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First- and second-order additionality and learning outcomes in collaborative R&D programs

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Abstract

In this paper, we distinguish between firm-level learning effects that result from 'first-order' and 'second-order' additionalities in innovation policy interventions. 'First-order' additionalities represent direct firm-level R&D subsidies, whereas 'second-order' additionalities result from knowledge spill-overs, horizontal knowledge exchanges between firms, and from other meso- or community-level effects. Analyzing data from collaborative R&D programs in Finland, we show that enhancing identification with a community of practice among R&D program participants (proxy for second-order additionality) enhances firm-level learning outcomes beyond those resulting from direct R&D subsidy (proxy for first-order additionality). Learning effects facilitated by second-order additionality are not confined to technological learning alone, encompassing also business and market learning. We also show that aspects of program implementation enhance identification with a community of practice, which then mediate the relationship between program implementation and firm-level learning outcomes.

Keywords: Additionality; Collaborative R&D programs; Innovation policy; Learning externality; Knowledge spillover

1. Introduction

During the past couple of decades, innovation policy interventions have progressed beyond promoting first-order additionality through R&D subsidies. Increasingly, policy initiatives seek to generate also second-order additionality[1] and promote externalities that facilitate firm-level innovation and learning outcomes (Cantner and Pyka, 2001; Malerba, 1997; Park, 1999). One rationale for such interventions draws on the recognition of the importance of knowledge spill-overs as a facilitating mechanism for innovation and learning within 'communities of practice' (Brown and Duguid, 1991; Jaffe

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[1] The authors would like to gratefully acknowledge the financial support of the Finnish National Technology Agency Tekes and the Academy of Finland ("Liike" Program). In this paper, we define 'first-order additionality' as firm-level technological learning and innovation outcomes that are the direct result of a firm-specific R&D subsidy (in the literature, also referred to as "input additionality"). 'Second-order additionality' is defined as firm-level technological learning and innovation outcomes that result from knowledge spill-overs, technology diffusion, and knowledge exchanges within communities of firms. The presence of first-order additionality (i.e., firm-level R&D subsidy) is not a necessary condition for the realization of second-order additionality in firms. For example, a sector-specific R&D program may, because of knowledge spill-overs, give rise to enhanced innovation outcomes even in firms that do not directly invest in R&D by themselves.

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and Trajtenberg, 1993). When knowledge spill-overs are present, economic agents can learn even without necessarily undertaking internal R&D by themselves (Katz and Shapiro, 1986; Oerlemans and Meeus, 2005). Therefore, by facilitating knowledge spill-overs within communities of practice, innovation policy interventions may create a learning-enhancing externality that promotes firm-level innovation and learning outcomes beyond the direct effect of firm-specific R&D subsidy (Mahmood and Rufin, 2005). When policy interventions address a collective of firms and research institutions simultaneously, the firms targeted by such interventions may start identifying themselves with a community of practitioners, the participants of which share an active interest in the development and use of a given technology (Kaufmann and Tödtling, 2001). By experimenting around a given technology and related business practice, a community of practitioners would operate as a locus for knowledge externalities that would help boost firm-level learning beyond the direct effect of firm-specific R&D efforts (Powell et al., 1996).

Hands-on, externality-focused innovation policy interventions are well exemplified by the National Technology Programs of the Finnish National Technology Development Agency, Tekes. Typically, a national technology program would seek to enhance the technological capabilities of the Finnish industry by carefully building a core group of firms and universities to jointly address a sector-specific innovation challenge. A national technology program could seek, for example, to enhance Finnish industrial capability in the manufacture of injection-molded plastic parts—an important industrial capability for the mobile telephony industry. The production of injection-molded plastic parts involves intense interactions among various players in the value chain, such as mold manufacturers, mobile phone designers, plastic part manufacturers, mobile phone manufacturers, as well as materials suppliers. To function effectively, these need to implement shared enabling technologies (such as shared computer-aided design systems) to facilitate coordination and the resolution of technical problems that may emerge when launching new mobile phone designs. The national technology program would assemble a core group of university departments and research institutes specializing in relevant technologies, as well as key firms undertaking the various value chain activities. Joint research projects would be set up, typically involving 1–2 universities and 1–3 industry participants. A program steering group would be formed to initiate, select, monitor, and prioritize projects, as well as to foster links and interactions among program participants. The program would be actively managed, and seminars and workshops would be arranged to foster exchange of experiences and knowledge, as well as promote collaboration among program participants. By actively fostering links among program participants, the intervention would attempt to support collective experimentation around given technologies and related organizational solutions, thereby enhancing the development and take-up of boundary-spanning technologies such as CAD–CAM and rapid prototyping applications. As numerous firms would jointly work on similar problems, they would learn from one another, the take-up of boundary-spanning technologies would be enhanced because of enhanced coordination among value chain participants, and the participating firms would discover not only new solutions to technical problems, but also, new ways to derive economic advantage from technological advances. Thus, the program would promote not only innovation around technical advances, but also, around related business practice.

The activities of a hands-on, targeted technology policy intervention, such as the injection molded plastic parts program described above, are clearly more encompassing than the simple provision of subsidies for firm-level R&D. What is particularly intriguing in such policy interventions is the emphasis given to the promotion of links and knowledge exchanges among program participants. In addition to correcting market failure through R&D subsidy, the intervention also addresses specific sector-level goals, such as collective learning and experimentation around new technologies, or the take-up of enabling technologies and related coordination solutions. However, such interventions also present challenges for measurement and evaluation. Whereas measuring the firm-level learning impact of direct R&D subsidy (i.e., direct input additionality, or ‘first-order additionality’) is relatively straightforward, measuring learning effects from knowledge spill-overs (denominated here as ‘second-order additionality’) is more difficult (Georhiou and Roessner, 2000). It is particularly challenging to separate one from the other. How can we tell whether policy-measures designed to foster knowledge spill-overs within communities of practice actually promote firm-level learning that goes beyond the direct effect of firm-level R&D subsidy? Even though such effects are often cited as justification for sector-specific, hands-on policy interventions (Malerba, 2002), they have not been demonstrated empirically. We propose that the lack of studies attempting to quantify and measure second-order additionality hampers the development and targeting of effective policy interventions. There is little literature that empirically distinguishes between first-order and second-order additionalities in innovation