The impact of policy support on firms' innovation outcomes and business performance

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The importance of R&D and innovation in explaining economic growth and productivity is well documented in the research literature. Government policies also increasingly recognise the benefits of supporting firms' R&D and innovation. In the UK, for instance, research and innovation have been placed at the heart of the Industrial Strategy, receiving investments of around £3bn pa.

Recent SOTA studies on a range of countries provide evidence of the effectiveness of public R&D and innovation policy in increasing private R&D investment and innovation. The most common direct types of policy interventions are subsidies or research grants, which are the subject of this SOTA Review, as well as tax credits. More limited in number are studies of the impact of policy support on firms' business performance, taking into consideration turnover or productivity. These generally confirm the existence of a positive relationship between public R&D support, innovation and firms' growth.

However, there remains heterogeneity of results across studies, in particular due to differences in the design and implementation of subsidy programmes across countries, regions, industries and time periods; the R&D stage in which policy is implemented; methodological issues, in particular selection and matching; data limitations; and, regarding collaborative projects, the types of partners involved.

Background

R&D investment has well-recognised social and private benefits (Mohnen, 1996; Ceh, 2009). However, the classic public goods problem means that R&D is both non-rivalrous and not (completely) excludable. Firms are therefore unable to fully appropriate the returns from their investments. Consistent with the theory, empirical evidence confirms that the private rate of return typically is below the social rate of return (Griliches, 1979, 1998). This mismatch of returns provides the key economic rationale for corrective public intervention to support firms' R&D investments (Arrow, 1962; Rigby and Ramlogan, 2013). Moreover, policy support is often justified by more strategic objectives linked to the desire to build capacity in specific sectors, technologies or localities.

In either case, the public policy objective is to incentivize firms to increase, or start, R&D activity as an input into the innovation process, which is likely to increase firms' innovation capabilities and innovation output, as well as business performance, in the longer term.

The extant literature has identified four mechanisms through which public policy support may lead to increased private-sector R&D and innovation, and economic performance. First, financial support raises firms' liquidity and financial slack, thus reducing the financial riskiness of R&D and innovation projects (Zona, 2012). However, slack resources may also encourage inertia or laxity in risk taking (Nohria and Gulati, 1996), hence suggesting an inverted U-curve effect (Görg and Strobl, 2007; Kilponen and Santavirta, 2007). Second, the cost-sharing resulting from public support reduces the investment required and de-risks this investment in terms of the technologies involved and commercial profitability (Keizer and Halman, 2007; Roper et al, 2008; Cabrales et al, 2008). Third, public support can play a market-making role in addressing particular social or economic challenges (Mazzucato, 2016), e.g. in terms of emergent technologies (Van Alphen et al, 2009) or wider social benefits (Zehavi and Breznitz, 2017). Fourth, policy can enable firms to access otherwise unavailable knowledge, one possible tool being innovation vouchers (OECD, 2010).

Evidence

Two recent reviews of the empirical evidence on the relationship between public policy on R&D as an innovation input conclude that the majority of studies find a positive effect (Zuniga-Vicente et al, 2014; Becker, 2015). The latter review also concludes that the more recent literature suggests a shift away from earlier findings that public subsidies can crowd out private R&D to the conclusion that subsidies typically stimulate private R&D, one reason being the availability of new econometric techniques that control for sample selection bias.

There is substantial evidence that the policy additionality effect is particularly strong for small firms, which are more likely to experience financial constraints. The inverted U-curve effect between financial support and R&D requires careful fine-tuning of policy, with lower and in particular intermediate levels of support stimulating private R&D, but overtly high levels of support leading to crowding-out. Dimos and Pugh (2017) use meta-regression analysis to investigate subsidy effects on firms' innovation input and on innovation output. They, too, reject crowding-out of private investment by public subsidies, however they do not find evidence of additionality, stressing the importance of controlling for firm heterogeneity and omitted variable bias in the estimation of effects.

The effect of public support on innovation outputs rather than inputs has received somewhat less attention in the literature, but is typically also confirmed to be positive. Recent evidence for the US indicates how bundling of uncommitted resources can improve innovation outputs (Marlin and Geiger, 2015). In a study on the UK and Spain, Becker et al (2017) suggest that national, as compared with regional and EU, innovation support is associated with a higher probability of, and a higher degree of novelty of, product or service innovation. Lee (2015) finds weaker evidence for Korea, however, depending on firm size and internal firm capabilities. Other recent studies include Moretti and Wilson (2014), Beck et al (2016) and Bronzini and Piselli (2016). Positive effects on innovation output as measured by patenting or patent applications include Czarnitzki and Lopes-Bento (2014), Doh and Kim (2014), Howell (2017) and Wang et al (2017), while Czarnitzki and Lopes-Bento (2013) identify positive R&D employment effects.

