European Commission

JRC POLICY BRIEF

Industrial Research and Innovation: Evidence for Policy

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1. Introduction[1]

The Europe 2020 strategy and its Innovation Union and Industrial Policy flagship [2] initiatives bring to the fore the importance of industrial research and innovation for the achievement of a smart, sustainable and inclusive growth in Europe. The high expectations on the effects of innovation on Europe's economy and society have enlarged the scope of innovation policy making. Innovation is now also acclaimed as a key solution to grand societal challenges.

As the cornerstones of their economic development strategies, continuous efforts are required from both Member States and EU regions to enhance or sustain their commitment into R&D and innovation. However, especially in the aftermath of the crisis, the pressure on governments to improve the quality of public spending and to ensure the creation of value for money from the public support has been more accentuated. In this context, the demand for adequate measurement and monitoring frameworks for industrial R&D and innovation activities and for innovation policy evaluations has never been so prominent.

This Policy Brief relies on the results of the fifth European Conference on Corporate R&D and Innovation[3], CONCORDi 2015, on "Industrial Research and Innovation: evidence for policy". It presents the main evidence-based insights for policy drawing upon the contributions and debates. Then it highlights the main implications for industrial and innovation policies[4] and for the science-policy interface. A series of open questions for policy-makers and researchers/analysts conclude the brief.

[1] The document has also relied on the Conference's summaries provided by the Members of the Scientific Committee and chairs of the sessions and on the key messages of its policy round table (the scientific committee's members, chairs of scientific sessions and the representatives of the policy stakeholders are listed at the end of this document).

[2] See European Commission (2010)

[3] CONCORDi 2015 Conference – Seville, Spain, 1-2 October 2015 – focused on 'Industrial Research and Innovation: Evidence for Policy', organised by the European Commission's Joint Research Centre http://iri.jrc.ec.europa.eu/concord/2015/index.html

[4] In the context of this policy brief, the industrial and innovation policy refers to the set(s) of policy instruments and programmes implemented mainly to support the R&D and innovation in manufacturing and services industries, acknowledging that both terms, "industrial" and "innovation" policies, may encompass a broader range of distinct topics and policy interventions.

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2. Background issues

The use of scientific evidence to inform policy is a topic of high relevance in the context of the EU agenda for a better regulation. Several efforts and actions have been undertaken to develop standards in the measurement of R&D and innovation (e.g. OECD's Frascati manual, the Eurostat's Community Innovation Surveys and the OECD-Eurostat's Oslo manual), and to evaluate industrial and innovation policies. These initiatives have facilitated the collection of data for international comparisons and a better integration of the multiple dimensions of R&D and innovation activities. In parallel, the computational and methodological advances have enabled improvements in the data treatment. Nevertheless, in spite of the knowledge accumulated so far on industrial R&D and innovation processes, on their measurements and on the evaluation of related policies, important issues remain open. The following paragraphs of this section raise some of these main issues[5].

The first issue relates to the limitations imposed by some prevailing theoretical frames used to support policy intervention in the area of industrial research and innovation. The traditional undersupply argument, reflecting the pessimistic expectations of firms and their reluctance to invest in uncertainty contexts (Arrow, 1962; Antonelli, 2009), has for long influenced the conception of indicators and empirical settings used to explain and monitor the processes of knowledge creation and innovation. More concretely, this framework has favoured the use of traditional R&D-related measures as the main basis for assessment and, more recently, for the setting of policy targets and benchmarks to stimulate the levels of investment in R&D and innovation. This excessive reliance on R&D-related indicators presents several limitations: first, R&D investments and intensities exhibit industry-specific features. Second, R&D-related indicators fall short to capture the transformation of inputs into outputs, which may lead to an overestimation of the effects of unproductive R&D. And this can be worsened by the use of narrow output indicators (e.g. patent counts) and direct economic outcomes (e.g. net sales growth). Third, official R&D statistics, based on territorial criteria, fail to properly capture the activities of large multinational enterprises (MNEs), which account for the majority of corporate R&D investments[6].

