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The R&D-growth paradox arises in fast-growing sectors

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ABSTRACT

Several notions of a R&D paradox can be found in the literature. In the Swedish Paradox version, the emphasis is normally on high and growing levels of business R&D connected to comparatively low GDP growth rates. This paper examines whether this pattern is consistent over time and, more importantly, which sectors drive the aggregate patterns. Based on an investigation of the entire Swedish economy 1985–2001, there is clear evidence that the paradox occurs only in fast-growing manufacturing and service sectors. Fast-growing sectors show an increasing gap between R&D and value-added growth, while the slow-growing sectors do not. This paradox is not interpreted as a sign of failure of the national innovation system, as the largest gap would then be for the slow-growing sectors, failing to transform R&D to economic growth. The gap between R&D and GDP is consistent with the idea of diminishing marginal returns to R&D investment in high-investing sectors. The evidence does not rule out, however, that rendering the innovation system more effective could yield better outcomes. As the findings of a gap are quite consistent over time, it seems fair to conclude that businesses have good reasons for their high R&D investments, despite not being on par with their production growth.

1. Introduction

There is much concern that investments to raise the level of knowledge in society do not pay off the way they should. Investments in education have been massive, but have not produced the desired outcomes (Pritchett, 2001). The idea that R&D efforts do not lead to sufficient GDP growth has been a stylised fact in the research policy debates (Dosi et al., 2006; Braunerhjelm et al., 2010). For the Swedish case, Ohlsson and Vinell (1987, p. 155) were the first to point out that R&D was high, but did not translate into sufficient production or exports. The idea of a paradox between output and input of R&D in Sweden was taken up again in the 1990s by Edquist and Mckelvey (1998), who based their paradox argument on an observation that Sweden had a high R&D in relation to GDP at the same time as R&D-intensive (high-tech) production made up a small share of the total manufacturing sector in Sweden compared to the OECD average. They interpreted the results as an indication of low productivity of the national innovation system, which called for a policy fix. Although there are many different formulations of the paradox, a generalised version suggests that there is a growing gap between R&D expenditures and GDP over time, with R&D efforts growing substantially faster than GDP (Andersson et al., 2002; OECD, 2005; Ejermo and Kander, 2009).

There could be several explanations for this paradox. One version suggests malfunctioning national innovation systems (Edquist and Mckelvey, 1998; Braunerhjelm, 1998). Another version interprets the paradox as a natural consequence of diminishing returns to increasing R&D investments (Jones, 2002). The political implications are, of course, very different in these two cases. While a malfunctioning innovation system calls for some policy fixes, nothing much can be done to counteract the law of falling marginal returns to investments. A third view is that these phenomena may co-exist; even though R&D investment may be subject to diminishing returns, in line with predictions of neoclassical economic theory, there may still be 'system failures'.

In the Swedish paradox debate the divergence between R&D and GDP is mostly treated as an aggregate phenomenon existing at the level of the entire economy. Little is known about the sectors or industries in which the paradox may arise. In this article, we argue that such a sectoral dimension is key to understanding whether the paradox arises due to problems in the national innovation system or to a phenomenon of natural diminishing returns. If the paradox arises in slow-growing sectors, this could be taken as evidence of a malfunctioning innovation system that is unsuccessful in transforming R&D to economic growth; but if the paradox arises in the successful, fast-growing sectors of the economy, this could be interpreted as diminishing marginal returns on investments in R&D. If

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the paradox is a feature of all sectors, it is impossible to distinguish between the two competing explanations; the paradox may be caused either by a malfunctioning innovation system or by falling returns to R&D.

The purpose of this paper is to investigate whether the gap between business R&D expenditures and economic growth is a consistent feature across all sectors of the economy, or specific to either fast-growing or slow-growing sectors. We use a Swedish combined long-term dataset that covers production and R&D data in the manufacturing and service sectors between 1985 and 2001. Inspired by the works of Dahmén (1950, 1984), we distinguish between growing and declining sectors in the economy, and analyse their long-term R&D patterns in relation to their added value.

The paper is structured as follows. In Section 2, we discuss the expected relationship between R&D and growth on sector level, and why this is an important dimension to analyse in order to track the mechanisms behind the paradox. Section 3 describes the data. Section 4 reports the empirical findings. Section 5 summarises the results and suggests directions for future research.

2. Sector-dimensions of the R&D-growth paradox

Sweden is possibly one of the countries where the paradox between high R&D and low output has been most prominent in the public debate. It has attracted the interest of several academic scholars (e.g. Braunerhjelm, 1998; Edquist, 2002; Jacobsson and Rickne, 2004; Granberg and Jacobsson, 2006; Mckelvey et al., 2007; Kander et al., 2007; Ejermo and Kander, 2009). While the paradox between academic (public) R&D and output (publications and patents) seems not to be very pronounced in Sweden (see discussions in Jacobsson and Rickne, 2004, and new evidence in Lissoni et al., 2008), the R&D-growth paradox is still subject to debate.

