EXTENDED ABSTRACT

Title: The economic effect of R&D subsidies in Spain: an input-output analysis as a tool to support the implementation of Smart Specialisation Strategy

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Abstract:

From a theoretical perspective, expenditures in Research and Development (R&D) are directly related to technological progress and economic growth[1]. Since R&D expenditures explicitly seek to generate innovation and create knowledge, the bigger they are the larger the differences among industries can be. For this reason, it is of utmost importance to allocate R&D investment funds to accelerate the twin transition (green and digital) efficiently across industries in order to make the most of the subsequent businesses R&D expenditures and their related spillover effects throughout the whole economy.

[1] Research and development expenditure, by sectors of performance (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D expenditures include all expenditures for R&D performed within the business enterprise sector (BERD) on the national territory during a given period, regardless of the source of funds.

With such purpose, we suggest a new approach (FIDELIO model) based on robust and long-standing input-output techniques[2] (Dietzenbacher and Los, 2002; Rocchi et al., 2019; Pedauga et al., 2021) to support policy makers in the most efficient allocation of R&D funds. Since the seminal work of Schumpeter (1934), a vast body of literature have provided evidence about that investing in R&D contribute to increase economic growth (see e.g. Aghion and Howitt, 1998; Falk, 2007). However, we should not be satisfied with just that statement but rather go beyond and search for new data and quantitative methods to assess different allocation scenarios and make the most of the public budget. For instance, besides the standard information on gross and businesses expenditures on R&D[3], we have also used data on the turnover associated to R&D expenditures by industry under the guidelines of the Community Innovation Survey (CIS) and its corresponding breakdown between labour and capital (Eurostat, 2022).

In growth theory, knowledge spillover effects from R&D investment is considered a fundamental source of positive externalities. Meaning that innovation effects do not only consist of the innovative activities created by a particular industry itself, but also innovations that are imported from other sectors via intermediary products, investment or the use of patents.

Knowledge spillovers arise when the knowledge embodied in an industry's innovation contributes to the innovation process of other industries. They occur when ideas (or the knowledge) are 'borrowed' by the research department of industry *j* from the research department of industry *i*. In this sense, assessing the effect of inter-industry flows of embodied R&D spillover has a long tradition in the input-output (IO) modelling approach. This type of model is capable to explain how R&D investment in one sector could have a positive effect in other sectors and the whole economy, resulting in a useful tool to show the knowledge flows and the economic rents that arise from R&D. Moreover, within the context of IO models, this type of inter-industry diffusion mechanism have been traditionally analysed through backward and forward multipliers, with some extra specific R&D information. In this sense, this approach can quantify how much R&D expenditures of industry *i* is embodied in the final demand (e.g. for consumption, investments, or exports) of industry *j* (backward). Likewise, it can also provide how much of the R&D costs incurred by industry *i* is embodied in the price of the corresponding product output values of industry *j*.

[2] We use the concept of R&D multipliers proposed by Dietzenbacher and Los (2002) and the Financial Social Accounting Matrix of Spain for 2018, compiled by Pedauga et al (2021).
[3] Eurostat's data on Gross expenditures in R&D (GERD) and Businesses expenditures in R&D (BERD).

In the literature, backward and forward linkages are widely accepted measures to characterize the inter-connectedness of an economy. Backward linkages measure how much the demand of products generates other demands for intermediate products across the whole production process. Forward linkages measure how much cost reductions (in the form of R&D grants, for instance) would affect the prices of the products produced by the R&D investors. The stronger these linkages, the more interconnected a sector is with respect to the rest of the economy (Miller and Lahr, 2001). In this sense, we look at both backward R&D multipliers and forward R&D multipliers to carry out a key sector analysis.

Our preliminary analysis, based on the case study of Spain for the year of 2018, allows to identify clusters of industries where the value added generated by R&D expenditures in an industry (or a group of industries) would drive the largest spillover effects over the R&D related value added in other industries (backward effects). Likewise, cost savings in industries with high forward effects thanks to the accumulation of R&D investments may contribute to higher price competitiveness of the products sold by R&D investors. Hence, this paper proposes to identify those key[4] industries with the largest backward and forward effects for strategic policy support in terms of R&D investment and further assesses various allocation scenarios where the overall total amount of R&D investment increases by 10% and it is distributed:

- Uniformly across industries proportionally to their gross value added (scenario 1);
- Across the top-3 industries with highest R&D expenditures (scenario 2);
- Across the top-3 industries with highest R&D expenditure intensities (scenario 3);
- Across the top-3 industries with the highest government funding in R&D investment (scenario 4).
- Across the top-3 industries with the highest growth potential in terms of its economic complexity (scenario 5).