Another fundamental concern emerges at the science-policy interface: how to adequately translate evidence on corporate R&D and innovation into operational and successful policy interventions? Recent studies call for more careful interpretation and translation into policy action of scientific results showing the links between innovation, employment and growth (e.g. Audretsch et al., 2014; Vivarelli, 2014). These works call for a better account of the different dimensions of firms' growth (e.g. sales, employment, profits, market value, etc.) and of their aggregated effects, which are not straightforward. Issues related to the transferability and predictive value of results, the realism of underlying assumptions and the choice of methodologies need to be taken into account. Furthermore, the above mentioned studies warn on the lack of suitable evidence-based frameworks in the design, implementation and evaluations of R&D and innovation policies, which can lead to misuses of available evidence.

The effectiveness and efficiency of innovation policies greatly depend on adequate and systematic evaluations undertaken at the different stages of the policy cycle. One key aspect to be considered in these evaluations, which is also illustrative of the methodological challenges involved, is the additionality of the public support. Additionality may refer to the real net increase[7] in firms' R&D investments, to outputs and outcomes or to changes in firms' learning and interactions following the receipt of public support to R&D and innovation. A key conceptual issue in the additionality literature consists in identifying the appropriate methodology to assess the relevant counterfactual

[5] See also Dosso et al. (2015) for a broader overview of the background issues of CONCORDi 2015.

[6] See for instance, European Commission (2014), The 2014 EU Industrial R&D Investment Scoreboard, for update statistics on the R&D investments of top 2500 R&D performers worldwide.

[7] As compared to a situation of no intervention.

(Georgiou, 2002; Söderblom et al., 2015). Partly in response to these concerns, a flourishing literature has paid more attention to the so-called "behavioural additionality" of innovation policies. This refers to the capacity of the public support to influence corporate behaviours and strategies (e.g. R&D management, cooperative behaviour, learning curve, etc.) and thereby to yield complementary positive effects over longer time horizons (OECD, 2006).

3. New evidence for industrial research and innovation policy

The importance to ground policy making into a sound scientific and academic basis has constituted the background of the scientific presentations and debates of the CONCORDi 2015. The keynote address of Martin (Sussex University, UK) has set the general scene, presenting the main key challenges for conducting what he realistically rephrased as an "evidence-influenced or -informed policy" [8]: (i) the relevance of available evidence for the policy need; (ii) the representativeness of the sampled population and; (iii) the reliability and theoretical and empirical foundations of the available evidence. These challenges reflect the more fundamental issue of the gap that exits between the academic and policy circles and perspectives. On the one hand, academics may be somehow confined to academic disciplines, which do not always map onto the interests and value proposition of policy makers. On the other hand policy makers may not have adequate academic background and competence requirements to access and absorb the scientific evidence.

The presentations and papers of CONCORDi 2015 have attempted to bridge this gap by bringing evidence and relevant reflection avenues on three key aspects as presented hereafter.

3.1 Theory, measurement and evidence on corporate R&D and innovation dynamics

The design of sound and more comprehensive theoretical and empirical frameworks is essential to apprehend the systemic and complex aspects of knowledge, R&D and innovation dynamics. This idea has been reflected by Antonelli's reference to CONCORDI 2015 as the *Conference for Complex*[9] *RD&I* in its re-examination of the traditional knowledge undersupply assumption. According to him, knowledge tends to spill over across economic agents, who do not often have sufficient absorptive capabilities to exploit this knowledge.

Policy message 1: the emphasis of policy intervention should be adapted to facilitate the circulation of knowledge among the multiplicity of actors involved in the innovation process and to promote their connectivity and interactions.

Backed by up-to-date empirical findings on a panel dataset of top corporate R&D investors worldwide[10], the contribution of Moncada-Paternò-Castello shows the importance of company level analysis to understand the causes of the R&D intensity gap between EU firms and their main international competitors. This is an issue at the core of the EU R&D and innovation agenda, translated into a headline target of its jobs and growth agenda (Europe 2020). The evidence shows that an important share of such gap comes from the EU industrial mix, rather than be exclusively related to individual low R&D intensities. Moreover the results show the essential role of young innovative firms, especially when new market emerge, for the dynamics of high-R&D intensity industries. This is very important for the EU which still records a relatively lower number of young and large firms in high-intensity industries as compared to the US.

