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The Impact of Innovation Policy on Firm Innovation and Performance: A Review of Recent Research Developments

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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. In Germany, the Hightech Strategy governs the focus of public research and innovation policies on identified areas of priority. For the European Union as a whole, the renewed European Agenda for Research and Innovation sets out that "innovation must be a central driver for EU policies and programmes for 2021-2027" (European Commission 2018, p. 6).

Recent research on a range of countries provides 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 review article, as well as tax credits.[1] More limited in number are studies of the impact of innovation policy support on firms' business performance, measured as, for instance, productivity or turnover growth. Results generally confirm the existence of a positive relationship between public R&D support, innovation and firm performance.

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 (Clausen 2009; Hottenrott et al. 2017); issues related to the research methodologies and the units of the analyses (Klette et al. 2000), in particular selection and matching (Jaffe 2013); data limitations; and, regarding collaborative projects, the types of partners involved.[2]

INNOVATION POLICY: RATIONALE AND IMPACT MECHANISMS

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 private firms' R&D investments (Arrow 1962; Nelson 1959; 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 typically is to incentivize firms to increase, or start, R&D activity as an input into the innovation process. This is likely to increase firms' innovation capabilities and innovation output, as well as business performance and hence ceteris paribus economic growth in the longer term. Less focus has to date been placed on policies designed to support innovation output directly. This could benefit in particular small or micro-enterprises, which often do not have the capacity for an R&D department and thus are not able benefit from R&D – innovation input – subsidies, whilst still being very innovative.

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 subsidy 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).[3]

[1] For a review of the literature on R&D policy instruments, see Martin (2016).
[2] This review is an extended version of Becker (January 2019).

[3] There is some evidence that award of a government subsidy may serve as a positive signal of a firm's quality and thus help the firm attract additional private funding. Through this channel, innovation policy will then indirectly help ease the adverse effect of capital market imperfections (Feldman and Kelley 2006; Meuleman and De Maeseneire 2012; Romero-Jordán et al. 2014).

THE EMPIRICAL EVIDENCE

The Effect of Innovation Policy on Firms' Innovation Input

Two recent reviews of the empirical evidence on the relationship between public policy and private 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 large body of more recent literature suggests a shift away from the earlier results that public subsidies often crowd out private R&D to finding that subsidies typically stimulate private R&D. One reason for this shift is the availability of new econometric techniques that control for sample selection bias, i.e. for the fact that firms that already are R&D-intensive may be more likely to apply for a subsidy. Since it is likley that these firms would have undertaken at least part of the R&D even in the absence of the subsidy, the results of studies that did not take account of the selection effect may have been biased towards finding crowding-out effects.

There is substantial evidence that the policy additionality effect on R&D is particularly strong for small firms, which are more likely to experience financial constraints. Small firms have less collateral in terms of existing assets to be used for obtaining loans, for instance, and as a group are likely to include more young firms. There also is evidence of a positive inducement effect, again in particular for small firms (e.g. Hall et al. 2009; Hall and Lerner 2010; Czarnitzki and Lopes-Bento 2012). Large firms often substitute incremental public funding for internal funding, as they would have performed the R&D anyway even in the absence of government support.

The inverted U-curve effect between financial support and R&D requires careful fine-tuning of policy. It indicates that lower and in particular intermediate levels of support stimulate private R&D, but overtly high levels of support lead to crowding-out (Görg and Strobl 2007; Kilponen and Santavirta 2007). So for any given public R&D and innovation budget, it may be more effective to grant intermediate levels of support to a larger number of firms than to provide large amounts of support to fewer firms.

The recent review by Dimos and Pugh (2017) employs meta-regression analysis to investigate subsidy effects on both, firms' innovation input and innovation output. These results, too, reject crowding-out of private investment by public subsidies, however the study does 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 Innovation Policy on Firms' Innovation Output

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). 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). Research finding positive effects on innovation output as measured by patenting or patent applications includes 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.

