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R&D in SMEs: a paradox?

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Abstract This paper has three objectives: (1) to survey the relevant literature addressing the (apparent) paradox of Research & Development investments carried out within Small and Medium Enterprises; (2) to provide focused summaries of the articles in this special issue; (3) to draw some general conclusions in terms of policy implications.

Keywords European policy · Innovation · R&D · R&D subsidies · SMEs

JEL Classifications O31 · L25 · L26

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1 Introduction

This paper has three main purposes.

Firstly, in Sect. 2, our aim is to position this special issue within the relevant literature addressing the (apparent) paradox of Research & Development (R&D) investments carried out within Small and Medium Enterprises (SMEs). SMEs may be thought of as having nothing to do with an expensive and risky activity such as R&D. The lack of financial assets, weaker competencies and absorptive capacity, and the absence of scale and scope economies are all strong arguments that militate against possible innovation in general and R&D in particular being implemented in SMEs. In Sect. 2, we will remind the reader of the long-standing debate on the possible role of SMEs as active participants in technological change, starting from the first and second hypotheses proposed by Schumpeter.

Secondly, Sect. 3 provides summaries of the articles in this special issue, particularly with regard to the empirical results presented. In this section we will relate the single contributions to each other and to the theoretical discussion put forward in Sect. 2.

Thirdly, in Sect. 4, we draw some general conclusions; these should prove useful in terms of policy implications. Indeed, if it is accepted that there is not necessarily a paradox in regarding SMEs as possible providers of R&D efforts, a question arises about a possible role for economic policy specifically addressed to supporting R&D activities within SMEs.

Whether this kind of policy is useful or not and whether it should be general or targeted, isolated or complemented by other policies, will be discussed in the concluding Sect. 4.

2 The reference literature

Some of the pioneer works by Schumpeter highlighted the importance of SMEs in innovation, suggesting that SMEs were likely to be the source of most innovations (Schumpeter 1934; from now on: Schumpeter Mark 1, SM1). Schumpeter insisted that innovations typically originated in new, small, entrepreneurial firms starting their operation creatively outside the "circular flow" of existing production activities. The small innovating firms that succeeded would eventually grow large, and their leaders would amass great fortunes (Schumpeter 1939).

This great Austrian economist subsequently focused his attention on capital market imperfections and claimed that large established firms possessing some degree of monopoly power were more likely to be the driving force behind technological progress. Market imperfections confer an advantage to large firms in terms of being able to secure finance for risky R&D projects, as size appears to be correlated with the availability and stability of internally-generated funds. Because R&D is very costly for small companies, which do not have the capital and extensive resources of their larger counterparts, and because it is less expensive for a small firm to imitate another firm's innovative activity rather than to innovate itself, the "second" hypothesis proposed by Schumpeter was that small firms would not choose to participate in many innovative projects (Schumpeter 1942; from now on: Schumpeter Mark 2, SM2).

As pointed out in the SM2, SMEs may be less likely to invest in R&D activities than larger firms. Nowadays, explanations from economic literature go beyond the capital market imperfections issue and can be related to the characteristics of a firm's growth strategy and the risky nature of innovation. More specifically, firstly, a diversification strategy activated by a large firm confers the possibility of spreading the risk over a large number of R&D projects. Secondly, larger firms do not face financial constraints in their R&D investment since they rely on financial liquidity deriving from both easier access to external finance and more extensive internal funding. Thirdly, although R&D is a profit-motivated activity, some important features make it very different from other types of investments; in particular, the skewedness in the distribution of R&D outcomes, due to a mix of high variance in expected returns and a very low probability of achieving the highest payoffs (Scherer and Harhoff 2000), influences a firm's investment decision (Scherer et al. 2000) and makes it more unlikely that SMEs will choose to finance through capital markets. Fourthly, large corporations in concentrated industries are characterized by a higher degree of market power, which helps them to deal with the uncertainty of innovation and to achieve a long-run competitive advantage (Galbraith 1952; Nelson 1959; Penrose 1959; Arrow 1962; Comanor 1967).

More generally, Cohen and Klepper (1996) argue that larger firms have an advantage in R&D because of the larger output over which they can apply the results of their R&D expenditures, both in terms of cost reduction (process innovation) and development of new products.