Policy message 2: policy intervention should target the promotion of new and potentially more risky (R&D-intensive) sectors, also favouring entrepreneurship, and the increase in number and size of EU leading firms in these sectors.

There is a need to improve current measurement frameworks, to properly assess innovation performances and

[8] The term may refer to the use of rigorous and tested evidence from science in the designing, implementation and evaluation of policy. A more detailed discussion is given by Martin at CONCORDi 2015 available at http://iri.jrc.ec.europa.eu/concord/2015/presentations.html)

[9] In the original formulation *Corporate*.

[10] See The EU Industrial R&D Investment Scoreboards at http://iri.jrc.ec.europa.eu/scoreboard.html

monitor policy implementation. The Best Paper Award's contribution by Andries, Hoskens, Janger, Rammer and Schubert examines in detail the new Innovation Output Indicator of the European Commission (European Commission, 2013) and underlines the bias of the indicator towards specific sectors. The paper brings relevant evidence of the need to rebalance the construction of the indicator to better capture not only progress towards structural change (shift of sectoral composition towards industries with higher innovation-intensity), but also innovation upgrading within industries (move of companies and sectors towards higher innovation intensity segments). Both aspects are needed, also to properly account for company heterogeneity within sectors and across countries. The current measurement bias results in an excessive focus on pre-defined knowledge-intensive sectors and might result in wrong policy choices. These choices may disregard the necessary promotion and upgrading of locally embedded activities that may not systematically relate to high or medium-high tech sectors.

Policy message 3: innovation output indicators used for international comparisons should properly account for sectoral differences between countries and measure both structural change and sectoral upgrading.

The contribution by Blind and Rainville exploits data on German firms to underline the links that exist between innovation and standardisation behaviour of companies in influencing public procurement. In general, the results also echo the calls for a better account of the interactions between innovation, standardisation and public procurement policies. Exploiting an EU-wide panel dataset of firms, a paper by Van Roy, Vertesy and Vivarelli, brings evidence on the potential job creation and destruction effects of innovation. It confirms the prior findings on sector-specific effects and brings evidence suggesting the importance to differentiate innovation quality. Particularly, citation-weighted patents are shown to have significant effects only on employment in high-tech sectors.

From a complementary perspective, the keynote contribution by Sachwald (Ministry of Education, Higher Education and Research, France) has brought evidence of the Europe's twin deficits, which reflect the lags in both the production and the transfer of knowledge. Different data sources from the OECD, Eurostat and the US National Science Foundation are combined to show that the EU-US publication excellence gap is especially high in frontier technologies such as ICT and health technologies, where also science literature is relatively more prominent. In addition, the speaker has underlined the need to assess the quality of research results, publications and their impacts on the innovation performances of the system.

Policy message 4: policy intervention targeting high-tech sectors should pay attention to the excellence of science in the related fields and to the quality of innovations targeted.

3.2. Entrepreneurship, firms' performance and territorial innovation policies

The achievement of a knowledge-driven economy relies on the presence of excellence centres driven by local knowledge production actors. Taking stance from the enlarged and more market-oriented role of universities as place-based actors, the presentation by Audretsch discusses evidence from the Technology Transfer Offices (TTOs) on university entrepreneurship in the United States. He underlines the risks of an underestimation of entrepreneurship from the universities and of the commercialization of their research and their innovation. Indeed most studies assessing the commercialization of university research focus on the activities reported by the Technology Transfer Offices (e.g. intellectual property disclosed to and registered). However, many scientists do not go through the offices to start a new firm, so that TTOs' reported activities are quite limited to properly assess university entrepreneurship. Such call for more comprehensive data on start-ups' activities has received repeated echoes all along CONCORDi 2015 debates.