One potentially important factor that remains under-researched to date is the role played by the specific funding source of the innovation policy support in the effectiveness of this support. Where it is analysed, typically one or two sources are compared, e.g. national versus EU support (Czarnitzki and Lopes-Bento 2014; Huergo and Moreno 2017), regional versus other support (Czarnitzki and Lopes-Bento 2013), or national support (Huergo et al. 2016). Szczygielski et al. (2017) compare the effects of domestic innovation support, which the authors define as receiving national and/or regional support, with EU support. This cross-sectional study is one of the relatively few studies that research the effect of innovation policy on innovation output in catching-up countries, or 'technology followers' (Catellacci and Archiburgi 2008); although with Turkey and Poland, it considers two such economies with comparatively high per-capita incomes and relatively well developed institutions. The results indicate that only domestic innovation policy support stimulates firms' process and product innovation in both countries. In a comparative panel data study on the UK and Spain, Becker et al. (2017) examine the effects of regional, national and EU funding sources. The results suggest that national innovation support is associated with a higher probability of, and a higher degree of novelty of, product or service innovation. Regionalised support is most influential in increasing the probability of undertaking innovation for process change and organisational innovation types. The comparison of the UK and Spain is particularly interesting given the very different levels of engagement of the public sector in the innovation system in the two countries, the greater regionalisation of innovation support in Spain (Mate-Sanchez-Val and Harris 2014), and other aspects of the business environment in the two countries such as regulation (Capelleras et al. 2008). The importance of innovation funding at the regional level as such is particularly emphasised in Zehavi and Breznitz' (2017) recent

research on 'distribution sensitive innovation policies', with one suggested measure being R&D funds targeted at relatively under-developed regions.

The Effect of Innovation Policy on the Innovation Activities of Firms Participating in Research Collaboration

A growing literature suggests positive firm level R&D or innovation effects of research collaborations between firms and a variety of institutions, and between firms and universities in particular. Consistent with these results, public subsidies targeted at such research collaborations has also been shown to stimulate participating firms' R&D investment and innovation. Benefits from research collaboration include risk and cost sharing, internalisation of spillovers, signalling of the quality of firms' innovative activities, and acceleration or upgrading of the innovations. Set against these advantages are possible adverse outcomes such as potential free-riding of partners on each other's R&D investments and opportunistic behavior, leakage of information, curtailing of competition in other stages of the firms' interaction, the costs of finding suitable partners, and the coordination and management of research networks (see, inter alia, Kamien et al. 1992; Laursen and Salter 2006; Grimpe and Keiser 2010; Lokshin et al. 2011; Love et al. 2011; Petruzzelli 2011; Hottenrott and Lopes-Bento 2016; Bellucci et al. 2019; for surveys see Hagedoorn et al. 2000; Caloghirou et al. 2003; Becker 2015). Results by Ponds et al. (2007) were among the first to indicate that proximity can matter more when cooperating partners have different institutional backgrounds than when partners have similar institutional backgrounds, and hence that geographic proximity may help overcome institutional differences between co-operators. Very recent evidence on the impact of collaborative subsidies on innovation input includes Bellucci et al. (2019), who compare the effectiveness of two regional research and innovation policies, one designed to support individual firms' research projects, and the other designed to support collaborative projects between firms and universities. The authors show that both policy programmes succeeded in stimulating additional private R&D investment, although the latter policy's effects were weaker. Scandura (2016) also finds positive effects on innovation input as well as innovation output measures from grants awarded to university-industry collaborations.

The Firm Performance Effect of Innovation Policy Targeted at Individual Firms

The ultimate, longer-term, objective of most R&D and innovation policy support to date has been to improve business performance. Overall, the evidence remains mixed. A number of recent studies conclude that research and innovation grants improve firms' financial performance (Zhao and Ziedonis 2012; Howell 2017), or increase their investments (Von Ehrlich and Seidel. 2015), employment growth (Criscuolo et al. 2019), value added (Duch et al. 2009) or productivity (Cin et al. 2017). Other studies, however, do not find significant positive effects from research and innovation grants on productivity, employment growth, export performance, venture funding or firm survival (Martin 2012; Karhunen and Huovari 2015; De Blasio et al. 2015; Wang et al. 2017; Criscuolo et al. 2019). With regards to the firm performance impacts of the European Union Framework Programmes, Bayona-Sáez and Garcia-Marco (2010), for instance, identify positive effects, while Hünermund and Czarnitzki (2019) conclude that effects can depend on the specific rule used to allocate the budget to recipients: Under a rule referred to as Virtual Common Pot, which avoids cross-subsidization between participating countries, there were no average job creation or sales growth effects, although positive effects could be observed for projects of high quality. However, the study indicates that substantial positive effects on employment and on sales would have been achieved under the standard situation of a Real Common Pot rule, whereby a single budget is allocated according to uniform project evaluation criteria.

