The long-run growth effects of R&D policy

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ABSTRACT

We assess the long-run growth effects of public policies to business R&D using data for US manufacturing industries and taking Schumpeterian growth theory as guideline. Our analysis indicates that R&D policy in the form of R&D tax credits fosters the rate of productivity growth over the long-term horizon. This effect is quantitatively important: increasing R&D tax credits by 10% raises the growth rate of labour productivity by 0.4% per year. We show that our findings are robust to controlling for several policy instruments, growth determinants and econometric issues. Moreover, the overall evidence is consistent with the predictions of second-generation fully-endogenous growth models.

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1. Introduction

Do changes in public policies aimed at stimulating business R&D lead to higher growth rates of productivity? If any, are these effects long lasting? Taking Schumpeterian growth theory as guideline, this paper addresses these questions by providing econometric evidence on the long-run impact of R&D policy on productivity growth of the United States.

Early models of R&D-based growth postulate that the long-run growth rate of productivity is proportional to the *level* of research undertaken in the overall economy (see, e.g., Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992). In these models, any policy change permanently affects the growth rate of productivity. In the mid-1990s, the critique formulated by Jones (1995b) against the prediction of these models on the scale effect of R&D stimulated the development of an array of second-generation growth models without scale effects. A first strand of studies makes the assumption of diminishing returns to knowledge and predicts that the steady-state level of productivity is an increasing function of the economy's size (and hence of the amount of R&D),

but not its growth rate. Accordingly, R&D policy has no impact on productivity growth in the long run, but only along the transition path. These models are referred to as of semi-endogenous growth as they contend that the growth rate of productivity is ultimately driven by the (exogenous) population growth rate (Jones, 1995a; Kortum, 1997; Segerstrom, 1998). Another line of research known as fully-endogenous growth theory (see, e.g., Dinopoulos and Thompson, 1998; Peretto, 1998; Young, 1998; Aghion and Howitt, 2008, ch. 12) builds upon the insight that, as an economy grows and new varieties are discovered, aggregate R&D effort becomes less effective because it spreads among a greater number of product lines. Productivity growth would depend on the R&D *intensity* at the firm level, explaining why growth can be stationary despite the increasing resources invested in R&D. Accordingly, any policy that affects R&D intensity has also an impact on the steady-state growth rate.

The present paper empirically assesses the long-run growth effect of public policies to business R&D in the US economy using a framework based on the latest strands of Schumpeterian growth theory. Our analysis is carried out in a dynamic panel data setting on twenty US manufacturing industries over the 1975–2000 period. Following the influential studies on tax changes and economic growth (see Lee and Gordon, 2005 and subsequent works), we estimate a growth equation which includes R&D policy instruments

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as explanatory variables, together with other growth determinants as suggested by the second-generation Schumpeterian growth models. We consider R&D tax credit and the proportion of direct (federal) funding on business R&D expenses as policy variables. The empirical model is estimated by means of a novel regression technique, the Cross-Sectionally Augmented Distributed Lags (CS-DL) estimator (Chudik et al., 2016). This approach is based on a dynamic representation which provides consistent estimates for the long-run parameters and is robust along a number of important dimensions (namely, misspecification of dynamics, error serial correlation, cross-sectional dependence, etc.).

Our analysis indicates that R&D policy has a persistent, if not permanent, impact on the growth rate of productivity, which provides strong support to fully-endogenous growth theory. However, the growth effects of R&D policy vary with the type of instruments used. We find that R&D tax credits have a significant and positive impact on growth that persists over the long-term horizon. This effect is quantitatively important: increasing the generosity of R&D tax credits by 10% raises the growth rate of labour productivity by 0.4% per year. Conversely, direct funding to R&D does not appear to significantly affect productivity growth in the long run, indicating that, at best, this policy instrument has only temporary effects. Our findings are shown to be robust to including various tax policy and economic controls, as well as to various econometric issues.

Our paper contributes to some important strands of the economic literature. First, it is related to a recent line of research evaluating whether semi-endogenous or fully-endogenous growth models are more empirically relevant (see the discussion in Dinopoulos and Thompson, 1999). Our paper fills an important gap in the literature as prior work has assessed the consistency of the two competing growth frameworks with productivity and innovation statistics and, based solely on this evidence, inferred whether innovation policies have permanent or temporary growth effects. Exploiting US manufacturing industry data, Zachariadis (2003) provides evidence in favour of the predictions of second-generation growth models, using a specification derived from a fully-endogenous growth setting. The subsequent empirical contributions have sought to discriminate between semi- and fully-endogenous growth theories. Ha and Howitt (2007) apply cointegration analysis to US macroeconomic data since the 1950s, finding strong support for fully-endogenous growth theory. This result appears to have general validity and is not limited to certain countries or certain stages of development. A similar conclusion is reached by Madsen et al. (2010) on the British transition to the post-Malthusian growth regime after the First Industrial Revolution, and by Madsen (2010) on the growth performance of OECD countries since the Second Industrial Revolution.[1] The present work makes a step forward in this literature by providing evidence in support of fully-endogenous growth theory through a direct estimation of the growth effects of R&D policies.