The Schumpeterian hypothesis (SM2) has been revisited in many contributions to the literature. Comanor (1967) found the existence of a positive size effect, with R&D rising more than proportionally with firm size. In contrast, Scherer (1965) claimed that innovation activity increases more than proportionally with size up to a certain threshold, whereupon the relationship becomes basically proportional. At the time, Scherer's work achieved almost generalized consensus (see also Scherer 1991). However, in other studies, researchers found that the size of the firm had a negligible positive effect on R&D intensity (i.e., R&D expenditures normalized by a measure of total output), and after controlling for industry belonging, the size effect disappeared (Cohen et al. 1987). Indeed, the link between a firm's size and R&D investment depends to a great extent on the technological characteristics of the sector to which it belongs (Kamien and Schwartz 1982; Dosi 1988). For instance, in a study by Scherer and Ross (1990), it is shown that R&D increases proportionally with size in most industries; as far as the remaining sectors are concerned, industries in which R&D spending increases more than proportionally with size slightly outnumber those characterized by the opposite pattern.

However, it has to be borne in mind that small firms mainly carry out informal R&D and that this

determines a downward bias in the estimate of their innovative propensity when only formal R&D expenditures are taken into account (Kleinknecht 1989; Kleinknecht and Reijnen 1991; Kleinknecht and Verspagen 1989). Moreover, SMEs often conduct non-permanent R&D, using resources from different departments of the firm. Finally, a different management structure (Rothwell 1989) and a less bureaucratic environment (Link and Bozeman 1991) allow a higher responsiveness to innovative opportunities by small firms and new entrants into the industry, through activities that are not at all related to accounted-for formal R&D expenditures. For example, process innovation in small firms is much more related to the "embodied technological change" incorporated in the physical capital formation rather than in intangible investment in R&D (Santarelli and Sterlacchini 1990; Conte and Vivarelli 2005; Vaona and Pianta 2008). Hence, official R&D statistics may underestimate innovation in small firms (Kleinknecht 1987; Kleinknecht and Reijnen 1991).

While SMEs may be less likely to conduct formal R&D than larger firms, their efficiency as R&D agents seems to be higher than that of larger firms, meaning that they tend to produce more patents and more innovations than larger firms by unit of input invested in R&D[1] (Acs and Audretsch 1990; Rothwell and Dodgson 1994; Van Dijk et al. 1997).

Obviously, sectoral belonging is also a key variable when we deal with SME innovation, being measured by more comprehensive indicators than formal R&D. In fact, some industries are more conducive to small-firm innovation, while others foster innovation activity in large corporations; in particular, sectors characterized by higher scale economies, higher concentration, and higher product differentiation give an innovative advantage to large firms, while the reverse is true in sectors characterized by opposite conditions (Acs and Audretsch 1987, 1988, 1990).

In this context, the evolutionary theorists of technological paradigms and technological trajectories[2] (Dosi 1982; Nelson and Winter 1982; Audretsch 1991; Lundvall and Johnson 1994; Malerba and Orsenigo 2000) put forward the idea that there is a continuous selection of firms by market mechanisms over time. More specifically, technologies differ drastically across the different sectors, and their development retains a highly autonomous internal logic. In addition to firm size or demand, technological opportunities and appropriability[3] conditions appear to be the most relevant factors affecting the dynamics of market structure and innovation (Winter 1984; Levin et al. 1985; Cohen et al. 1987; Levin et al. 1987; Malerba and Orsenigo 1995, 1996; Breschi et al. 2000; Lin and Huang 2008). Therefore, large firms will be the drivers of R&D and innovation activities in the highly concentrated sectors, characterized by low entry rates, higher appropriability conditions, and lower technological opportunities ("routinized sectors", SM2), while smaller firms will play a crucial role in those "entrepreneurial sectors" characterized by the opposite conditions (SM1).

Together with these general conclusions, the recent literature also highlights the high degree of heterogeneity within the SME aggregate. The contributions by Audretsch (2001, 2002) provide a conceptual and empirical account of the dynamic role of SMEs, at least in some sectors of the economy. For example, evidence is provided to show that SMEs are important sources of employment growth, and innovation in the high-tech sectors, both through existing firms and "New Technology Based Firms" (NTBFs; see Colombo and Grilli 2007; Santarelli and Vivarelli 2007; Vivarelli 2007).

