Note: This document is an English translation of the corresponding Japanese core content text (excluding figures and tables) compiled by the Core Curriculum Editorial Committee. The secretariat of the Committee, the SciREX Center of National Graduate Institute for Policy Studies contracted the translation out to professional translators. If readers notice questionable English translation, please refer to the Japanese text of the core content.)

2.0.3 Legitimacy of science, technology and innovation policy

NAGATA Akiya[1]

First Published August 28, 2018 Final Updated April 25, 2019

Abstract

This paper provides an overview of the theoretical basis upon which policy interventions in the process of science, technology and innovation have been justified.

Keywords

Public goods, market failure, incentives, development competition, external economies, external diseconomies, crowding out

1 Introduction

The major players in technological innovation are the companies that develop and introduce new products and processes. Their economic activities are conducted through the market, which is a system of value exchange. If the market mechanism is fully functioning and the resources necessary to carry out the innovation are efficiently mobilized, or if the market adjustment function is operating in spite of temporary inefficiencies, then policy intervention in this process is redundant and even harmful insofar as it involves an unnecessary waste of resources. In this context, traditional debate on innovation policy has grounded the legitimacy of policy interventions in the factors that lead to "market failure."

In other words, the rationale this justification presupposes is the existence of a market mechanism that achieves equilibrium in the allocation of resources. However, the recent history of economic theories

1 Professor, Kyushu University Faculty of Economics Graduate School of Economics.

emphasizing the "limited rationality" of decision-making and the existence of "asymmetric information" in market transactions is a history of objections to the equilibrium theory, and these objections have provided important clues to a deeper understanding of the innovation process. Accordingly, we should not rely on theories that view factors causing inefficiencies in resource mobilization as "failure" factors undermining the original market mechanism, but search for theories that reconsider them as intrinsic attributes of market transactions and base innovation policy thereon. However, to embark on such an exploration, it is essential to first understand the framework of the traditional debate. In light of its purpose as a core text, this paper focuses on basic concepts and other issues that have traditionally grounded the legitimacy of innovation policy.

2 Why do governments intervene in the process of scientific and technological innovation?

Coombs et al. (1987) identified a variety of reasons used to justify government intervention (i.e., support and regulation) in science, technology, and innovation. These can be summarized as follows:

- There is a causal relationship between science, technology, and innovation and economic growth.
- The scale of R&D investment in new and advanced technologies is so large that individual companies are unable to assume the risks associated with such investment.
- We need to support industries that are facing international competition.
- There is not always a return on investment in technology in areas that are critical to industry or society as a whole, such as energy, transportation, and communications.
- Basic knowledge will be useful to the industry in the long run.
- As many basic and academic research areas do not necessarily lead directly to discoveries that produce technological change, market mechanisms make the allocation of resources to these areas inefficient.
- Small industrial sectors such as agriculture lack sufficient R&D resources to create economically and socially desirable technological change.
- Research and development in areas such as health services should not be governed solely by market mechanisms.
- Research and development related to national defense is by definition a matter of policy.

That is not to say that these reasons each have their own basis; in some instances, they are interrelated. As Coombs et al. note, many such reasons also include the claim that the social benefits of R&D conducted by companies are greater than the private benefits enjoyed by the companies concerned. These arguments have been based on the fact that knowledge or information about technology—the result of research and development—has the character of a "public good," as will be discussed later.