Explanations for the paradox have primarily focused on the weaknesses of the innovation systems, such as inefficient linkages of R&D, inventions, innovations and growth outcomes. Edquist and Mckelvey (1998) argued that government support to ailing mature industries and repeated currency devaluations obstructed renewal of the economy. More recently, lacking entrepreneurship has been singled out as a hampering factor for growth (Braunerhjelm et al., 2010; GEM, 2010). The factors inherent in the transformation to an increasingly knowledge-intensive economy could also account for parts of the paradox. Jones (1995), for example, has pointed out that the number of scientists engaged in R&D in the US has grown dramatically over the last 40 years, while GDP has not displayed equally high growth rates. With the co-existence of a Swedish, a European and an American paradox, it is reasonable to believe that economic growth expectations from R&D have simply been too high (Kander et al., 2007). With lower and more realistic expectations, no paradox will exist.

Some of the unrealistic expectations arose from early, overly optimistic formulations of endogenous growth theory, in which economic growth was proportional to R&D investments. The returns to capital in a wide sense (human and physical) did not need to face diminishing returns to scale, but could even have increasing returns (Romer, 1990; Aghion and Howitt, 1992; Grossman and Helpman, 1994). This resulted from modelling knowledge spillovers as pervasive, making R&D investments a strong growth stimulus. In response to the so-called Jones critique (Jones, 1995), which pointed out that there was no proportional relation between R&D and GDP growth in the USA after the 1940s, some endogenous growth modellers have adjusted the effects of R&D on growth downwards. Aghion and Howitt (1998) modify their original model so that rising R&D in a steady state does not cause an increase in the growth rate. These modelling efforts imply that there are diminishing returns to R&D appearing at an economy-wide level. Jones (2002) is even closer to a more conventional growth theory and its emphasis on the decreasing returns to investments; he maintains that the present economic growth rates are upheld due to ever-increasing R&D investment ratios. Consequently, advanced economies will eventually reach a state where they are unable to increase R&D to GDP ratios further, and will thereafter be faced with lower growth rates.

If growth in advanced contemporary economies is, by necessity, R&D intensive, the Swedish paradox should perhaps not come as a great surprise, nor should it be viewed as a very problematic feature. High and increasing R&D is, in such a case, simply the premium we need to pay to maintain reasonable rates of economic growth, as suggested by Jones (2002). However, if the paradox originates in deficiencies of the innovation system and is not due only to a general tendency to diminishing returns to R&D, the paradox is a more problematic phenomenon for the economy. Such a scenario would also provide a justification for innovation policies.

Alternatively (and not necessarily contradicting the previous explanation), there may be reasons to expect that the paradox has quite different features for different sectors or industries in the economy, because of diverging technological opportunities. Not only do sectors differ substantially with regard to their technological features and knowledge bases (Lundquist, 1996; Asheim, 2007), but the R&D-to-growth ratio could also be affected by the position of the industry in the economy. If research efforts geared towards product innovation are more uncertain and more costly than research efforts directed towards process innovation, the industries with more product innovations should, almost by default, show a large gap between R&D and growth. This fundamental uncertainty would partly decrease with the transition of the industry to consolidation and larger sales volumes, and partly with the transition from product to process R&D. As a result, the gap between R&D and value added growth would dwindle.

Of course, the idea that sectors differ with respect to R&D and innovation patterns is not a novel one. Research at SPRU, Sussex (e.g. Pavitt, 1984; Freeman and Lourca, 2001) and elsewhere has been influential in forming the literature on sectoral innovation systems (Malerba, 2002, 2005), which emphasises the fact that sectors differ with respect to the style of innovation (cf. Levin et al., 1987). Furthermore, Pavitt (1984) suggests that industries may 'import' technology from related industries. From this perspective, some industries may be seen as vital technology suppliers to other industries in the economy. That sectors or industries differ widely in their use of R&D is also apparent in the industrial taxonomy of Ohlsson and Vinell (1987). They identify several R&D-intensive industries in the economy, which have dramatically increased their shares of the economy in terms of production in recent decades (Svensson Henning, 2009), and might have an impact on the aggregate patterns of R&D and growth. Still, economy-wide sector approaches have been little used to empirically analyse the R&D-growth paradox. To rectify this, we compile a growth taxonomy and consistent time series of growth and R&D on industry level. The next section describes how this is done.

3. Data, measurement issues and industry taxonomies

For the purpose of this study, information from two databases on the Swedish economy has been used: (1) Databases of Evolutionary Economic Geography in Lund and (2) CIRCLE Innovation Databases for Economic Research. Our data were originally supplied by Statistics Sweden. The series used in this article comprise plant or firm-specific data on value added and R&D for most commercial firms in Sweden over the period 1985–2001.[1] The value-added

[1] When calculating fixed prices from the nominal prices, we use different deflators for different series. For manufacturing industries, we use industry-specific producer