The entry process is a clear example of heterogeneity within SMEs: at one extreme, new entries can

[1] Elaborating this theme further, Cohen and Klepper (1992, 1996) have argued that large firms can apply their innovations to a larger level of output and so will undertake more marginal and risky R&D projects than smaller firms, which will cause them to generate fewer innovations per dollar spent on R&D.

[2] A technological paradigm refers to the specific form of knowledge, the procedures, and the basic system on which a particular economic era is based. Moreover, it results from a complex selection process whose variables have a scientific, institutional, and economic nature (Dosi 1982; Dosi and Grazzi 2006). The emergence of each technological paradigm represents a technological breakthrough, and technological trajectories describe the rate and the cumulative direction of technological change within each technological paradigm.

[3] Levin et al. (1987) consider as appropriability devices: patents, secrecy, lead effect, cost and time for duplication, learning curve, superior sales and service efforts, economies of scale.

simply be "revolving door" SMEs doomed to an early failure; at the other extreme, newborn innovative entrepreneurial SMEs may be able to renew an entire industrial sector (see Foti and Vivarelli 1994; Arrighetti and Vivarelli 1999; Audretsch et al. 1999; Koellinger 2008; van Praag and Versloot 2008).

Other authors have emphasized the possible positive effects of smallness in generating innovation (see, for instance, Rothwell and Zegweld 1982). For example, some works associate small firms in certain sectors with the commercialization of disruptive technologies that generate discontinuous innovations (Kassicieh et al. 2002; Spencer and Kirchhoff 2006), while for others, certain types of SMEs have a greater ability to rely on external networks (Nooteboom 1994; Rothwell and Dodgson 1994) and to create innovative alliances (van Dijk et al. 1997).

However, even the innovative SMEs operating in SM1 sectors may be affected by adverse conditions and serious drawbacks with respect to becoming involved in R&D and innovation activities—a (limited) access to finance (Freel 2007; Riding et al. 2007; Won Kang et al. 2008), limited capabilities, and administrative burdens (van Stel et al. 2007; Dewaelheyns and van Hulle 2008) seem to be the most common problems. As an example, SMEs generally tend to underinvest in R&D because of a lack of knowledge about how and where to acquire the necessary competence; by the same token, technological suppliers often demonstrate a poor understanding of their actual competence needs (Czarnitzki 2006; García-Quevedo and Mas-Verdú 2008).

In this perspective, the presence of some formal R&D activities within SMEs may be crucial, not only as a pre-requisite for in-house innovation, but also as a primary asset for increasing their "absorptive capacity" (Cohen and Levinthal 1989, 1990) in terms of external knowledge and for gaining value from technological spillovers and cooperation from larger firms and knowledge institutions, such as universities or public labs (see Audretsch and Vivarelli 1994; Piga and Vivarelli 2004; Simonen and McCann 2008).

On the whole, the more recent published studies and analyses, while providing a better understanding of the relative advantages and disadvantages of SMEs in dealing with R&D and innovation, have arrived at the conclusion that testing the Schumpeterian hypothesis as a general theory does not make any sense. In other words, when one looks at a particular SME, sectoral belonging, the particular nature of the innovation involved, and the particular nature of the firm itself do count. Hence, we end up with some industrial sectors lying close to SM1, others close to SM2, and others in an intermediate position. Moreover, even within a given sector, small firms are quite heterogeneous, ranging from highly innovative NTBFs to traditional and financially constrained SMEs for which R&D and innovation are irrelevant.

3 R&D in SMEs as a European policy target

The role of private R&D investment by corporate firms has been recognized as a fundamental engine for productivity growth at both the macro- and microeconomic levels (see Baumol 2002; Jones 2002). Indeed, increasing R&D investment is an issue of major concern for long-term European policy strategy. This is the rationale behind the "Lisbon Agenda 2000", which aims to make Europe the most dynamic knowledge economy in the world by 2010, and behind the more specific "Barcelona target" which, 2 years later, committed the EU to reaching the objective of an R&D/Gross Domestic Product level of 3%, two-thirds of which is to be accounted for by the private sector (European Commission 2002; European Council 2002).

