Research Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Repairing the R & D market failure: Public R & D subsidy and the composition of private R & D

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ARTICLE INFO

Keywords:
R & D subsidy
Composition of R & D
Crowding-out effects
Pharmaceutical industry

ABSTRACT

We examine the role of government subsidy in addressing market failure in research and development (R & D). Prior studies have shown that allocating market resources for R & D is not socially optimal due to the expected market failure in private R & D investment. Using Korean pharmaceutical industry data, we analyze the relationship between public R & D subsidy and private R & D investment. We also investigate the impact that public R & D subsidy has on the composition of private R & D expenditures. We find that the government's R & D subsidy stimulates rather than crowds out private R & D activities of small biotechnology venture firms. This finding provides additional empirical evidence that government R & D subsidy can successfully address market failure in private R & D investment. Yet, the empirical evidence that the R & D subsidy program stimulated the biotechnology venture firms to expand their new product R & D activities is found to be rather weak. Consequently, the idea that the Korean government's R & D subsidy program successfully addressed the underinvestment in R & D below the socially optimal level by inducing small venture firms to expand their R & D activities in new product R & D areas is only partially supported. Limitations of this study, the extent to which the test results can be generalized in other industries, qualitative assessments in a broader context, and areas for further study are also discussed.

1. Introduction

Many economists, such as Nelson (1959), Arrow (1962), Krugman (1987), Romer (1990), and Grossman and Helpman (1991), provide theoretical background that justifies government intervention or patronage in private research and development (R & D). Because private firms will not fully recoup their investment in R & D that is intended for public value, the private market lacks the incentive to fund R & D for public benefit. Market failure, such as spillover effects, financial constraints, uncertainties, risk aversion, and dynamic externality, further reduces private funding of R & D.[1] R & D subsidy is a policy tool explicitly designed to help firms undertake socially beneficial private R & D (e.g., Aerts and Schmidt, 2008; Fu et al., 2012; Li, 2012; Meuleman and De Maeseneire, 2012).[2]

Although the market failure theory justifies government R & D subsidy, one major concern is that the theory is not very clear on whether the government can identify R & D projects that are subject to market failure. Government R & D subsidy might simply support private R & D projects that would have been undertaken even without a subsidy and might just crowd out private R & D (David et al., 2000; Dimos and Pugh, 2016; Kauko, 1996; Schneider and Veugelers, 2010; Zuniga-Vicente et al., 2014). Therefore, in most cases, the focus of research is on whether government R & D subsidy complements or substitutes for private R & D, or how much corporate R & D is generated per dollar of R & D subsidy (Gonzalez and Pazo, 2008; Wolff and Reinthaler, 2008). This kind of criterion, however, which only concerns the effect of the government's subsidy on the total amount of private R & D, is too broad.

One criterion that has been neglected is the effect of the subsidy on the composition of private R & D (Zuniga-Vicente et al., 2014). The most distinguishable feature of an R & D subsidy is that the government can target R & D projects that have large expected social benefits but that cannot be undertaken by private firms because those projects will not provide adequate benefits to the firms. On the contrary, other policy instruments, such as tax deductions or credits for private R & D, do not discriminate between R & D projects; therefore, R & D projects with a large gap between public and private returns would not necessarily be

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[1] An alternative theory of R & D competition suggests the possibility of overinvestment in R & D in specific environments such as a patent race (Green and Scotchmer, 1995). This is a rather exceptional case, however, and generally the underinvestment problem dominates.

[2] Extensive lists of prior studies that tested the effectiveness of subsidy programs are summarized by David et al. (2000).

http://dx.doi.org/10.1016/j.respol.2017.06.009
Received 21 December 2012; Received in revised form 22 June 2017; Accepted 29 June 2017

selected even if the total R & D increases with the support of tax incentives (Cappelen et al., 2012). Firms have the greatest difficulty in appropriating returns from new products, which can be reverse-engineered more readily by competitors. Even technologically successful new products might not be adopted in the market because of market uncertainty (Eggers, 2012; Hellmann and Perotti, 2011).[3] Studies have shown that the firms that first develop successful product innovations are not necessarily the firms that ultimately reap the profits. This phenomenon is observed in many businesses that produce automobiles, typewriters, and CT scanners, among other products. In contrast, Cohen and Klepper (1996a,b) suggest that firms can appropriate returns from process or incremental product innovations with relative ease because the firms enjoy higher profits from simply lowering production cost or improving the quality of existing products. If the R & D subsidy program is to be successful, it should be designed to support projects that are the most difficult for private firms to benefit from (Dodgson et al., 2011).

Zuniga-Vicente et al. (2014) claimed that "after almost five decades of research, the empirical evidence (related to the impact of public subsidies on firm R & D investment) is mixed." It is our aim that this research contribute to the literature by providing more empirical evidence regarding how effectively public subsidy addressed the underinvestment of private R & D and the effect of the subsidy on the composition of private R & D using Korean pharmaceutical industry data. The data in this study include the R & D activities of the majority of firms that perform R & D with a response rate of over 80%. This minimizes the self-reporting and sample selection bias found in previous studies.[4] Moreover, the time series nature of these data enables us to conduct a panel analysis. We thus address many conceptual and practical empirical challenges in testing the effects of subsidies. Further, a detailed breakdown of R & D expenditures in different types of innovation (i.e., product and process innovation) in the dataset allows for in-depth analysis, especially on the effect of R & D subsidy on the composition of private R & D.