Regarding the focus on entrepreneurs and start-ups, the presentation of Brännback discusses the potential misalignments between innovation policy instruments and the needs of young firms and entrepreneurs. Relying on factual observations and firm-

level data on Finnish start-ups, the paper suggests that an exclusive focus on high growth may be more destructive for the profitability of some types of start-up firms, especially those with a low-profit or very young entrants. In this framework, the study justly asks for more inquiries and evidence on the growth-profitability relationship as, so far nothing guarantees that growth (sales growth or employment) translates into profitability that is generally sought by entrepreneurs. In addition, growth may not be always good and is often quite problematic and hardly sustainable.

Policy message 5: policy intervention to support start-ups should be based on a more comprehensive account of sectoral contexts. Targeting growth exclusively, with no account of profitability, can be damaging.

In the continuity of the debates on the relationships between innovation and growth, the contribution by Bianchini, Pellegrino and Tamagni confirms the difficulty to single out the effect of innovation on average growth. As prior findings suggest, they show that internal R&D investment is a better predictor than various innovation measures. Moreover their results suggest that the patterns of innovation activities (e.g. internal vs external R&D, product vs process innovation, new-to-the-firm vs new-to-the-market innovations) matter in order to assess the impacts of innovation in terms of sales growth.

The contribution by Alstadsæter, Barrios, Nicodeme, Skonieczna and Vezzani brings evidence on the relation between patent boxes [11] modalities, patents location and local R&D in the European context. The paper exploits the new European Commission, Joint Research Centre and Organisation for Economic Co-operation and Development's patents dataset of the top 2000 corporate R&D investors worldwide[12]. The most salient finding is that patent boxes do not seem to encourage local innovation, although they do attract patents, especially high-quality ones. The study also shows that the larger the scope in terms of tax base definition, the stronger effects they will have on the location of patents. In a nutshell, patent boxes seem to be of limited value in achieving their claimed purpose.

Policy message 6: the implementation of favourable fiscal conditions for R&D, through for instance patent boxes or IP boxes, requires the introduction of development conditions to guarantee that research activities are effectively undertaken, balancing tax motivations.

In line with the keynote speech on *Evidence-based policy*, Dosso and Hardeman examine the current status and future prospects of evidence-based R&I policy. From a conceptual parallel between evidence-based medicine and evidence-based policy, the paper identifies the challenges for the applicability of evidence-based policy concept and principles to smart specialisation strategies[13]. Key challenges include the review and translation of contextual evidence into specific development paths. There seems to be simply no academic field with a mandate to provide theory and a framework as well as the supporting empirical evidence for what was referred to in the session as the *strategic management of places*[14]. Besides the further clarification of key concepts, the paper calls for a deeper analysis of the existing available evidence, among other, on the micro-entrepreneurial dynamics, on the phenomena of agglomeration, territorial specialisation and related variety, as well as of their links with economic performances.

Policy message 7: the definition of targets and progress measures for smart specialisations are necessary to monitor the innovation policy results. More, systematic reviews and assessments of available evidence and sound evidence-based frameworks are crucial to limit undesirable outcomes in the design and implementation of smart specialisation strategies.

3.3. Impact of public policies and their additionality in supporting corporate R&D and innovation

The evaluation of the outcomes of public policies have either focused on input

[11] They generally refer to a set of tax advantages for the location of patents and other IPs in a given territory.

[12] See Dernis H., Dosso M., Hervás F., Millot V., Squicciarini M. and Vezzani A. (2015). *World Corporate Top R&D Investors: Innovation and IP bundles*. A European Commission-JRC and OECD report. Luxembourg: Publications Office of the European Union, for the related report at http://iri.jrc.ec.europa.eu/other-reports.html

[13] The presentation mainly refers to smart specialisation as an industrial and innovation policy framework to support R&D and innovation-driven territorial development.

[14] See Audretsch's presentation for a discussion of this notion in relation to entrepreneurship.

additionality to private R&D spending (increase in firms' R&D following public support), on output additionality (e.g. patents, productivity) or on the behavioural additionality [15] (e.g. changes in firms' capabilities and learning curves, the economic signals they face, their interactive behaviour). In an holistic perspective of innovation policy, the contribution of Edquist has tackled the issue of additionality in the Swedish context of risk capital financing. Besides the urgent need to reform the state risk capital provision, the speaker has insisted on the necessity to provide a more accurate mapping of the shortages of risk capital in terms of sectors and stages. More, the paper asks for a better specification of the conditions under which public and private risk capital funding should be combined (i.e. the size of the subsidy, the stages, etc.).

