Research Policy 45 (2016) 1075–1090

Contents lists available at ScienceDirect

Research Policy

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

Why it pays off to pay us well: The impact of basic research on economic growth and welfare

Klaus Prettner[a,*], Katharina Werner[b]

[a] University of Hohenheim, Institute of Economics, Schloss, Osthof-West, 70593 Stuttgart, Germany
[b] Department of Economics, University of Göttingen, Platz der Göttinger Sieben 3, 37073 Göttingen, Germany

ARTICLE INFO

Article history:
Received 8 May 2015
Received in revised form 16 February 2016
Accepted 1 March 2016

JEL classification:
H41
J11
J24
O32
O41

Keywords:
R&D-based growth
Basic science
Optimal governmental research policies
Endogenous schooling
Endogenous fertility

ABSTRACT

We analyze the growth and welfare effects of governmental basic research investments in an R&D-based growth model with endogenous fertility and endogenous education. In line with the empirical evidence, our model accounts for (i) the negative effect of population growth on economic growth, (ii) the positive effect of education on economic growth, (iii) the positive association between the level of per capita GDP and expenditures for basic research, and (iv) the gestation lag of basic research investments. Our results indicate that there exists an interior long-run welfare-maximizing investment rate in basic research that is much higher than the rates observed in OECD countries. The model-based explanation that we provide for this discrepancy is that raising public investments in basic research toward the optimal level reduces the growth rate of GDP and welfare in the short run because taxes have to increase and resources have to be drawn away from other productive sectors of the economy. These adverse short-run welfare effects are one potential explanation for the reluctance of governments and their currently living voters to increase public R&D expenditures despite the long-run benefits of such a policy.

If we knew what it was we were doing,
it would not be called research, would it?
(Albert Einstein)

1. Introduction

In the beginning of the 1990s, a series of seminal articles (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992) explained the evolution of technology endogenously within a general equilibrium setting. These frameworks relied on the profit motive for research and development (R&D) in the sense that innovative firms capture a part of the rewards for designing new and/or better products by siphoning the monopolistic rents associated with the corresponding patents. With these tools at hand economists were increasingly able to analyze the impact of incentives, market structures, preferences, and policy measures on the R&D intensity and the pace of technological progress of industrialized countries (see Aghion and Howitt, 1999, 2005; Gancia and Zilibotti, 2005, for interesting overviews).[1]

Employees of publicly funded universities and research institutes are very well aware of the fact that the introductory quote of Einstein clarifies in its own way: apart from profit-driven research to design new and/or better products, there is another important but often neglected dimension of R&D, namely, basic research. Mokyr (2002), in particular, distinguishes between the *techniques* that a society can draw from, and the *propositional knowledge* that it has at its disposal. The former can be patented and is often the result of profit-driven R&D, while the latter cannot be patented and represents a society's knowledge of natural phenomena and regularities. Propositional knowledge, however, is a necessary input

* Corresponding author.
E-mail addresses: klaus.prettner@uni-hohenheim.de (K. Prettner), kwerner@uni-goettingen.de (K. Werner).

[1] Since these early endogenous growth models counterfactually implied hyper-exponential economic growth in the face of population growth and that larger countries would grow faster than smaller ones (scale effect), they were subsequently refined in the vein of semi-endogenous growth frameworks (Jones, 1995; Kortum, 1997; Segerström, 1998) and scale free Schumpeterian growth frameworks (Peretto, 1998; Young, 1998; Howitt, 1999). See Jones (1999), Li (2000, 2002), Jones (2002), Ha and Howitt (2007), Madsen (2008), and Venturini (2012) for an ongoing debate on the suitability of these approaches.

http://dx.doi.org/10.1016/j.respol.2016.03.001
0048-7333/

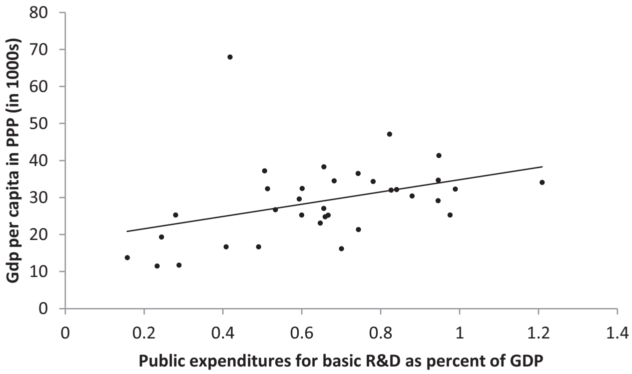

Fig. 1. Association between PPP-adjusted per capita GDP and public research expenditures as a fraction of GDP in 2009. *Note*: The data for basic R&D-expenditures are obtained from the OECD (2012) and the data on PPP-adjusted GDP per capita are obtained from the World Bank (2012). Basic R&D-expenditures in Greece, Australia, and Switzerland were only available for 2005, 2008, and 2008, respectively.

for the development of new techniques, and therefore, according to Mokyr (2002), acts as their *epistemic base*. Examples for propositional knowledge are the knowledge of basic mechanics, knowledge regarding the properties of materials, plants, and animals, or knowledge regarding the functioning of the human body (cf. Mokyr, 2002, p. 5).