The ultimate, longer-term, objective of most R&D and innovation policy support to date has been to improve business performance. Tables 1 and 2, respectively, provide a detailed breakdown of the recent evidence of the performance impacts of public R&D subsidies awarded to individual firms, and public subsidies awarded to R&D collaborations involving firms as partner(s). Whilst most studies to date identify a positive impact of R&D and innovation policies on business performance measures such as profitability, productivity, employment growth and value added, the evidence remains mixed.

Table 1: Post-2010 studies on the effect of public R&D subsidies to individual firms on business performance

Study / Estimation methodology / Sample period	Type of subsidy	Data	Measure(s) of performance	Conclusions: Statistically significant effect on firm performance?
ZHAO, ZEDONIS (2014) *Regression discontinuity design (among others)* 2002-2008	Direct R&D awards from the Michigan Life Science Corridor (MLSC), renamed Michigan Technology Tri-corridor (MTTC), then both subsumed under 21st Century Jobs Fund (21CJF) (consecutive Michigan state innovation programmes, US technology start-ups)	Michigan Economic Development Corporation (MEDC) for applicant-level data; Michigan Department of Licensing and Regulatory Affairs database for commercial viability data, VenturXpert for follow-on VC financing, SBIR awardee lists for SBIR awards, Delphion for successful applications of U.S. patents.	Survival (commercial viability) Receipt of follow-on venture capital financing	Positive Positive (for firms lacking prior VC-backing or Small Business Administration (SBA) awards; no signif. effect otherwise
DE BLASIO, FANTINO, PELLEGRINI (2015) *Regression continuity design* 2001-2007	Fund for Technological Innovation (Italian firms), providing funding for projects that focus on the development component of R&D	Ministry for Economic Development archive for the programme; Cerved data sets of financial statements; patent applications data from the European Patent Office.	Sales (in logs) Financial conditions (long-term debt / assets, cash flow / assets) Assets (logs) Return/assets	No signif. effect No signif. effects Positive No signif. effect
KARHUNEN, HUOVARI (2015) *Combined matching and difference-in-differences* 2002-2012	Public R&D funds granted by Tekes, one of the agencies of the Ministry of Employment and the Economy (Finnish SMEs)	Business Register and Financial Statement databases for firm level data; patent database for patents applied for in Finland and in Europe and patents granted in the US; Concern database for information on whether a firm belongs to larger group; Statistics on Business Subsidies database (all Statistics Finland databases); Employee Characteristics database created from the Finnish Longitudinal Employer–	Labour productivity (value added / number of FT employees, in logs) Employment Survival	No signif. effect in the 5-year period after a subsidy is granted, Negative effect 1-2 years after the subsidy year Positive Positive

		Employee Data (FLEED) by Statistics Finland		
CRISCUOLO, MARTIN, OVERMAN, VAN REENEN (2016) *Firm level regressions: various (OLS, reduced form, first stage, instrumental variables)* 1997-2004	Regional Selective Assistance Programme (RSA) (UK geographical areas at different levels; plant level; firm level)	Selective Assistance Management Information System (SAMIS) database for information on programme applicants; the Interdepartmental Business Register (IDBR) for the construction of jobs variables; unemployment data from the local areas labour market statistics through the ONS Nomis service; Annual Respondents Database (ARD) from the Annual Business Inquiry (ABI) for information on firms' investment, wages, productivity	Employment (manufact., in logs) Capital investment (in logs) Output (in logs) Total Factor Productivity (in logs)	Positive (small firms only) Positive Positive No signif. effect
CIN, KIM, VONORTAS (2017) *Difference-in-differences* 2000-2007	Government R&D subsidy programme (Korean SMEs)	Annual Report of the Financial Statement of firms and public subsidy data; National Information and Credit Evaluation (NICE) for financial firm data; Small and Medium Business Administration (SMBA) for data on government R&D subsidy	Value-added productivity (value added / number of employees, in logs)	Positive
HOWELL (2017) *Regression discontinuity design* *OLS, zero-inflated negative binomial panel regressions* 1995-2013	Government Department of Energy's (DOE) Small business innovation research (SBIR) programme (US firms) (grants awarded in two phases, about two years apart)	Data from the DOE offices of Fossil Energy and of Energy Efficiency and Renewable Energy; patents data from Berkeley's Fung Institute; metropolitan statistical area level data from the Federal Reserve Economic Data research centre	 Venture capital or angel investment received by firm after the grant competition's award Revenue (in logs)	Phase1 grant: Positive / Phase2 grant: No signif. effect Positive / No signif. effect
WANG, LI, FURMAN (2017) *Linear probability models* *Regression discontinuity design* 2005-2010	Innofund programme (Chinese firms) (Evidence of bureaucratic intervention in award process, in that applicants' evaluation scores are non-randomly missing and that some firms with scores below funding standards did receive grants)	Innofund programme data on grant applications and project ratings; patent applications from China's State Intellectual Property Office (SIPO); data on firm survival and ownership structure from the Beijing Administration of Industry and Commerce (BAIC).	Firm survival (exit measure: firm death by 2015) Equity investment received from venture capital or private equity firm by 2015	No signif. effect No signif. effect

