CROWDING IN OR CROWDING OUT? NEW EVIDENCE ON PRIVATE AND PUBLIC ENERGY RD&D INVESTMENTS

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Overview

One of the most important issues in designing efficient innovation policies is whether private and public R&D expenditures behave like complements or substitutes. Preoccupations over this question stem from the concern that public investment inflows to the R&D sector substitute for the private investments that firms would otherwise undertake rather than correcting for market-failures in the knowledge-creation market (David and Hall 2000). The empirical evidence with respect to crowding out of private R&D is rather controversial (David, Hall, and Toole 2000). There has been so far no structural or analytically-grounded model taken as reference by empirical studies, which often ask a plethora of different research questions and whose results are often plagued by omitted-variable bias and data availability.

Assessing the relationship between private R&D investments and public innovation support is particularly important with respect to energy and environmental R&D. Environmental problems marry the issue of innovation with that of environmental externalities. This typically calls for the combination of two regulatory instruments, namely environmental policy and innovation/technology policy (Tinbergen 1975, Carraro et al. 2010). Notwithstanding this peculiarly, only a few of the existing contributions focus on the energy and environmental R&D sector, mostly due to a pervasive scarcity of data (Popp and Newell, 2011). To our knowledge none of the existing studies look at the power sector.

Methods

Our empirical framework is that of a knowledge production function derived from R&D-based growth models, in which technology is the fundamental source of economic growth. Contrary to most studies that approximate technology with total factor productivity, we use knowledge stocks from patents to approximate the growth rate in technology. This approach allows for a technology-specific analysis based on existing data, which is complemented with a broader assessment of the power sector (by focusing on the industry "Electricity, Water and Gas Distribution"). Using this framework, we test whether there is complementarity or substitutability between private and public R&D on the one hand, and dedicated and general purpose R&D on the other hand.

The first contribution of this analysis is the creation of a novel database that complements available private and public energy R&D investments from different sources with energy venture capital data, for both OECD and developing countries. In fact, while public energy R&D is to some extent available for a broad number of countries, private R&D has proven more difficult to measure. We discuss and propose different methodologies to define and compute private R&D in the power and energy sector. In addition, we discuss the more general concept of innovation investments, which should not be confined to R&D expenditure or patent data (Hall, 2011).

The second contribution of our paper is to extend the analysis of complementarity and substitutability between public and private R&D investments beyond the traditional US-based and manufacturing-based focus, both in terms of geographic and sectoral coverage. Our empirical application examines the interactions between public and private funds with a focus on (1) the maturity of the funded technologies, (2) the type of public support to innovation, (3) the role of energy and environmental policy and (4) the importance of a specific technology in a country's economy. This allows examining whether certain conclusions proposed by the literature are specific to the US context or can be generalized to other countries, including emerging economies.

Results

We provide country-level statistics and aggregate trends for both private and public R&D in the power sector, with particular attention to individual technologies such as renewables, nuclear, and fossil fuels. Power sector R&D is only a subset of energy-related R&D in a country. Energy-related R&D also includes investment in mining and extraction, transportation technologies, buildings, and more general energy efficiency. However, the power sector is one of the sectors with the highest emission abatement potential and for this reason it is the focus of our research.

The collected data reveals that the power sector is not particularly R&D-intensive in terms of private expenditures (at most about 2% of total business R&D in countries such as China, Canada, and France). More precisely, three patterns characterize business R&D in this sector. First, the power sector is more R&D-intensive in nuclear-oriented countries. Looking at the different technologies in the power sector for selected nuclear-oriented countries, most private power R&D goes to nuclear power and fossil power energy, which between 2007 and 2010 grew by 6% and 9%, respectively. Average annual business investments between 2007 and 2010 in fossil and nuclear power have been between 450 and 630 1995USD mn, with larger investments in nuclear. Although private R&D dedicated to renewable power in 2007 was only 130 USD mn, this amount grew between 2007 and 2010 by 66%. To some extent, this pattern is similar to that observed in the allocation of public R&D resources, which have been increasingly in fossil (+14% between 2007 and 2010) and renewable power (+56% between 2007 and 2010) while nearly constant in nuclear (0.25% between 2007 and 2010).

Second, top innovating countries when considering manufacturing and other sectors, are often not top innovators in power sector technologies. For example, while the US private R&D expenditures in the manufacturing industries are the highest (157 1995USD bn in 2000), the business sector in the USA invests less than the French business sector in power (in 2000 146 1995USD mn versus 502 1995USD mn). As a matter of fact, a lot of energy R&D occurs outside what is strictly classified as "power" sector. A number of the top world companies are not classified under the sector electricity because their main product segment is not power generation, but they perform R&D that is relevant to the power sector. We develop a methodology to estimate private R&D that is related to the power sector, though not strictly classified under the electricity sector. Results show that neglecting the power-related business R&D classified under other sectors significantly underestimate the size of business power R&D, especially in top R&D investing countries, such as Japan, Germany, and the USA. For example, in Japan accounting for the power R&D that is classified in other sectors adds almost 300 USD mn.

A third pattern observed is that, while in some countries private power R&D represents most of the overall private energy R&D (i.e. Denmark, Portugal, Sweden, Mexico, Japan), in countries with large natural resource endowments (i.e. United States, China, and Russia) most of private R&D occurs in non-power energy sectors (i.e. mining and quarrying, coke and petroleum products). In some countries private venture capital funds play a significant role in fostering early development, deployment, and market diffusion of energy technologies around the world. We are able to combine R&D data with venture capital only in the power renewable sector. We observed that while this type of funds has been particularly important in the USA and Canada, over the last ten years fast-developing countries have become major players in the development and production of energy technologies. In fact they have been attracting an increasing share of venture capitalitsts' funds. In addition, the amount of cross-country investment is also significant, showing that the market for energy technologies is global. A comparison of investment statistics with data on patents for renewable and fossil fuel technologies shows that innovation in energy sector and technology diffusion through patent duplication has increased, albeit with important differences across technologies.

Regarding the relationship between public and private R&D, patterns are highly country-specific. In most countries we observe an increase in both private and public R&D in the renewable power sector, pointing in the direction of complementarity between private and public funds. In contrast, the recent economic crisis and the green stimulus package seem to have affected mostly private venture capital investments in the power renewable sector. There are few exceptions such as India and Germany where private venture capital investments did not decline despite the increase in funding from public sources.

Conclusions

The evidence provided in this paper clarifies the dynamics of public versus private R&D investment and lays the grounds for a solid empirical analysis of the relationship between private and public energy investments, with a specific focus on the power sector. Because of the wider sectoral and geographical coverage of our dataset, the analysis qualifies whether the conclusions that have emerged from assessments specific to the US context hold more generally for different countries and sectors.

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