The Firm Performance Effect of Innovation Policy Targeted at Research Collaborations

The smaller literature on the performance impacts of public R&D subsidies awarded to research and innovation collaborations also remains mixed, although on balance it suggests that there is a positive relationship between public policy support of close-to-market R&D cooperation and economic performance (Aguiar and Gagnepain 2017). Research on the EU Framework Programmes, for example, suggests that there is a positive effect on the growth of intangible fixed assets of Spanish firms that participate in thus supported research collaborations, and an indirect positive effect on these firms' productivity (Barajas et al. 2012). Similarly, Aguiar and Gagnepain (2017) conclude that there are strong long-term effects on the labour productivity of firms collaborating on projects funded under the 5th EU Framework Programme. Scandura (2016) finds positive effects on firms' share of R&D employment two years after the end of their university-firm collaborations funded by the Engineering and Physical Science Research Council in the UK. Analysing all projects funded by all Research Councils' in the UK, Vanino et al. (2019) identify positive short-term and medium-term effects on the employment and turnover of participating firms.

The relative firm performance effects of innovation funding of individual firm projects compared with collaborative R&D projects may depend on the country-specific absorptive capacity, as suggested in Guisado-González et al. (2017). The study concludes that due to the low absorptive capacity of Spanish manufacturing firms, receiving public subsidies through participat-

ing in R&D cooperation agreements has a lower impact on the firms' productivity than the sum of the individual effects of R&D cooperation and R&D subsidies. Heterogeneity in the results from different studies may also be related to, for instance, the differences in the frameworks of the supporting programmes, the types of the collaboration partners and the focus of the cooperation projects, e.g. whether this is industry-oriented or knowledge oriented (Hewitt-Dundas et al. 2017; Du et al. 2014). In a similar way, as for the R&D additionality effect (Engel et al. 2016), the funding history also plays a role in the firm performance effect in that, as might be expected, firms participating in a series of funded collaborative projects experience stronger performance improvements than firms participating in only a single project (Vanino et al. 2019).

RESEARCH OUTLOOK AND CONCLUSION

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, the source of the public R&D funding, and other firm constraints have not received very much attention so far.

There is substantial evidence that firm size matters in the effectiveness of policy support. The R&D and innovation additionality effects have 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 in order 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 innovation policy support on firm performance. However, overall, findings confirm the existence of a positive relationship between public R&D support, innovation and firms performance. Again firm size matters, as do productivity levels and sectors (e.g. Vanino et al. 2019). Greater access to, and use of, administrative data could contribute to moving the knowledge frontier forward here (e.g. OECD 2013; Card et al. 2011, for NSF; Costanzo, for ISTAT; UK Data Forum 2018).

REFERENCES

Aguiar, L. and P. Gagnepain (2017), "European co-operative R&D and firm performance: Evidence based on funding differences in key actions", *International Journal of Industrial Organization* 53, 1–31.

Arrow, K. (1962), "Economic Welfare and the Allocation of Resources for Invention", NBER Chapters in *The Rate and Direction of Inventive Activity: Economic and Social Factors*. National Bureau of Economic Research, Inc., Princeton University Press, 609–626.

Bayona-Sáez, C. and T. Garcia-Marco (2010), "Assessing the effectiveness of the Eureka Program", *Research Policy* 39, 1375–1386.

Barajas, A., E. Huergo; and L. Moreno (2012), "Measuring the economic impact of research joint ventures supported by the EU Framework Programme", *Journal of Technology Transfer* 37, 917–942.

Beck, M., C. Lopes-Bento and A. Schenker-Wicki (2016), "Radical or incremental: Where does R&D policy hit?", *Research Policy* 45, 869–883.

Becker, B. (2015), "Public R&D policies and private R&D investment: A survey of the empirical evidence", *Journal of Economic Surveys* 29, 917–942.

Becker, B. (2019), The impact of policy support on firms' innovation outcomes and business performance. State Of The Art (SOTA) Review, Enterprise Research Centre, https://www.enterpriseresearch.ac.uk/wp-content/uploads/2019/01/No17-SOTA-The-impact-of-policy-support-on-firms%E2%80%99-innovation-outcomes-and-business-performance-B.-Becker-Final-1.pdf (accessed December 12, 2019).

Becker B., S. Roper, J. Love (2017), "The effectiveness of regional, national and EU support for innovation in the UK and Spain", *Academy of Management Proceedings*, uploads/2017/01/ERC-ResPap52-Becker-RoperLove.pdf (accessed December 12, 2019).