Within this context, in 2007, a group of experts advising the Commission on the *European Industrial Research and Innovation Monitoring System* (EIRIMS) pointed to the need to better investigate corporate R&D within SMEs, as a preliminary step for tailoring research and innovation policies specifically addressed to European SMEs.

Indeed, when taking into account the strengths and limitations of SMEs in particular, a number of essential policy questions arise. For instance, should we leave the decision to undertake corporate R&D activities to market incentives alone—with the possible risk of market failure, such as the financial rationing of potentially innovative SMEs (see previous section)—or is there a general need for R&D-supporting policies, with the risk of government/policy failure? Should SMEs be the beneficiaries of targeted policies, or should there be similar treatment of companies across all size classes? Moreover, if

there is a need for special R&D policies for SMEs, should such supportive measures focus *erga omnes* or should some specific categories of SMEs be targeted [for instance, NTBFs, or "gazelles" (i.e., fast-growing SMEs), or SMEs in high-tech sectors]? And, finally, if there is a rationale for such policies, which would be the best instrument for helping them: providing subsidies, allowing tax exemptions, or implementing indirectly-supportive framework policies?

On behalf of the European Commission, the Joint Research Center–Institute for Prospective Technological Studies (JRC-IPTS) invited scientific experts, policy analysts, and policy-makers to a comprehensive workshop dedicated to discuss these questions, held on September 19th, 2008 at the IPTS headquarters in Seville, Spain. This Special Issue provides a compilation of the papers[4] presented at that workshop.[5] By tackling the most relevant scientific aspects as well as addressing key policy questions, such as those raised above, the papers presented in this issue seek to strengthen our common understanding of the *Drivers and Impacts of Corporate R&D in SMEs*. The papers can be divided into three main fields of interest, as follows: (1) the links between R&D, innovativeness and productivity; (2) the role of corporate R&D as a driver of SME growth; (3) the role of the institutions in fostering R&D in SMEs.

3.1 The links between R&D, innovativeness, and productivity

When investigating the innovativeness of a certain company and thus how R&D activities may affect it, two mechanisms are commonly assumed: (1) the direct mechanism—R&D activities may lead straight to the development of a new product and/or production process—versus (2) the indirect mechanism—raising the company's knowledge base and absorptive capacity together with the technological awareness of the employees, and so possibly leveraging the firm's innovative performance. In the literature this dualism is usually called the "Dual Nature of R&D" or the "Two faces of R&D" (see the discussion about "absorptive capacity" in the previous section).

Two papers on this topic were presented and discussed at the workshop: the first, entitled "Innovation and productivity in SMEs: Empirical evidence for Italy", by Bronwyn Hall, Francesca Lotti, and Jacques Mairesse, focuses on R&D-performing firms, providing empirical evidence of the link between formal R&D activities, a firm's innovative performance, and its productivity. In contrast, the second paper, "Innovation success of non-R&D performers: Substituting technology by management in SMEs", by Christian Rammer, Dirk Czarnitzki, and Alfred Spielkamp, analyzes SMEs that may manage to be innovative without carrying out any formal R&D.

The main research question tackled by these two papers is to what extent in-house R&D activities are crucial for the innovation success of a company. Is there common evidence of a positive return on corporate R&D in the form of productivity gains, and does this depend on firm size and/or sectoral belonging? Further, can R&D be successfully complemented by other measures, such as certain management tools? Is it possible to be innovative purely by re-arranging existing knowledge and practices, i.e., by being an innovator without doing any formal R&D?

Using their empirical results, Hall et al. argue that R&D is positively related to productivity; however, in-house R&D does not capture all aspects of innovation, which often occurs via other channels, especially in SMEs. In this regard, Rammer et al. argue that to a certain extent in-house R&D activities can be either coupled with or even replaced by external research and by innovation management tools (such as training, cooperation, networking, contracting external knowledge/R&D). In general, it is expected that higher innovativeness will leverage a firm's productivity, whether achieved exclusively by performing formal in-house R&D or not. Hence, since innovativeness is linked to productivity, and this in turn is vital for economic development, any policy measure supporting it, such as providing support for in-house corporate R&D, facilitating spillovers and innovative networks,

[4] Six papers were selected out of a pool of 15 submissions; these were subsequently revised through two referee rounds.