The remainder of this paper is organized as follows. We review theoretical arguments about the effect of the government R & D subsidy in addressing market failure in private R & D, in particular regarding the effect of the government R & D subsidy on the size of private R & D and R & D composition of subsidized firms. We also briefly describe the market failure in the pharmaceutical industry, which is the context for this research. Then, we discuss the data and method of analysis as well as the research findings regarding the effect of a subsidy on the firms' R & D activities in terms of the amount and the composition of privately financed R & D. We conclude with a discussion of the implication of this research.

2. Theoretical background

2.1. Effects of public R & D subsidy on the size of private R & D

Ideally, the effectiveness of the subsidy policy would be evaluated using cost-benefit analysis, that is, comparing the social cost and the social benefit of the subsidy. However, this type of analysis is almost impossible because it requires complete and detailed information on social cost and benefit. On the one hand, social cost should take into account the opportunity costs in terms of forgone benefits from alternative uses of the R & D budget spent for the subsidy, as well as all the distortions created by the R & D subsidy. On the other hand, social benefit should account for all the relevant benefits, for example, knowledge spillover effects as well as new consumer surplus created by otherwise unrealized innovations. In the absence of this information, previous studies on the effect of direct R & D subsidy on private R & D mostly used the alternative approach of estimating how much corporate R & D is generated per dollar of R & D subsidy, to reveal whether government R & D subsidy "complements" or "substitutes for" private R & D.

David et al. (2000) and Zuniga-Vicente et al. (2014) provide extensive survey results on empirical literature on the relationship between public R & D subsidy and private R & D investment. Their studies reveal considerable heterogeneities with regard to the impact of public R & D subsidy on private R & D investment. For example, David et al. (2000) examined 33 case studies prior to 2000 that reported the relationship between public R & D subsidy and private R & D at both the firm and industry levels, and they found that one-third of the case studies they examined failed to reject that public R & D subsidy crowds out private R & D. David et al. (2000) also reported the marked difference between the U.S.-based case studies and those of other countries with regard to the proportion of "net" substitution effect between public and private R & D investment. The overall complementary relationship for the U.S.-based data is only about 57%, whereas the corresponding proportion among the non-U.S.-based data is approximately 83%. These findings reflect the existence of the regional factors that differentially influence local institutional norms in funding private R & D (David et al., 2000).

Similarly, the survey by Zuniga-Vicente et al. (2014) reports about 19.5% of case studies support the crowding-out hypothesis. In spite of studies that uphold the stimulating effects of government R & D subsidy (Hamberg (1966), Howe and McFetridge (1976), Klette and Møen (1998), Koga (2005), etc.), several studies show that R & D subsidy actually displaces or substitutes for private R & D effort rather than stimulates it (e.g., Shrieves (1978), Lichtenberg (1984), Toivanen and Niininen (2000), and Wallsten (2000)). Further, some studies suggest mixed results. Busom (2000) finds that public funding has complete crowding-out effects in about 30% of Spanish firms in her sample data, while on average receiving government R & D subsidy induces more private R & D. Using the Israeli manufacturing firm data during 1990–1995, Lach (2002) finds that R & D subsidy stimulated privately financed R & D expenditures but has a negative effect on the R & D of large firms. Based on his findings, Lach (2002) suggested that public R & D subsidy should be directed toward small firms.

More recent meta-regression analysis in a study conducted by Dimos and Pugh (2016) reported an overall additionality effect of the R & D subsidy on private R & D. Dimos and Pugh (2016) investigated the 52 case studies published in or after 2000 and examined the effect of public R & D subsidy on private R & D after controlling for publication biases. Importantly, their findings reject the crowding-out effect of private investment by public subsidies. However, their findings fail to provide evidence of a substantial additionality effect (Dimos and Pugh, 2016), which calls for the need for more empirical studies with better measures and data to evaluate the relationship between the public subsidies and private R & D investment.

2.2. R & D composition of subsidized firms

If the government attempts to effectively address the underinvestment of private R & D, it should target the areas where the market failure in innovations would be greatest. However, one major concern is whether or not the government can really devise "subsidy programs" through which R & D subsidy is channeled to R & D projects with greater market failure. If R & D subsidy is applied broadly, it may largely displace private R & D expenditures or induce only additional projects where firms can still appropriate returns, but the private returns are less than the cost of R & D. Then, the effect of R & D subsidy on the firm-level private R & D expenditures could be too broad a measure.

[3] A good example is the beta-type VCR, which was overtaken by the VHS-type of VCR in the 1980s (see Cusumano et al., 1992).

[4] For example, Branstetter and Sakakibara (1998) find that Japanese firms that possessed the most promising R & D projects were reluctant to receive government R & D funding. Moreover, Klette et al. (2000) reported that the insignificance of the Norwegian government's R & D program in the Norwegian IT industry is a result of the fact that the R & D subsidy was mainly directed toward large technology firms that encountered problems during the IT industry restructuring in the late 1980s.