Bellucci, A., L. Pennacchio, and A. Zazzaro (2019), "Public R&D Subsidies: Collaborative versus Individual Place-Based Programs for SMEs", *Small Business Economics* 52, 213–240.

Bronzini, R. and P. Piselli (2016), "The impact of R&D subsidies on firm innovation", *Research Policy* 45, 442–457.

Cabrales, A.L., C.C. Medina, A.C Lavado, and R.V. Cabrera (2008), "Managing functional diversity, risk taking and incentives for teams to achieve radical innovations", *R & D Management* 38 (3) 5–50.

Caloghirou, Y., S. Ioannides, and N. Vonortas (2003), "Research joint ventures", *Journal of Economic Surveys* 17, 541–570.

Capelleras, J.-L., K.F. Mole, F.J. Greene, and D.J. Storey (2008), "Do more heavily regulated economies have poorer performing new ventures? Evidence from Britain and Spain", *Journal of International Business Studies* 39, 688–704.

Card, D., R. Chetty, M. Feldstein, and E. Saez, (2011), Expanding Access to Administrative Data for Research in the United States, written for the National Science Foundation (NSF) call for white papers on 'Future Research in the Social, Behavioural & Economic Sciences'.

Castellacci, F., and D. Archibugi (2008), "The technology clubs: the distribution of knowledge across nations", *Research Policy* 37, 1659–1673.

Ceh, B. 2009. A review of knowledge externalities, innovation clusters and regional development. *Professional Geographer* 61, 275–277.

Cin, B.C., Y.J. Kim, and N.S. Vonortas (2017), "The impact of public R&D subsidy on small firm productivity: evidence from Korean SMEs", *Small Business Economics* 48, 345–360.

Clausen, T.H. (2009), "Do subsidies have positive impacts on R&D and innovation activities at the firm level?", *Structural Change and Economic Dynamics* 20, 239–253.

Costanzo, L. Use of Administrative Data and Use of Estimation Methods for Business Statistics in Europe: an Overview. National Institute for Statistics Italy (ISTAT), Division of Statistical Registers, Administrative Data and Statistics on Public Administration, available at https://www.ine.pt (December 12, 2019).

Criscuolo C., R. Martin, H.G. Overman, and J. Van Reenen (2019), "Some causal effects of an industrial policy", *American Economic Review* 109, 48–85.

Czarnitzki, D. and C. Lopes-Bento (2012), "Evaluation of public R&D policies: A cross-country comparison", *World Review of Science, Technology and Sustainable Development* 9, 254–282.

Czarnitzki, D. and C. Lopes-Bento (2013), "Value for money? New micro-econometric evidence on public R&D grants in Flanders", *Research Policy* 42, 76–89.

Czarnitzki, D. and C. Lopes-Bento (2014), "Innovation subsidies: Does the funding source matter for innovation intensity and performance? Empirical evidence from Germany", *Industry and Innovation* 21, 380–409.

De Blasio, G., D. Fantino, and G. Pellegrini (2015). "Evaluating the impact of innovation incentives: evidence from an unexpected shortage of funds", *Industrial and Corporate Change* 24, 1285–1314.

Dimos, C. and G. Pugh (2016), "The effectiveness of R&D subsidies: A meta-regression analysis of the evaluation literature", *Research Policy* 45, 797–815.

Doh, S. and B. Kim (2014), "Government support for SME innovations in the regional industries: The case of government financial support program in South Korea", *Research Policy* 43, 1557–1569.

Du, J.S., B. Leten, W. Vanhaverbeke, and H. Lopez-Vega (2014), "When research meets development: Antecedents and implications of transfer speed", *Journal of Product Innovation Management* 31, 1181–1198.

Engel, D., M. Rothgang, and V. Eckl, (2016), "Systemic aspects of R&D policy subsidies for R&D collaborations and their effects on private R&D", *Industry and Innovation* 23, 206–222.

European Commission (2018), A Renewed Agenda for Research and Innovation – Europe's Chance to Shape its Future. Brussels, Belgium, available at https://ec.europa.eu/commission/sites/beta-political/files/communication-europe-chance-shape-future_en.pdf (accessed December 12, 2019).

Feldman, M.P. and M.R. Kelley (2006), "The ex ante assessment of knowledge spillovers: Government R&D policy, economic incentives and private firm behaviour", *Research Policy* 35, 1509–1521.

