Who should do R and who should do D?†

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Abstract

This article studies the reasons for the under-investment in research vs. development in the decentralized equilibrium and argues that this bias provides a micro-foundation for the government direct involvement in conducting applied research rather than just financing it.

Keywords: Innovation, Research, Development, Public involvement in R&D, R&D subsidies.

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1. Motivation

Should the government be directly involved in R&D activities? So far, the economic literature on R&D policy has focused exclusively on the foundations for R&D subsidies. That is, for the government to reduce the private cost faced by companies when conducting R&D activities (see, e.g., Aghion and Howitt, 1998, and Jones and

Williams, 1998, 2000). There are good reasons to subsidize R&D.[1] R&D investments produce knowledge that helps other researchers in developing new innovations in the future. Because this societal gain is not internalized by innovators, researchers end up devoting fewer resources to R&D activities than what a social planer would. To correct this underinvestment, the government should subsidize R&D.

This argument leads to the conclusion that R&D subsidies suffice to implement the first best allocation of resources. Therefore there is no rationale for the government (or public organizations) to be directly involved in the conduit of R&D activities.

One exception to this conclusion is the case of strategic projects such as those in national defense. Government involvement in those projects can be justified on several grounds. First, the necessity of keeping secret both the process and product of the research. Second, the urgency of some national defense projects requires a degree of coordination with the government that is only achieved by being directly involved in the process.[2] Those two features are absent in the majority of research projects. Therefore, the conclusion that the government should not be directly involved in R&D (other than in strategic defense projects) prevails.

However, there are many examples of innovations that have been not only financed but also developed by researchers in public organizations. Take for example the German public organization Fraunhofer. Fraunhofer is famous for the invention of the MP3. However, this is just one of the approximately 500 patented innovations it develops per year. Fraunhofer innovations span all areas of science and engineering. Some examples include the developing of the Dandellion Rubber, new techniques for printing electronic circuits in flexible materials, new methods of detection of specialized tumor markers, special glue for plane wings, specialized sorting machines, new techniques for the production of highly resistant plastics, etc.

The significance of public R&D we observe in the world raises important questions: Is it possible to attain the efficient allocation of resources just with R&D subsidies? If not why? Is it optimal that public organizations directly engage in R&D? What types of R&D should the government focus on, if any?

This paper provides some answers to these questions. First I clarify the important distinction between research and development and argue that private research organizations will focus primarily in the latter. In section 3, I describe how a socially

[1] There are also reasons to tax R&D activities since successful innovators steal the rents from incumbent innovators and perceive as private gains what is just a transfer (see, e.g., Aghion and Howitt, 1998).
[2] One famous example is the Manhattan project that led to the development of the atomic bomb.

optimal allocation of resources will differ from the competitive equilibrium. In particular, the social planner will want to devote more resources to applied research than private companies do. As a result, the competitive equilibrium will have a disproportionate amount of resources devoted to development relative to applied research.

Of course, private incentives can be affected by government subsidies. However, it may be difficult (and too costly) for the government to verify ex-post whether an R&D activity is research or development. If the government cannot distinguish between research and development activities, it cannot subsidize these activities at different rates. In section 4, I describe how the direct government involvement in R&D may be a way to solve this problem and help implementing the first best allocation of resources between research and development.

2. Types of R&D

There are three types of R&D activities which differ in the stage of the innovation process at which the activity takes place. Basic research develops fundamental scientific knowledge. Applied R&D uses basic research to develop new prototypes for products and processes. Finally, product development activities take existing prototypes and polish them until a product that is ready to be brought to the market is developed.

Researchers face two distinct challenges to move new technologies from Research to Development. The first is a funding gap. Basic research is financed by public funds that often go to universities. Development (i.e. once you have a prototype that works) is financed by venture capital, investors or industry. But the bridging function, applied R&D, is often considered too applied for public funds and too risky for private capital to jump in. In other words, applied research is typically too far from the stage where research output can be monetized for private companies to find it an attractive investment.

The second element that creates a barrier between research and development is a knowledge gap. According to Andre Sharon, director of the Fraunhofer Center for Manufacturing Innovation, “basic researchers are typically not best suited or motivated to develop the research into functional technologies.” On the other hand, most companies do not have the capabilities to transform basic research into well-developed products and services.[3]

[3] See Comin, Trumbull and Yang (2011, 2012a and 2012b).

As a result of the high costs, high risks, and lack of technological expertise in applied R&D, private companies tend to invest significantly less in applied research than in development activities.

3. Market allocation vs. social planner

The relevant policy issue, however, is not whether there is more applied R&D or development investments in the economy but whether this imbalance corresponds to what the social planner would choose. That is, whether the market bias against development activities is shared by the planner or not.

There are reasons to believe that the market allocation of resources presents a greater bias against applied R&D than the social planner. Applied R&D activities tend to produce greater knowledge spillovers than product development. That is the case for several reasons. First, greater knowledge is produced when trying to come out with a prototype than in perfecting it. Because part of this knowledge may spillover the researcher benefiting other researchers for free, researchers will under-invest in research, and more so in applied research than in development activities.

All knowledge needs to be assimilated by the researcher for other people to have access to it. Private companies may lack the capacity from assimilating much of the knowledge they produce in their applied research activities (Cohen and Levinthal, 1990). This is the case for at least two reasons. First, applied research knowledge is more general than development knowledge. That is, it more widely applicable in other fields. Second private companies tend to be too narrow. Instead of being wide and cover many areas, they tend to focus on one area because their ultimate goal is to bring products to the market which is what provides revenues. If for these reasons private researchers cannot appropriate the knowledge they produce, they cannot reap the value it has for society and they will tend to under-invest in applied research activities.

Finally, the ability of the researcher to appropriate the future stream of revenues produced in society from the knowledge produced is lower the further the research is from revenue generation point. Since companies generate most of their revenue by either selling products or using processes (that is after the innovation has gone through the development stage), discoveries/innovations from applied research are further from the revenue generation point than development activities.

Note that, the severity of this last driver of private under-investment in applied research would be smaller if applied research knowledge was something that could

be easily sold between developers and users. If this was the case, applied researchers could monetize directly the output of their research without having to wait to the development of products that embody them. However, in most circumstances, applied research knowledge is not marketable. It is hard to verify ex-ante the quality of the applied research. Significant portions of the knowledge produced are not patentable. They reside within the organization's expertise and they are hard to transfer to other organizations and to describe in a contract.

In summary, private companies under-invest more in applied R&D than in product development for the difficulty of translating the research output into a profit stream, and the difficulty of absorbing all the knowledge produced.

4. Implementing first best under non-verifiability of R&D type

One way to fix these distortions is by combining a standard R&D subsidy with the creation of a public institution that specializes in conducting applied R&D. The R&D subsidy would alleviate the general under-investment in R and D. The creation of the institution that just does applied research, can address the bias towards R vs. D that characterizes the decentralized equilibrium. In particular, the institution should be publicly financed, at least partially. It should cover many areas of applied science and engineering to take advantage of the cross-over possibilities between different fields and to facilitate the assimilation of knowledge created.

Finally, it remains to be addressed how the research output of this public institution is transferred to society so that companies can benefit from it. I see three channels. First, private companies will have access to the patented knowledge the institution creates. Second, researchers from public institution can go to work with private companies that can benefit from the knowledge they have acquired. Third, and most importantly, private companies can engage in collaborations with the public institution by which they present the institution their technological problems and the institution assembles a team that uses the stock knowledge the institution has acquired to solve the problem.

Incidentally, these design features of the public institution are shared by the German public organization, Fraunhofer.

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