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Policy implications of endogenous growth models: A Note

Joerg Lingens
University of Regensburg

Abstract

In this note we analyse the effect of an increase in the amount of resources devoted to research within a general RDgrowth model. We show that the initial effect of this increase is independent of whether the spill−over in RDis linear or not. Even after two decades along a transitional growth path the direction as well as the magnitude of this effect on the rate of growth is very similar. Thus, linear spill−over models could be interpreted as a proxy for the transitional behaviour of non−linear spill−over models. If we consider transitional dynamics to be relevant, linear spill−over models could be reasonable descriptions of real world growth processes.

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1 Introduction

In the growth literature much concern has been devoted to the problem of the so-called scale effect. Basically, all of the early endogenous growth models which formalise the idea that innovation is the primary source of economic growth are characterised by this effect. They imply that the rate of economic growth increases with the amount of resources devoted to the research sector. Hence, the size(=scale) of an economy determines its rate of growth. This result of the "first generation" endogenous growth models is driven by the assumption of a linear spill-over effect in R&D.

The scale effect of "first generation" endogenous growth models has been questioned on empirical grounds (see, e.g. Kremer (1993), Jones (1995a), Young (1998)). Based on this empirical observation many theoretical models emerged–the "second generation" growth models–which removed this effect on the rate of growth (see, eg. Jones (1995b), Segerstrom (1998), Eicher and Turnovsky (1999)). An implication of these models (in their simplest form) is that the rate of growth is only a function of the rate of population growth. Thus, channels via which policy can influence the rate of growth are very limited in the "second generation" models.

Thus, one could conclude that results which were derived within "first generation" models, e.g. the effect of R&D subsidies, the effect of public investment or the effect of imperfect labour markets, should be considered obsolete. In this note, however, we demonstrate that a change in the amount of resources employed in the research sector has identical effects in "first generation" and "second generation" models initially after the shock. Moreover, we show that the magnitude of this effect is very similar in both types of models for a fairly long period of time.

As such, if we believe transitional dynamics to be important in the real world, we could interpret comparative static results of "first generation" models as a convenient way to proxy the effects on the transitional growth path in "second generation" models. This offers the advantage that researchers can use simple and well understood models to derive valid policy implications.

Section 2 develops the theoretical argument, the calibration is done in section 3. Section 4 briefly concludes.

2 The Model

Consider the simple growth model proposed by Jones (1999). Output Y is produced using a constant and exogenous fraction $(1 - s)$ of the primary resource base L. The production function is CRS and reads:

$$Y = A^{\sigma}(1 - s)L, \tag{1}$$

where A denotes efficiency and σ is the output elasticity with respect to efficiency. Due to R&D effort, efficiency of the production process grows. The differential equation which drives this growth process is given by:

$$\dot{A} = A^{\phi} sL \Leftrightarrow \frac{\dot{A}}{A} \equiv g_A = A^{\phi-1} sL, \tag{2}$$

where a dot over a variable denotes the time derivative and s denotes the fraction of resources employed in the research process.

By equation (1), the rate of output growth is a linear function of the efficiency growth rate:

$$g_Y = \sigma g_A.$$

Research sector production is characterised by a spill-over effect. The strength and direction of this spill-over effect is driven by the parameter $\phi \leq 1$. If ϕ is positive (negative), the same absolute increase in efficiency gets cheaper (more expensive) in terms of primary resource input as the level of efficiency increases.

Following the literature (see, e.g. Jones (1999)) we distinguish two cases. With $\phi = 1$ the spill-over is linear and equation (2) reflects the situation in the "first generation" endogenous growth models (see, e.g. Grossman and Helpman (1991) or Barro and Sala-i-Martin (1995)). In this case equation (2) directly determines the balanced growth path, i.e. $g_A = sL$. This path is exogenously determined by the amount of resources devoted to the R&D sector. An increase in this amount, increases the rate of (efficiency) growth. This property is called the scale effect (see, e.g. Jones (1999)) since the size of the economy determines the rate of growth.