3 Knowledge as a commodity

Arrow (1962) pioneered the perspective of analyzing knowledge or information about technology (hereinafter, technical knowledge) as a good.[2] Arrow considered the development of inventions and new technologies (R&D) as an activity that produces technical knowledge, and discussed the factors that cause inefficiencies in the allocation of resources to its production through the following three points: (1) the fact that R&D involves "uncertainty"; (2) the indivisibility of the technical knowledge produced makes it difficult to sell in the market; and (3) the technical knowledge produced has the qualities of "inappropriability" and "non-excludability of consumption" by third parties, making it difficult to recover the benefits of the technical knowledge. All of these points have been cited as factors that undermine R&D incentives and lead to firms underinvesting in development. Of these, "uncertainty" is associated with the productive activity of invention, while "indivisibility" and "non-proprietary" (i.e., the "non-excludability of consumption") are factors associated with technical knowledge itself as a good. Moreover, the latter factor, referred to as the impossibility of exclusivity or the impossibility of exclusion of consumption, is what gives technical knowledge in particular its character as a "public good."

4 What is a public good?

Public goods are defined as goods that have one or more of the following characteristics: (1) non-excludable consumption, which refers to the inability to exclude third parties, other than producers and economic agents with whom one has a business relationship, from consuming the good without paying for it; and (2) non-rivalrous consumption, which refers to the ability of multiple economic agents to consume at the same time without incurring additional costs. Goods with both of these characteristics are called "pure public goods," goods with one of these characteristics are called "quasi-public goods," while goods with neither of these characteristics are known as "private goods."

The benefits that the non-excludable nature of consumption provides to third parties other than those party to the transaction are called "external economies." As the production of goods of this nature is not accompanied by sufficient incentives, this may lead to underinvestment, that is, investment below socially desirable levels. In this sense, the nature of public goods that generate external economies has been regarded as one of the factors that bring about "market failure." Scientific knowledge is an example of a pure public good. Although its production may entail significant economic and time costs, producers do not have a monopoly on unpatentable scientific knowledge, and benefits acquired by third parties through the use of knowledge are an external economy. The production of such knowledge is expected to be underdeveloped because no one is willing to actively invest in its production, generally preferring to act opportunistically to enjoy the external economy of knowledge produced by others instead.

2 For a detailed discussion of Arrow's (1962) argument and critiques thereof, see Motoshige Ito, Kazuharu Seino, Masahiro Okuno, and Kotaro Suzumura (1988).

5 Development competition and external diseconomies

While Arrow (1962) demonstrated the possibility of underinvestment in R&D, Dasgupta and Stiglitz (1980a), Dasgupta and Stiglitz (1980b), and others have criticized the analysis for failing to take into account competition over technological development. As long as there is a possibility of monopoly profits exceeding the development investment for the company that succeeds in R&D the earliest, the competition among companies will not end and duplicate investments will be made for the same development issues. However, as the improvement of social welfare can only be achieved when one of the development projects succeeds, this situation generates over-investment above socially desirable levels.

In contrast to the external economies mentioned earlier, external diseconomies are those that bring costs or disadvantages rather than benefits to economic agents other than the parties to the transaction. The duplication of investment brought about by the rush to develop is said to be analogous to the external diseconomies of traffic "congestion."

6 Justified policy

The type of policy that is justified depends on whether the current situation surrounding corporate R&D is one that generates underinvestment or overinvestment. Situations of underinvestment are amenable to policies that either directly involve the production of knowledge as a public good, or that supplement the incentives of firms. Specific measures include government investment to promote research and development at universities and public research institutions, measures to promote R&D in the private sector (e.g., tax incentives for R&D, R&D subsidies, government-contracted R&D, government procurement, and low-interest loans for R&D by government-affiliated financial institutions), and strengthening the protection of intellectual property rights.

On the other hand, situations of overinvestment are suited to the policy types that reconcile firms' interests. Specific measures include promoting government-led collaborative R&D projects, technology licensing, and technological standardization. Adopting regulatory policies is justified if the technology developed generates external diseconomies.

7 Negative effects of government investment

Under the circumstances mentioned above, where the technical knowledge subject to R&D is of a public goods character and there is underinvestment by firms, a policy of direct government involvement in the production of such knowledge is justified. If such policy choices are appropriately made, they can have the effect of inducing companies to invest in R&D for the purpose of applying and putting to practical use the knowledge generated by government investment.

