Determinants of Energy Research Output in Top Energy Research-Producers: The Role of R&D Intensity and Rate of Return

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Overview

The literature has always shown that there are two important factors in the improvement of a country's research output: Gross Domestic Product (GDP) and R&D Expenditures. Taking the discussion a step further, and in an effort to provide policy recommendations on what is needed to boost research capacity, this paper aims at decomposing the change in energy research papers into three factors: GDP, R&D intensity (ratio of energy R&D to GDP), R&D rate of return (number of papers per unit of R&D expenditure). The group of countries is selected due to its top performance in research production and in order to provide policy lessons to other countries. The findings showed that during periods of high research productivity (2000-2011) the direction of the impact of the three different factors is completely opposite to low research productivity periods (1981-2000). The R&D intensity and return effects turn into positive contributors to changes in the energy-related research output, while GDP became negative, albeit smaller in magnitude than the positive contribution before 2000.

Methods

Decomposition techniques have been used extensively in the energy literature to decouple the effects of various factors on the evolution of emissions or energy consumption for example (Inglesi-Lotz & Blignaut, 2011; Inglesi-Lotz & Pouris, 2012; Shao, et al., 2016; Sumabat, et al., 2016; Xu, et al., 2016). Within the IDA approach, there are various methods to employ but there is no consensus as to which one is the best. We decided to follow the method proposed by Ang and Liu (2001) and Ang (2004) who argue that the logarithmic mean divisia index (LMDI) should be preferred to other methods.

Using the equation below, the assumption is that the drivers of energy research (measured by the number of academic papers) do not interact with each other; but their relative contributions in both sign and magnitude can be detected and compared over time. In the LMDI method used here, changes in energy academic publications (Research) are decomposed into three factors: the country's GDP, the R&D intensity (R&D expenditures as a share of GDP), and the return of R&D expenditures (research output/ R&D).

$$Research_i = \sum GDP_i * \ R\&Dintensity_i * \ R\&D\ return_i \quad (1)$$

Hence, changes in research output are equal to the sum in changes of each of all the drivers. The logarithmic scheme (weight) used here is adopted from Zhao, Ma and Hong (2010) where w_{it}= ln ($Research_{it}/Research_{i0}$)=($Research_{it}$-$Research_{i0}$)/ln($Research_{it}/Research_{i0}$).

The data are derived from the IEA RDD Budgets database (IEA, 2018), and the Thomson Reuters databases (Thomson Reuters, 2017) for the period 1981- 2011 for the ten most prolific countries in energy-related issues (Ecology, Energy & Fuels, Environmental Studies, Water resources) as classified in Thomson Reuters: US, UK, Canada, Germany, Australia, France, Japan, Spain, Netherlands, and Italy.

Results

Looking at the results for the countries group in its entirety for the full period from 1980 to 2011, that changes in R&D intensity and R&D return had a negative impact to changes in energy-related research output, while changes GDP (as expected) was the main reason for the increases. Individually for each country, changes in GDP are the main and high positive contributor to changes in research output, while R&D return rates were the counter/negative contributor in all countries. The effect of R&D intensity varied among different countries with Spain and Australia exhibiting it as a positive (but small) contributor to changes in research output, contrary to all the rest.

The period from 1981 to 2011 was characterized by drastic changes in economic growth and in the interest of the literature in energy-related fields. Especially after the 2000s, the consequences of climate change as well as issues in energy security have attracted attention by researchers. Based on this, the study proceeds with a separate decomposition exercise for two periods: 1981-2000 and 2001-2011. The results show that in the two periods the role of the determinants is mirror- opposite. During the higher research producing years (after 2000), the R&D intensity and return effects turn into positive contributors to changes in the energy-related research output, while GDP became negative, albeit smaller in magnitude than the positive contribution before 2000. These reflect the higher R&D intensity from the 2000s both in values and as a percentage to GDP, showing the attention of R&D investors towards energy –related issues.

Conclusions

The results of this paper confirm and promote the importance of R&D expenditures as a share to total GDP into production of knowledge in the form of publications. However, a boost in such expenditures in energy-related fields have potential risks towards an optimal allocation of R&D expenditures. Popp and Newell (2012) stress the fact that many studies support the positive impacts of R&D expenditure to the development of energy technologies and knowledge, however it is imperative to discuss where this funding is derived from. An example is Roediger-Schluga (2003) that has shown that many firms substituted other types of R&D and redirected their funds to R&D in environmental applications. In past literature, models such as Nordhaus (2002) made strong assumptions such a fixed R&D labour, and hence, energy R&D crowds out either types of R&D. On the other side, studies such as Buaonanno et al. (2003) deal with R&D expenditures in various fields as complementary – in that way, crowding out does not exist. This study does not evaluate such crowding out effects, more importantly since the indicator used here is the energy R&D expenditures as a percentage to GDP and not as a percentage to total R&D of the countries.

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