Table 2: Post-2010 studies on the effect of public R&D subsidies for R&D collaboration on business performance

Study / Estimation methodology / Sample period	Type of subsidy	Data	Measure(s) of performance	Conclusions: Statistically significant effect on firm performance?
BARAJAS, HUERGO, MORENO (2012) *Recursive four equation model (step 1 ML Probit with sample selection (eqs. 1&2); steps 2&3 OLS random effects model, using predicted value from respective previous step)* 1995-2005	International research joint ventures supported by the EU Framework Programme (FP) (Spanish firms)	Centre for the Development of Industrial Technology (CDTI) database for information on all EU FP funding proposals, whether eventually granted or not; combined with SABI database for information on firms, e.g. employment.	[Intangible fixed assets per employee (in logs, to capture firms' technological capacity)] Labour productivity (sales per employee, in logs)	[Positive] Indirect positive effect via technological capacity
SCANDURA (2016) *Propensity score matching* 1997-2007	Engineering and Physical Science Research Council (EPSRC) grants awarded to university-industry (U-I) collaborations (UK firms)	Dataset on EPSRC U-I partnerships, collected by funding agency; combined with Office for National Statistics' (ONS) Business Structure Database (BSD) for information on firms, e.g. employment, location; and the ONS' Business Expenditure on R&D (BERD) database, for information on firms' R&D employment	Firm's share of R&D employment	Positive (2 years after the end of the collaboration project)
AGUIAR, GAGNEPAIN (2017) *Two-step (step 1 Logit, step 2 OLS and IV)* 1998-2002	Industry-oriented research joint ventures supported by the EU Framework Programme (FP), specifically the 'user-friendly information society' (IST) sub-programme (EU firms)	Community Research and Development Information Service (CORDIS) for information on the IST projects; AMADEUS from Bureau van Dijk for information on firms	Labour productivity (value added per employee) Profit margin (profit before tax as a ratio to operating revenue)	Positive No signif. effect
BELLUCCI, PENNACCHIO, ZAZZARO (2018) *Difference-in-differences propensity score matching*	Regional research and innovation subsidies for collaborative research projects between SMEs and universities (Italian firms)	Data on regional programme collected by Marche Innovazione, the regional development agency for	Firm's sales Firms' profitability (return on equity)	No signif. effect Negative in short term, positive in medium term

2003-2005		innovation, together with Department of Information Engineering (DIIGA) of Univ. Polytechnic of Marche, Ancona; AIDA from Bureau van Dijk for accounting data on subsidized and non-subsidized firms; REGPAT from OECD for information on patent applications to the European Patent Office at the regional level		

Summary and evidence gaps

While some heterogeneities in research results remain, recent evidence confirms that public R&D and innovation policy support can play a significant role in increasing firms' R&D investment and innovation. However, issues such as firms' R&D dynamics and composition (Zuniga-Vicente et al, 2014), the source of R&D public funding (Czarnitzki and Lopes-Bento, 2014) and other firm constraints have been largely neglected so far.

There is substantial evidence that firm size matters in the effectiveness policy support. The additionality effect has been shown to be particularly prevalent for small firms, which are more likely to experience external financial constraints. For small firms there also is evidence of a positive inducement effect. Moreover, many small or micro-enterprises do not have the capacity for an R&D department, while still being very innovative. So to maximize the effectiveness of policy support, it is important to target those types of firms and industries, for which additionality is largest, and to support both innovation input and output.

Somewhat more heterogeneity exists in the results of the smaller literature on the impact of policy support on firms' business performance. However, overall, findings confirm existence of a positive relationship between public R&D support, innovation and firms' growth. Again firms' size matters, as do productivity levels and sectors (e.g. Vanino et al, 2018). Greater access to and use of administrative data could contribute to moving the knowledge frontier forward here (e.g. Scandura, 2016; Vanino et al, 2018).

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