However, government investment does not necessarily have a positive effect on private sector investment.3 This is because greater government spending can crowd out private investment by increasing government borrowing and raising the interest rate. Moreover, even in the context of low interest rate policies, government investment may discourage private sector investment if its objectives are substitutive in nature for private sector investment.

David et al. (2000) reviewed thirty-three previous studies analyzing the relationship between government R&D and private R&D and reported a net substitution effect in nine of nineteen studies that used finer units of analysis below the firm level, while two of the fourteen studies used larger units of analysis above the industry level. These differences in the results of the analysis occur not only between the levels of data aggregation, but between the countries included in the analysis. Studies using data from the US, where the federal government provides large amounts of contract research funds, have often reported substitution effects for private R&D, while studies on other countries have reported relatively few cases of substitution effects, even when the level of data aggregation is small. An analysis using data on government R&D investment by country and purpose would be required to identify the reasons for these differences.

8 Conclusion

The argument based on the equilibrium theory explained in this paper suggests that the type of policy that is justified in terms of optimizing the allocation of resources to R&D differs depending on whether a company's R&D investment is in a situation of underinvestment or overinvestment, and that the measures that should be taken also differ. This approach to policy selection implicitly assumes the view that "firms are not in a position to achieve total optimality even if they attempt to be rational, so policymakers maximize the benefits to society as a whole by designing appropriate institutions."

However, the approach taken here must be developed from the following critical perspectives. First, the task of science, technology and innovation policy does not stop at optimizing the allocation of resources to R&D if firms are not in a position to achieve the overall optimum. If there are also factors that limit the rationality of firms in the R&D process, as well as in the process by which the results are used and disseminated, then complementary and coordinated interventions by policy are justified. Second, just as the rationality of firms is limited, so policymakers are not always rational institutional designers. The policy process must be understood as an evolutionary process involving trial and error, and in order to learn from trial and error, policy evaluation must be justified as forming part of the policy process. By considering the perspectives above, we can understand the rationale for the system of science, technology and innovation policy as a whole.

---

3 For more details on the following, see Nagata Akiya (2003).

References

Arrow, K. J. (1962). Economic welfare and the allocation of resources of invention. In The rate and direction of inventive activity. Princeton University Press.
http://www.nber.org/chapters/c2144.pdf

Coombs, R., Saviotti, P., and Walsh, V. (1987). Economics and technological change. Macmillan.
http://wrap.warwick.ac.uk/24619/

Dasgupta, P. and Stiglitz, J. (1980a). Industrial structure and the nature of innovative activity. The Economic Journal, 90(358):266–293.
https://www.jstor.org/stable/2231788?seq=1#page_scan_tab_contents

Dasgupta, P. and Stiglitz, J. (1980b). Uncertainty, industrial structure, and the speed of R&D. The Bell Journal of Economics, 1–28.
https://academiccommons.columbia.edu/download/fedora_content/download/ac:160374/content/5748978.pdf

David, P. A., Hall, B. H., and Toole, A. A. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. Research Policy, 29(4–5):497–529.
https://eml.berkeley.edu/~bhhall/papers/DavidHallToole%20RP00.pdf

Motoshige Ito, Kiyono Kazuharu, Okuno Masahiro, and Suzumura Kotaro. (1988). Sangyō seisaku no keizai bunseki [Economic analysis of industrial policy]. University of Tokyo Press.
http://www.utp.or.jp/book/b300778.html

Nagata, Akiya. (2003). Seifu kenkyū kaihatsu no yakuwari to keizai kōka [The role and economic effects of government R&D (Special issue on R&D investment and the Japanese economy)]. Economic Seminar,(587):25–28.
https://ci.nii.ac.jp/naid/40006008917/

Information on related course subjects and research projects

- Kyushu University Graduate School Core Curriculum, "Introduction to Science, Technology and Innovation Policy" (Responsible: NAGATA Akiya)