Second, our paper also relates to a large body of research examining the role of public support to R&D (direct public engagement, direct subsidies, tax credit, etc.). This literature has concentrated on two major issues: (1) the additionality issue, i.e., whether public support raises, or reduces, private R&D investment (crowding-in or crowding-out effect); and (2) whether R&D tax credits are more or less effective than direct subsidies in stimulating business R&D.[2] In the United States, with the diffusion of the R&D tax credit

nationally and among the US states since the early 1980s, much of the debate has centred on evaluating whether tax credits are more effective than direct funding in stimulating business R&D. Using industry-level data, Mamuneas and Nadiri (1996) document that incremental R&D tax credit and the immediate deductibility provision of R&D expenditures have a significant impact on privately-funded R&D investment; on the other hand, publicly-financed R&D induces cost savings but crowds out privately-funded R&D investment. Guellec and van Pottelsberghe (2003) show that, in OECD countries, direct government funding spurs business-financed R&D (apart from when it is oriented towards defence), while tax incentives have short-lived effects. Bloom et al. (2002) quantify the impact of fiscal incentives on R&D investment by estimating an R&D demand equation for few OECD countries. They find that a 10% fall in the cost of R&D stimulates over a 1% rise in the R&D effort in the short run, and almost a 10% increase over the long run. Thomson (2015) performs an industry-level analysis for a large set of industrialized countries finding for business R&D a short-run responsiveness of 5–10% increase in fiscal discounts. The present work extends this strand of literature by assessing the ability of public policies to business R&D in promoting productivity growth, drawing on the latest developments of Schumpeterian growth theory.

Finally, our work is also related to the vast literature on the relationship between taxation and economic growth. The seminal contributions by Easterly and Rebelo (1993) and Mendoza et al. (1997) showed that the effects of taxes on growth are difficult to isolate empirically (the so-called Harberger's superneutrality conjecture). This issue has been further investigated by a number of subsequent studies which find a significant association between taxation and economic growth. The most recent contributions in this field focus on the design of growth-friendly tax policies and conclude that the corporate income tax is particularly detrimental for income growth (Kneller et al., 1999, Lee and Gordon, 2005) and income levels (Arnold et al., 2011). Gemmell et al. (2015) find that tax effects on GDP growth operate largely through changes in factor productivity, rather than via investment. This conclusion is in line with the view developed in Peretto (2003, 2007) and Lee and Gordon (2005) who stress the importance of innovation and entrepreneurship as transmission channels of taxation on GDP growth. Our contribution to this literature shows that, for a knowledge-based economy such as the United States, R&D activities represent an important transmission channel of the effects of taxation on productivity growth.

The rest of the paper is organized as follows. Section 2 contrasts the main features of fully- and semi-endogenous growth theory and provides the theoretical background of the empirical analysis that follows. Section 3 describes the empirical specification and presents the data used. The econometric analysis is developed in Section 4 where we discuss the main results and a number of robustness checks. Finally, Section 5 concludes and outlines future research directions.

2. Second-generation endogenous growth models

The latest generation of Schumpeterian growth theories without scale effects, namely semi-endogenous growth theory and fully-endogenous growth theory, has opposite policy implications. This section reviews the two approaches and provides a brief background for the empirical analysis which follows. To focus on the mechanisms identified by second-generation endogenous

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[1] Other earlier works assessing the soundness of second-generation growth models using US industry data are Venturini (2012a) and Venturini (2012b).

[2] See David et al. (2000), Alonso-Borrego et al. (2014) for comprehensive surveys. Another important channel through which public policy can raise private R&D is through public procurement (see, e.g., Cozzi and Impullitti, 2010; Slavtchev and Wiederhold, 2015). Other valuable works on R&D tax incentives are those of Lokshin

and Mohnen (2013) on the effect of these policy instruments on researchers' wages and Castellacci and Lie (2015) on their heterogeneous impact across industries and firms.