Görg, H. and E. Strobl (2007), "The effect of R&D subsidies on private R&D", *Economica* 74, 215–234.

Griliches, Z. (1979), "Issues in assessing the contribution of research and development to productivity growth", *Bell Journal of Economics* 10, 92–116.

Griliches, Z. (1998), *R&D and Productivity: The Econometric Evidence*. University of Chicago Press, Chicago.

Grimpe, C. and U.Keiser (2010), "Balancing internal and external knowledge acquisition: The gains and pains from R&D outsourcing", *Journal of Management Studies* 47, 1483–509.

Guisado-González, M., J. González-Blanco, J.L.Coca-Pérez, and M. Guisado-Tato (2017), "Assessing the relationship between R&D subsidy, R&D cooperation and absorptive capacity: an investigation on the manufacturing Spanish case", *Journal of Technology Transfer* 43, 1647–1666.

Hagedoorn, J., A. Link, and N. Vonortas (2000), "Research partnerships", *Research Policy* 29, 567–586.

Hall, B.H. and J. Lerner (2010), "The financing of R&D and innovation", in Hall, B.H. and Rosenberg, N. (Eds.) *Handbook of the Economics of Innovation*. Elsevier/North Holland.

Hall, B.H., F. Lotti, and J. Mairesse (2009), "Innovation and productivity in SMEs: Empirical evidence for Italy", *Small Business Economics* 33, 13–33.

Hewitt-Dundas, N., A. Gkypali, and S. Roper (2019), "Does learning from prior collaboration help firms overcome the 'two-worlds' paradox in university-business collaboration?", *Research Policy* 48, 1310–1322.

Hottenrott, H., C. Lopes-Bento, and R. Veugelers (2017), "Direct and cross scheme effects in a research and development subsidy program", *Research Policy* 46, 1118–1132.

Hottenrott, H. and C. Lopes-Bento (2016), "R&D partnerships and innovation performance: Can there be too much of a good thing?" *Journal of Product Innovation Management* 33, 773–794.

Huergo, E. and L. Moreno (2017), "Subsidies or loans? Evaluating the impact of R&D support programmes", *Research Policy* 46, 1198–1214.

Huergo, E., M. Trenado and A. Ubierna (2016), "The impact of public support on firm propensity to engage in R&D: Spanish experience", *Technological Forecasting & Social Change* 113, 206–219.

Hünermund, P. and D. Czarnitzki (2019), "Estimating the causal effect of R&D subsidies in a pan-European program", *Research Policy* 48, 115–124.

Howell, S.T. (2017), "Financing innovation: Evidence from R&D grants", *American Economic Review* 107, 1136–64.

Jaffe, A. (20139, "An economic perspective on science and innovation policy", inWorking Paper, Motu Economic and Public Policy Research, Presented at the Economic Analysis of Industry and Innovation Programs Design Workshop. Australian National University, 20 September 2013.

Kamien, M.I., E. Mueller, and I. Zang (1992), "Research joint ventures and R&D cartels", *American Economic Review* 82, 1293–1306.

Karhunen, H. and J. Huovari (2015), "R&D subsidies and productivity in SMEs", *Small Business Economics*, 45, 805–823.

Keizer, J.A. and J.I.M. Halman (2007), "Diagnosing risk in radical innovation projects", *Research-Technology Management* 50, 30–36.

Kilponen, J. and T. Santavirta (2007), "When do R&D subsidies boost innovation? Revisiting the inverted U-shape", *Bank of Finland Research Discussion Paper* No. 10/2007.

Klette, T.J., J. Moen, and Z. Griliches (2000), "Do subsidies to commercial R&D reduce market failures? Microeconometric evaluation studies", *Research Policy* 29, 471–495.

Laursen, K. and A. Salter (2006) "Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms", *Strategic Management Journal* 27, 131–150.

Lee, S. (2015), "Slack and innovation: Investigating the relationship in Korea", *Journal of Business Research* 68, 1895–1905.

Lokshin, B., J. Hagedoorn, and W. Letterie (2011), "The bumpy road of technology partnerships: Understanding causes and consequences of partnership mal-functioning", *Research Policy* 40, 297–308.

Love, J.H., S. Roper, and J.R. Bryson (2011) "Openness, knowledge, innovation and growth in UK business services", *Research Policy* 40, 1438–1452.

Marlin, D. and S.W. Geiger (2015), "A re-examination of the organizational slack and innovation relationship", *Journal of Business Research* 68, 2683–2690.