[5] The chief editors of this Journal are Zoltan Acs and David Audretsch; the discussants were Werner Bönte, Pedro Faria, Piergiuseppe Morone, Simon Parker, Roy Thurik, and Mirjam van Praag; the participants to the workshop round table were Rui Baptista, Maria Callejón, Enrico Santarelli, Ulrich Schröder, and Barend Verachtert; the IPTS officials Xabier Goenaga, Andries Brandsma, and Pietro Moncada Paternò Castello provided extremely useful comments to the presented papers, and their suggestions were implemented in the second referee round.

or improving innovative management practices, could be justifiable.

3.2 The role of corporate R&D as a driver of SME growth

What triggers SME growth? Is it R&D and innovation, or other comparative advantages, such as entrepreneurship,[6] a firm's location, or sectoral belonging? Werner Hölzl, Erik Stam and Karl Wennberg seek to provide answers to these questions by analyzing the role of R&D in fast-growing SMEs (gazelles) on the one hand, and by considering what can be said about the role of R&D in start-ups, on the other. Thus, the two papers "Is the R&D behavior of fast growing SMEs different? Evidence from CIS-III data for 16 countries", authored by Hölzl, and "Innovation capabilities and growth in the early life course of firms", by Stam and Wennberg, consider SMEs in different stages of their economic trajectories.

According to the empirical investigation conducted by Hölzl, the role of R&D in the growth of gazelles is related to their proximity to the technological frontier, this being greater for those SMEs operating in countries that are technologically more developed. In other words, only if carried out in a sufficiently high-tech environment may R&D activities significantly trigger SME growth.

From a European policy perspective, the emergence of these national peculiarities indicates that there are important limits regarding a possible centralization of policies aiming to foster high-growth SMEs.

Referring to the early life course of firms, Stam and Wennberg found that of the innovation capabilities, inter-firm alliances have positive effects on the growth of the smallest firms in general, while performing R&D significantly stimulates the growth of NTBFs only. Hence, as in the previous paper, this contribution also points out the presence of important peculiarities and heterogeneous patterns within the SME context.

Summing up these findings, the catalyzing role of R&D for firm growth can be confirmed only to a limited extent: in terms of fast-growing companies, only for those that operate in close proximity to the technological frontier; for young firms, only for NTBFs. From a policy point of view, this evidence casts severe doubts on policies which support R&D activities *'erga omnes*. Such a generalized approach, therefore, appears to be inappropriate, since R&D was not found to be crucial for all categories of SMEs and start-ups. Instead, if support to corporate R&D has to be undertaken, specific categories of SMEs should be targeted. Furthermore, the findings that rapid growth does not necessarily depend on R&D activities and that opportunities differ across countries and sectors underline the need for spatial and sectoral distinguishing components in economic policy-making.

3.3 The role of the institutions in fostering R&D activities in SMEs

Rufin Baghana and Pierre Mohnen investigate whether tax incentives are a suitable approach for leveraging corporate R&D activities and whether firm size and the stage of a firm's life-cycle actually do matter in this regard. In the final contribution, Erol Taymaz addresses the rather general question of whether SMEs in a middle-income developing country face specific challenges; within this framework, he analyzes the role of public R&D spending in supporting corporate R&D. The contributions provided by these two papers feed into the policy debate on how to design policy instruments that may lead to more R&D "additionality". In this context, the policy-maker has to choose between direct (subsidies) versus indirect (fiscal incentives) intervention and to balance the costs and benefits of these instruments, given the specific characteristics of the SMEs.

According to the analysis by Baghana and Mohnen on "Effectiveness of R&D tax credits in small and large enterprises", there is a clear deadweight loss associated with R&D support in favor of large firms. In contrast, in terms of additional R&D investment, small firms appear to be highly sensitive to tax credits both in the short- and the long-run.