Policy message 8: additionality should be at the core of the rationale for policy intervention. Its assessment should go beyond the concept of opportunity cost and be related to the different policy intervention options and the design of instruments.

The contribution of Demeulemeester and Hottenrott estimates the impact of R&D subsidies on firms' cost of debt. The paper exploits a panel dataset of R&D and non-R&D performing Flemish companies. It brings further support to the provision of R&D subsidies to financially constrained firms. In addition of some resources and certification effects, the R&D subsidy programme is shown to affect the learning-to-apply for funds in small firms independently of the success or failure of the application. This effect is detected in a further reduction in the cost of accessing debt of young firms, which thus benefit from a formation effect.

In a complementary perspective, Radicic, Pugh and Douglas focus on behavioral additionality in terms of incentives to cooperate in a sample of European SMEs. Their findings suggest that manufacturing SMEs receiving subsidies are more likely to cooperate in innovation to different extent depending of the partner. The propensity to cooperate is stronger with higher education institutions, the government and public research centers and lesser with customers, suppliers, and consultants.

Policy message 9: the public support to R&D can also affect the behaviour of firms in terms of learning processes and attitude towards cooperation.

Furthermore, firms often combine different types of public support. Relying on evidence on a sample of Belgium firms, a paper by Neicu tackles this issue and investigates the effects of R&D tax credits, R&D subsidies and of their joint use. The two instruments may impose different requirements on firms. While R&D subsidy programmes often screen projects and often concern specific firms, sectors and collaborations for innovation, R&D tax credit are less constraining with respect to the choice of the project. Besides, they may generate quite different costs, as R&D subsidies, particularly for small firms, may be more costly to use. Direct and indirect R&D support does not crowd each other out and all instruments combined or not, are shown to yield additionality. However actions zones may be identified; in other words, tax credits increase spending on applied research and development, while subsidies seem to have significant effects only on applied research. Overall the paper calls for more research on how firms combine different types of support and whether this relates to specific market failures.

Policy message 10: the combination of R&D subsidies and R&D tax credits can be effective in increasing firms' R&D spending. Their individual or combined effects depend on the type of R&D project targeted (basic, applied research or development).

4. Conclusions and implications for the science-policy interface[16]

The main results deriving from CONCORDi 2015 merit some further considerations.

(i) EU young innovative firms and start-ups face barriers to innovation and growth that still need to be fully identified in order to ensure an effective shift towards a more knowledge-intensive and innovation-oriented Europe industry. Particularly in the

[15] See OECD (2006) for the multiple dimensions of behavioural additionality and country case-studies.

[16] This section combines the insights from the previous sections and further contributions from the scientific summaries and the final scientific and policy panels (see acknowledgements).

context of the knowledge-sharing economy, where regulators are currently facing several challenges, the right balance has to be found to limit the deteriorating effects of regulatory barriers on firms' growth and innovation. In this respect, further research integrating the multiple dimensions of firms' growth and its relation with other firms' performances indicators is needed. Furthermore a distinction should be made between the start-up companies with a business plan and ambition to grow independent from those at the project or experimental stage expecting to be acquired. Policy targets should be adjusted accordingly, or else policy makers' expectations may fail to materialize.

(ii) The type and intensity of innovation targeted by the policy instruments matter. The notion of newness remains quite blurred in both the formulation and the implementation of innovation policy. These innovations may be new to the world, new to market, new to a region, new to the entrepreneur, etc. The effectiveness of policy instruments may differ according to the type of innovation targeted. This is also an area where further research is needed. Moreover the characterisation of innovation as a binary variable does not fit with an in-depth understanding of the different kinds and intensities of innovation and of the differences between companies, sectors and territories.