Martin, B.R. (2016), "R&D policy instruments – a critical review of what we do and don't know", *Industry and Innovation* 23, 157–176.

Mate-Sanchez-Val, M. and R. Harris (2014), "Differential empirical innovation factors for Spain and the UK", *Research Policy* 43, 451–463.

Mazzucato, M. (2016) "From market fixing to market-creating: a new framework for innovation policy", *Industry and Innovation* 23, 140–156.

Meuleman, M. and W.De Maeseneire (2012), "Do R&D subsidies affect SMEs' access to external financing?", *Research Policy* 41, 580–591.

Mohnen, P. (1996), "R&D Externalities and Productivity Growth", *STI Review* 18, 39–66.

Moretti, E. and D.J. Wilson (2014), "State incentives for innovation, star scientists and jobs: evidence from biotech", *Journal of Urban Economics* 79, 20–38.

Nelson, R.R. (1959), "The simple economics of basic scientific research", *Journal of Political Economy* 67, 297–306.

Nohria, N. and R. Gulati (1996), "Is slack good or bad for innovation?" *Academy of Management Journal* 39, 1245–1264.

OECD (2010), *Innovation Vouchers*, ed. O.I.P. Platform. Paris: OECD.

OECD (2013), New Data for Understanding the Human Condition: International Perspectives, OECD Global Science Forum Report on Data and Research Infrastructure for the Social Sciences, available at http://www.oecd.org/sti/sci-tech/new-data-for-understanding-the-human-condition.pdf (accessed December 12, 2019).

Petruzzelli, A.M. (2011), "The impact of technological relatedness, prior ties, and geographical distance on university–industry collaborations: A joint-patent analysis", *Technovation* 31, 309–319.

Ponds, R., F. Van Oort, and K. Frenken (2007), "The geographical and institutional proximity of research collaboration", *Papers in Regional Science* 86, 423–444.

Rigby, J. and R. Ramloga (2013), *Access to Finance: Impacts of publicly supported venture capital and loan guarantees*. London: Nesta.

Romero-Jordán, D., M.J. Delgado-Rodríguez, I. Alvarez-Ayuso and S. De Lucas-Santos (2014), "Assessment of the public tools used to promote R&D investment in Spanish SMEs", *Small Business Economics* 43, 959–976

Roper, S., J. Du, and J.H. Love (2008), "Modelling the innovation value chain", *Research Policy* 37, 961–977.

Scandura, A. (2016), "University–industry collaboration and firms' R&D effort", *Research Policy* 45, 1907–1922.

Szczygielski, K, W. Grabowski, M.T. Pamukcu, and V.S. Tandogan (2017), "Does government support for private innovation matter? Firm-level evidence from two catching-up countries", *Research Policy* 46, 219–237.

UK Data Forum (2018), Strategy for Data Resources for Social and Economic Research 2013-2018. A five-year plan to inform and guide the development and related resources for social and economic research, https://esrc.ukri.org/files/research/uk-strategy-for-data-resources-for-social-and-economic-research/ (accessed December 12, 2019).

Van Alphen, K., J. Van Ruijven, S. Kasa, M. Hekkert, and W. Turkenburg, (2009), The performance of the Norwegian carbon dioxide, capture and storage innovation system, *Energy Policy* 37, 43–55.

Vanino, E., S. Roper, B. Becker (2019), "Knowledge to money: Assessing the business performance effects of publicly-funded R&D grants", *Research Policy* 48, 1714–1737.

Wang, Y., J. Li, and J.L. Furman (2017), "Firm performance and state innovation funding: Evidence from China's Innofund program", *Research Policy* 46, 1142–1161.

Zehavi, A. and D. Breznitz (2017), "Distribution sensitive innovation policies: Conceptualization and empirical examples", *Research Policy* 46, 327–336.

Zhao, B. and R.H. Ziedonis (2012), State governments as financiers of technology startups: Implications for firm performance. http://dx.doi.org/10.2139/ssrn.2060739 (accessed December 12, 2019).

Zona, F. (2012), "Corporate investing as a response to economic downturn: Prospect theory, the behavioural agency model and the role of financial slack", *British Journal of Management* 23, 42–57.

Zuniga-Vicente, J.A., C. Alonso-Borrego, F.J. Forcadell,and J.I. Galan. (2014), "Assessing the effect of public subsidies on firm R&D investment: A survey", *Journal of Economic Surveys* 28, 36–67.