In his microeconometric study, Erol Taymaz sheds light on R&D activities within Turkish manufacturing firms. His empirical evidence suggests that although SMEs are less likely to conduct R&D at all, if they do overcome this first hurdle, they tend to spend proportionally more on R&D than their larger counterparts. Moreover, public R&D support

[6] For a recent in-depth discussion of the concept of "entrepreneurship", see Gartner 2008.

encourages firms to intensify their R&D activities, and its impact is significantly higher for small firms.

4 Conclusive remarks and policy implications

Taking into account the theoretical framework and the empirical results from the literature discussed in Sect. 2 and the outcomes from the articles in this special issue summarized in Sect. 3, we can draw some conclusions which, for the sake of clarity, we will organize around three (related) policy questions: (1) Is there a case for an R&D policy addressed to European SMEs? (2) If such is the case, should R&D policy be *erga omnes* or targeted at particular categories of SMEs? (3) In a more general context, is R&D policy enough or should it be complemented with other kinds of public intervention?

(1) The answer to the first question is YES—there is a case for a European R&D policy specifically addressed to SMEs.

As discussed in Sect. 2, R&D and innovation are costly and risky activities; moreover, clear market failures emerge as far as the capital market is concerned. In particular, asymmetric information implies the possibility of under-investing in R&D activities that are socially desirable. This kind of market failure is particularly likely in the case of SMEs, which are generally liquidity constrained and unable to compensate for asymmetric information.

Nevertheless, the presence of a market failure is a necessary but not sufficient condition to justify an economic policy addressed to supporting R&D activities within SMEs, since both "deadweight" and "substitution" effects may arise. However, the risk of a deadweight effect should be lower in the case of SMEs in that—given the relevant liquidity constraints affecting SMEs—in most cases the subsidized R&D investment would not have been made without the policy. By the same token, the substitution effect should also be lower in the case of SMEs; in fact, in contrast with large firms, the crowding out of in-house R&D should be negligible.

In this context, the result obtained by Baghana and Mohnen that the "bang for the buck" from R&D policy addressed to SMEs is much more obvious than that from the same policy addressed to large firms is not surprising at all, but rather consistent with a view that points out the likely occurrence of market failures in the financing of R&D activities in SMEs. Consistently, Taymaz's conclusion that R&D support is more effective when received by SMEs rather than by their larger counterparts is further confirmation that an R&D policy addressed to SMEs may be considered appropriate.

(2) The answer to the second question is that a targeted R&D policy addressed to particular sub-groups of SMEs should be preferred to a general-purpose *erga omnes* policy.

Although there is a case for R&D policy addressed to SMEs, this public support should not be general, but very selective and targeted at specific categories of SMEs. For example, Stam and Wennberg's results show clearly that among newborn firms R&D is a crucial growth asset only for the tiny minority of the so-called NTBFs. Similarly, Hölzl's contribution reminds us of the fact that R&D is crucial in transforming an SME into a gazelle only in the technologically advanced countries.

Overall, SMEs are very varied and policy-makers should avoid considering the aggregate as a "unicum". While some SMEs are potentially innovative and ready to grow, others are revolving-door firms which stay for a while in an industry fringe with no chance of entering its core, rather, being doomed to exit the market. In this context, the European R&D policy for SMEs should be extremely cautious, selective, and tailored in terms of country, sector, and technology specificities.

(3) The answer to the third question is NO—R&D policy is not enough and should be complemented with other policies.

As shown by Rammer, Czarnitzki, and Spielkamp, innovative SMEs rely heavily on external knowledge, such as that embodied in capital formation or that absorbed through direct technological acquisition and spillovers. Hence, in SMEs, external knowledge is a crucial complement to in-house R&D, and innovation management practices, such as those involving human resource management, are of paramount importance, sometimes even being substitutes for formal R&D.

In such a context, R&D policy should be considered as part of a more comprehensive European innovation policy favoring SMEs. This policy should address a

variety of goals, such as to (1) facilitate access to other innovative inputs in addition to R&D, (2) support organizational innovation, (3) promote skill-upgrading and human resources practices, (4) foster innovative networking and fruitful supplier–user relationships, and (5) create the necessary framework conditions for facilitating the spillovers from larger firms and universities or research centers to SMEs.

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