(iii) The returns and additionality of EU and Member States' R&D and innovation schemes should be assessed in order to make a more efficient use of public money. A key issue here is to better understand the links between the design of policy instruments and the outcomes in order to disentangle the merely side benefit of the public support. Moreover evidence on the interaction of different policy instruments and their additionality is particularly needed in the context of the current reforms of the tax support to R&D and the intellectual property regimes. Beyond patents, more inquiries on the role of the different intangibles for firms' performances are necessary; parallel improvements in the access of intellectual property dataset on wider sample of firms is also needed.

(iv) More appropriate channels for the transmission of evidence from science to policy-makers are required to inform on the conditions for policy implementation. In this respect, constant or more regular exchanges between policy makers and science could help. Because of different agendas and deadlines, policy makers will usually refer to their own "true sources" of evidence or rely on the limited, often contextual, evidence. In the current context of the implementation of smart specialisation strategies, and focusing on corporate R&D and innovation, more comprehensive evidence is required to offer a sound and adequate support to EU regions. Although the demand for evidence is continuously rising, researchers need to be cautious in deriving policy conclusions. This means being transparent about the limitations of the analysis in terms of scope, data and methodologies. Obviously, a necessary condition is the production of high-quality data ("the best econometric techniques cannot fix bad data").

5. Open questions

From the above, a number of questions on a EU evidence-informed policy are still open and deserve some further research and policy debate, for instance:

(a) How to better coordinate EU and Member States' policy frameworks and tools to avoid duplication or crowding out in policy making and implementation? or How to improve territorial innovation policy coordination?

(b) How evaluations can be used to ensure that policy learning effectively takes place?

(c) How to integrate other socio-economic dimensions that matter for innovation performances (i.e. attitudes toward risk, product market and labour market regulation, etc.) in innovation policy making?

(d) How is the hierarchy of evidence and methodologies accounted for in the design of policies and policy interventions?

(e) How to improve the science-policy dialog to limit the use of one-piece-of-work-based evidence given the often contextual and contestable nature of the scientific findings?

(f) Is there a room for policy experimentation before the introduction of measures tailored to corporate R&D and innovation at larger scale?

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Papers presented at CONCORDi 2015

PLENARY SESSION I - Theory, measurement and evidence on corporate R&D and innovation dynamics

Cristiano Antonelli. Knowledge appropriability and economic policy.

Pietro Moncada-Paternò-Castello. Evolution of EU corporate R&D: intensity gap, sector dynamics and firms demographics.

Petra Andries, Machteld Hoskens, Jürgen Janger, Christian Rammer and Torben Schubert. The new EU 2020 innovation indicator: a step forward in measuring innovation output?

Vincent Van Roy, Daniel Vertesy and Marco Vivarelli. *Innovation and employment in patenting firms: empirical evidence from Europe*.

Knut Blind and Anne Rainville. Innovation and standardization as drivers of companies' success in public procurement – An empirical analysis.

PLENARY SESSION II - Entrepreneurship, firms' performance and territorial innovation policies

David B. Audretsch. Scientist entrepreneurship and the strategic management of places?

Malin Brännback. Data as basis for assumptions underlying policy measures with respect to high growth entrepreneurship.

Annette Alstadsæter, Salvador Barrios, Gaetan Nicodeme, Agnieszka Skonieczna and Antonio Vezzani. Patent boxes design, patents location and local R&D.

Stefano Bianchini, Gabriele Pellegrino and Federico Tamagni. Innovation strategies and firm growth: new longitudinal evidence from Spanish firms.

Mafini Dosso and Sjoerd Hardeman. Current status and future prospects of evidence-based research and innovation policy: the case of smart specialisation.

PLENARY SESSION III – Impact of public policies and their additionality in supporting corporate R&D and innovation

Charles Edquist. Public innovation policy and firm innovation strategies: public risk capital funding should be seed funding – but additionally is not there!

Sarah Demeulemeester and Hanna Hottenrott. R&D subsidies and firms' cost of debt.

Dragana Radicic, Geoffrey Pugh and David Douglas. Additionality effects of public support programmes on cooperation for innovation: evidence from European manufacturing SMEs.

Daniel Neicu. Mix and match: evaluating the additionality of the R&D policy mix.

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Nevertheless, the statements and views expressed in this document reflect our own opinions and we are responsible for any errors.

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Abstract
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