Government-Funded Basic Research: What's in It for Firms?

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Abstract

We rely on previous research and highlight the subtle pathways by which state-funded basic research has the potential to affect economic growth and livings standards in the long run. In so doing we acknowledge that basic research itself does not immediately lead to marketable products. The channel that we focus on is that basic research paves the way for profit-driven applied R&D. Without a sound knowledge base about how nature works (the "epistemic base"), new technologies would be difficult to develop and firms would be less willing to invest in applied R&D in the first place. In other words, government-funded basic research has a strong effect on the productivity of private profit-driven applied research. In many cases, government-funded basic research is even a necessary input for profit-driven applied R&D.

There is widespread agreement among economists that long-run economic prosperity is determined by productivity growth, which is in turn largely driven by technological progress.[1,2] We get a glimpse into the improvements in living standards that new technologies (invention) and improvements of already existing technologies (innovation) have brought about over the last two centuries when reading, for example, the recent contributions of Angus Deaton or Robert Gordon on technological progress and the escape from poverty.[3,4] Innovation and invention are themselves determined by purposeful investments in research and development (R&D). What is less clear and subject to intensive debate, however, is the extent to which different forms of investments in R&D affect technological progress. While it is without doubt that a backbone of innovation and invention are the many innovative firms that invest in applied R&D in order to create the new and better products that improve our daily lives so much, there is less agreement on the role of the government in the process. Some claim that the state itself is a major driver of innovation and invention and should therefore invest more in R&D.[5] Others point towards the inefficiencies of government-financed research and claim that the state should refrain from running R&D projects.[6] One reason for this disagreement may be that technological progress becomes evident to the general population only after it is tangibly embedded in the goods (and, maybe to a lesser extent, services) that one can use or at least see how others use them. The major breakthroughs of basic research are therefore rarely recognized by the general public.

In our contribution we rely on previous research and highlight the subtle pathways by which state-funded basic research has the potential to affect economic growth and livings standards in the long run.[7-10] In so doing we acknowledge that basic research itself does not immediately lead to marketable products. The channel that we focus on is that basic research paves the way for profit-driven applied R&D. Without a sound knowledge base about how nature works (the "epistemic base"), new technologies would be difficult to develop and firms would be less willing to invest in applied R&D in the first place.[11] In other words, government-funded basic research has a strong effect on the productivity of private profit-driven applied research. In many cases, government-funded basic research is even a necessary input for profit-driven applied R&D. Without a sound knowledge base generated by basic research, firms would not be able to successfully implement the applied R&D projects that are needed to create the highly valued new and better technologies that can compete on the market.

By taking the spillover effects between basic research and profit-driven applied research accurately into account, we quantify our theoretical model and find that the social welfare-maximizing level of basic research expenditure by the government is substantially higher than the levels we observe nowadays in OECD countries. In the medium variant of our simulations, we find that the level of basic research outlays that would maximize the long-run social welfare level is around 5% of GDP, while the average within OECD countries between 2000 and 2009 was 0.66% of GDP.[12] At first glance, this massive difference of a factor of 8 might seem large, but calibrations by other growth economists together with the parameter values from empirical studies imply that (public and private) research expenditures together would have to rise by a factor of 15 to reach their long-run optimal levels.[13,14]

As far as concrete examples are concerned, there are numerous breakthroughs in government-funded basic research that have unleashed enormous potential for profit-driven applied research, and have led to substantial technological progress. Virtually all high-tech goods that we are using today build upon major insights from basic research in the past. The brief list below provides only a small sample of the long-run impact of basic research but nevertheless illustrates that the factor of 8 by which government funding for basic research would have to increase to attain the welfare-maximizing level as derived by our simulations, might not be too high:

- modern computers are based on the mathematical logic and on the binary system developed by Leibniz in the 17th century;[15]
- the internet was developed at the government-funded "European Organization for Nuclear Research", better known under its acronym CERN;[16]
- without Einstein's theory of relativity, GPS would not function as we know it today;[17]
- without Einstein's insights on electromagnetic radiation, lasers might not exist, and, of course the many applications of lasers ranging from laser pointers, DVD players, and surgical laser to lasers used for cutting different materials at an industrial scale, would be infeasible;[18]
- the chemical foundations of fertilizers were developed by basic research at universities that led to industrial applications only later;[19]
- without an understanding of nuclear fission as gained in the late 1930s at public research institutes, nuclear power plants would not exist.

Most of these examples show that at the time at which the basic research took place, nobody was able to foresee the enormous benefits of these technologies and the potential for firms to develop marketable products based on the newly created knowledge.

Against this backdrop, the question arises as to how it is possible that governments continue to invest such inefficiently low amounts in basic research. If everybody benefits when more resources are devoted to basic research, why does the political process not converge to such a situation? The answer to this question might be that there are short-run costs that have to be shouldered before the fruits of government-funded basic research investments can be collected. Since the corresponding "gestation lag" for basic research is long, the incentives for governments to invest in R&D are rather low because they primarily care about getting reelected in the short run (which is, admittedly, more likely when pensions are raised or when social benefits are distributed, than when funding is provided to double the collision energy at the Large Hadron Collider from 7 tera-electronvolts to 14).

As far as managerial consequences are concerned, our results imply that a close collaboration between firms and universities or public research institutes is likely to increase the potential for mutually beneficial scientific discoveries. The closer the private profit-driven research sector collaborates with publicly-funded research facilities, the more likely it is that new products and/or products with a substantially higher quality emerge. This has the potential to generate large profit opportunities for firms who are among the first movers in using the discoveries from basic research to create new and/or improve existing technologies.

Potential opportunities for collaboration between innovative firms and the public basic research sector might include:

- sponsoring grants by firms to carry out basic research, ideally in close collaboration with in-house applied scientists;
- granting stipends for applied researchers of in-house R&D departments to work on basic research projects in areas that are related to those areas in which the firms that grant the stipends plan to innovate;
- establishing joint research labs in specific promising areas with the purpose of carrying out basic research that could lead to breakthroughs that are necessary for applied research – e.g. collaboration between airlines and public basic research institutes in the development of second-generation biofuels that can be used by planes;
- facilitating student exchange programs between industry and universities, where promising students are offered the opportunity to carry out joint research with in-house R&D departments. The results of this research could then be part of a Master's or PhD thesis.
- financing endowed professorships in fields that are of crucial interest to firms and/or industries;
- sponsoring research workshops, conferences, and think tanks, where the mutual exchange between basic scientists and applied scientists can be facilitated.

Scaling up these types of collaborations could lead to profitable business opportunities and might generate beneficial side effects from a general public relations (or marketing) point of view. Based on our own (basic) research, we are confident that the benefits we described would indeed materialize.

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