Preliminary result, provides evidence about to what extent the value added associated with expenditures in R&D differs across industries depending on where the R&D investment funds have been allocated. The results show that the manufacturing of computer and electronics, other transport equipment and the pharma industry are the sectors most reactive to an increase of 10% in the overall amount of business R&D spending in ES for 2018, distributed proportionally to the current distribution of business R&D expenditures. The overall return rate would be 8%. However, should the

[4] Rueda-Cantuche et al. (2011) describes the fundamentals of key sector analysis for value added.

same amount be allocated to the top-3 sectors with the highest R&D expenditure intensity, then the 1,477 million EUR invested in R&D would generate a return rate of 12% (+50%), mostly in the same most reactive industries mentioned above.

In particular, the results of the impact assessments proposed by this research show how the heterogeneity in the degree of intensity in R&D plays a discriminating role in the impact on value added associated with the investment in R&D. In the case of the second scenario, we found that although in absolute terms, the first three sectors share approximately one third of the simulated shock, the degree of response of two of them (basic pharmaceutical products and other transport equipment) results considerably greater than that observed in the manufacture of motor vehicles. In fact, when examining the rest of the sectors, the spillover effect of the transport sector stands out, since sectors such as manufacture of fabricated metal products, basic metals or rubber and plastic products are among the top-ten sectors with greatest impact on value added in R&D.

For its part, in the case of the scenario in which we take into account the degree of investment intensity (see shock 3 in figure 3), highlights the relevance of intensity in the growth of the value added. This fact, because this sector manages to respond at the same level as the other two simulated sectors (approximately close to 5%), despite the computer and electronics sector shares over 12.7% of the simulated expenditure amount. In this case scenario, the spillover effect seems to be dominated by the computer and electronic sector, since activities such as scientific and technical, reproduction of recorded media, employment activities and architectural and engineering activities are included in the top ten list of this shock.

Finally, the fourth scenario made it possible to evaluate the role played by investment grants in promoting economic growth. In this case, it is observed that although sectors such as Manufacture of machinery and equipment and Manufacture of food products, beverages and tobacco products are everywhere among the first three sectors to receive investments grants, the degree of reaction is not as great as that observed in the sector of other transport equipment, whose response is significantly higher. Moreover, the food sector, despite playing a leading role in the shock, is relegated to fourth position. All this, revealing the importance that the degree of intensity and the spillover effects have within the economic structure when trying to discriminate its degree of response when the R&D is promoted at sectoral level.

In this sense, an overall increase of 10% of the total amount of business expenditures in R&D in Spain for 2018, distributed proportionally to the current distribution of business expenditures on R&D by sectors, would lead to an increase of roughly 1% of the value added generated by the R&D activities of the manufacturing of computer and electronics, other transport equipment and the pharma industry.

Alternatively, should the same amount be allocated to the top-3 sectors spending most on R&D activities, would lead to increases of nearly 4% in the pharma and other transport equipment industries. Or, should the same amount be allocated to the top-3 sectors with the highest R&D expenditure intensity, would lead to increases of nearly 5% % in the pharma and other transport equipment industries and 4.5% in the computer electronics industry. Eventually, should the same amount be allocated to the top-3 sectors with the highest R&D expenditure funded by the government, would lead to a 6.4% increase in other transport equipment and farther down, machinery and equipment with almost 2%.

Taking into account the heterogeneity transmitted by the different levels of intensity in R&D expenditure, a comparison between simulations results useful to put in order the different scenarios proposed. As can be seen in figure 5, in the case of the base scenario (Shock 1), an additional injection based on 10% of the BERD structure, distributed proportionally (symmetric) over all sectors, would generate an increase in the value added (associated with R&D) equivalent to 8% of the total new R&D investment. However, if this same stimulus (same amount) is allocated following the different criteria described above, we can see that they present different responses. In this sense, we can see that allocating funds to the sectors with higher R&D intensities generate a return of 11.9%. This is followed by the case where the grants are received by the sectors, with the highest BERD expenditures (10.6%), and eventually the scenario where R&D grants are allocated to the sectors with the highest government support in R&D (9.5%). Indeed, a smart specialisation could have the potential to increase the return of the R&D investments by 50%, from 8% (shock 1) to 11.9% (shock 3).

This paper sketches a new methodology based on robust techniques and official statistics on national accounts and R&D data in order to inform policy makers about how to allocate R&D investment funds smartly across industries, therefore making the most of the subsequent businesses R&D expenditures and their related spillover effects throughout the whole economy.

As a result, we show evidence that a smarter specialization on specific sectors with higher R&D expenditure intensities over GDP (or gross value added) for Spain can increase up to 50% the return of the R&D investment throughout the whole economy. For instance, reallocating R&D investments to the top-3 industries with highest R&D intensities would lead to a return rate of almost 12% while doing it uniformly would just generate a rate of return of 8%. By industries, the pharma industry, other transport equipment and computer and electronics manufactures had the biggest contributions to that of 12%.

Finally, the next steps pursued by this research are applying the same methodology to others EU Member States involved in the pilot action "Partnerships for Regional Innovation[5]" (PRI), as a tool to support the directionality of national innovation policies.

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[5] For more details see https://s3platform.jrc.ec.europa.eu/pri

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