Basic research to improve a society's understanding of natural phenomena and regularities is mostly carried out at publicly funded research facilities. The reason is the substantial difference between basic research and applied research with respect to excludability – while techniques are at least partially excludable because of the patent system, the knowledge of natural laws and phenomena cannot be patented, i.e., propositional knowledge is non-excludable. Consequently, there are barely any profits that basic research institutions (or individual scientists) are able to reap. This implies that the public is decisive in financing a society's quest for understanding natural phenomena and regularities.[2] Without any public funding, systematic basic research could not be carried out, with all the negative repercussions that this has on innovation and economic growth (cf. Mansfield, 1980; Toole, 2012, for empirical evidence). The association between basic research and economic prosperity is also illustrated in Fig. 1, where we plot the basic research expenditures of OECD countries as a fraction of GDP against their level of PPP-adjusted per capita GDP in 2009. Consistent with the evidence by Mansfield (1980) and Toole (2012) there seems to be a positive association, although, of course, this illustration does not imply any causal effect.

In our contribution we aim to analyze the importance of basic research for economic growth and welfare. We show that, starting from the levels of basic research outlays of the OECD countries, higher basic research investments raise per capita output and welfare in the long run, while there is a short-run fall of output and welfare. The reason for this short-run fall is the presence of a gestation lag of basic research and the fact that fostering basic research requires an increase in taxes and a reallocation of labor from other productive sectors of the economy (final goods production and applied research) toward the basic research sector. These short-run costs are a potential explanation for the reluctance of governments to increase public R&D expenditures despite the long-run benefits of such a policy.

A distinction between basic research and applied research has also been made by Park (1998), Morales (2004), Gersbach et al. (2009, 2013), Gersbach and Schneider (2015), and Akcigit et al. (2013). While representing highly valuable steps in analyzing the implications of basic science for economic growth, these models abstract from some features that allow for a more realistic description of long-run economic development processes and the associated welfare implications. First, these models abstract from the endogenous nature of human capital accumulation and population growth, which are known to be the central drivers of technological progress and long-run economic prosperity (cf. Galor, 2005, 2011; Strulik et al., 2013). Our analysis indicates that a model that misses out on the endogenous interaction between individual human capital accumulation and population growth would predict a different association between population growth and the long-run utility maximizing investment level in basic research. Second, these frameworks assume that physical capital does not play a role in the production process with the consequence that transition phases (and therefore gestation lags of basic research) cannot be analyzed properly. Third, with the notable exception of Gersbach and Schneider (2015),[3] these papers do not analyze the intertemporal welfare trade-off that is associated with different basic research policies in the presence of the mentioned gestation lags.

We present a tractable R&D-based growth framework with basic research, endogenous human capital formation and endogenous population growth, endogenous physical capital accumulation, and a fairly general description of *intersectoral* knowledge spillovers *between* basic and applied research and *intertemporal* knowledge spillovers *within* these two research sectors. In so doing, we integrate a child quality–quantity trade-off in the vein of Becker and Lewis (1973) and a publicly funded basic research sector in the vein of Park (1998) into a discrete-time formulation of the generic growth framework of Romer (1990) and Jones (1995). The resulting qualitative implications are consistent with the empirical findings of (i) a positive effect of education on growth (see de la Fuente and Domenéch, 2006; Cohen and Soto, 2007; Hanushek and Woessmann, 2012, for empirical evidence), (ii) a negative effect of fertility on growth (see Li and Zhang, 2007; Herzer et al., 2012, for empirical evidence), (iii) a positive association between basic research investments on the one hand and productivity and per capita GDP on the other (see Mansfield, 1980; Czarnitzki and Thorwarth, 2012, for empirical evidence), and (iv) a gestation lag of basic research of around 20 years (see Adams, 1990; Toole, 2012, for empirical evidence[4]). Altogether, the consistency of our model with these stylized facts is reassuring and allows us to analyze the importance of changing basic research policies for economic growth and welfare in the short run as well as in the long run. In so doing we solve the model numerically and are able to show that the long-run welfare-maximizing basic research investments are much larger than the levels that we currently observe in the OECD.

The paper proceeds as follows. Section 2 describes the model that integrates endogenous fertility, endogenous education, and publicly funded basic research into an R&D-based economic growth framework. Section 3 contains our analytical results and propositions regarding the long-run balanced growth path. Section 4

[2] See also Nelson (1959), Shell (1966), Mansfield (1980), and Park (1998) for interesting discussions regarding the role of publicly funded research.

[3] In the supplemental material to their publication available at http://www.sciencedirect.com/science/article/pii/S0304393215000203, Gersbach and Schneider (2015) provide an interesting comparison between the long-run growth rates that would emerge in a situation in which governments of two open economies maximize consumption of one period (20 years in their setting) and a situation in which governments of two open economies maximize consumption over an infinite time horizon. Irrespective of whether the governments coordinate their efforts, the long-run economic growth rates are substantially higher if governments have a longer planning horizon. Note however, that there is no short-run growth slowdown (and no short-run welfare decline) in their framework because it does not feature transitional dynamics.

[4] The latter of the two contributions is focused on the pharmaceutical industry.