For $\phi < 1$, the rate of efficiency growth is a function of the level of efficiency level. As such, the rate of growth in (2) is in general *not* constant throughout time. The balanced rate of growth (see, Jones (1999)), i.e. the rate of efficiency growth which is constant over time, can be derived using (2):

$$\dot{g_A} = A^{\phi-1} s\dot{L} + (\phi - 1)A^{\phi-2} sL\dot{A} = 0,$$

$$\Leftrightarrow \dot{g_A} = g_A n + (\phi - 1)g_A^2 = 0 \tag{3}$$

$$\Leftrightarrow g_A^* = \frac{n}{1 - \phi}, \tag{4}$$

where n is the exogenous rate of population growth. This case is the focus of the "second generation" endogenous growth models (e.g. Jones (1995b) or Segerstrom (1998)). The amount of resources devoted to R&D does not play any role in the determination of the (balanced) rate of growth. As such, there is no scale effect anymore. On the one hand this matches the empirical observations. On the other hand the model does not offer channels for growth enhancing policies other than increasing the rate of population growth. Policy changes which aim e.g. at increasing the amount of resources devoted to R&D only have level effects. Remember, however, that this policy invariance only holds along a balanced growth path. The transitional rate of growth, i.e. the rate of efficiency growth which is not constant throughout time, changes with the amount of primary resources devoted to R&D even in the case in which $\phi < 1$.

Equation (2), however, depicts a property which is especially important for the interpretation of policy results derived in "first generation" endogenous growth models ($\phi = 1$):

$$\frac{\partial g_A}{\partial s} = A^{\phi-1}L = \frac{g_A}{s}. \tag{5}$$

Starting from a situation in which the efficiency growth rates are identical, the effect of a change in s is identical in the "first" and the "second generation" growth model, initially. After the policy shock, the growth rate of A remains at the higher level if $\phi = 1$ or, if $\phi < 1$, declines again and approaches its unchanged balanced growth value given by (4).

Since the impact effect of a policy change is independently of the strength or the direction of the R&D spill-over, ϕ, this begs the question how fast the dynamic system in the case for $\phi < 1$ converges to its balanced path. If transition is slow, see e.g. Steger (2003), the results derived in "first generation" endogenous growth models can serve as good proxies for the dynamic behaviour of "second generation" models.

3 Calibration

In this section we analyse the transition path of the rate of efficiency growth after the policy shock of increasing s.[1] In order to perform this analysis we have to solve the differential equation which governs the transitional rate of efficiency growth in the case of $\phi < 1$. By (3), this differential equation is given by:

$$\dot{g_A} = n g_A + (\phi - 1) g_A^2. \tag{6}$$

[1]We could have also analysed the transitional path of output. Since $g_Y = \sigma g_A$, the focus on g_A does not affect any of the conclusions.

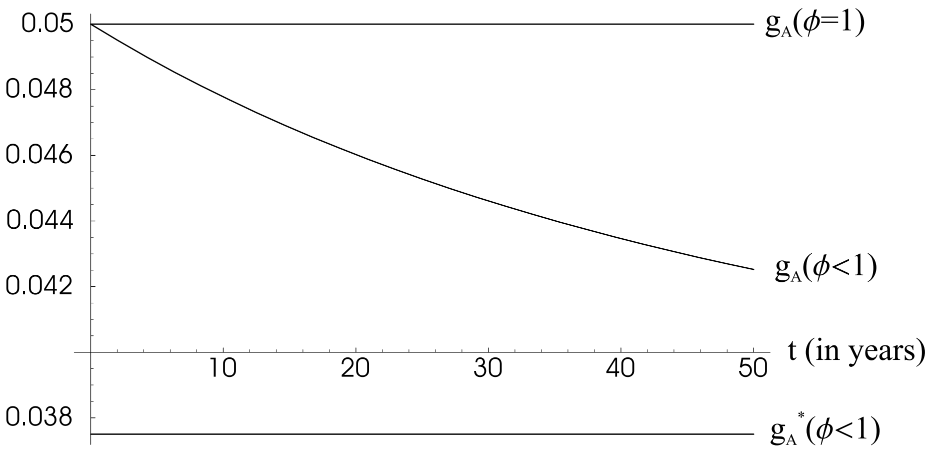

Figure 1: Growth Paths

To solve this equation, we have to specify an initial value for the (balanced) growth rate. Following the literature (see, e.g. Eicher and Turnovsky (2001)) we assume $n = 0.015$ and $\phi = 0.6$. This yields an initial rate of efficiency growth of $g_A^* = 0.0375$. The initial growth rate in the benchmark model for $\phi = 1$ is assumed to be $g_A = 0.0375$, too. Parameters in both models are such that the rate of efficiency growth is identical. The policy experiment is an increase in s to increase the rate of growth to $g_A \mid_{\phi=1} = g_A \mid_{\phi<1} = 0.05$.

This latter value is the starting point of the transitional rate of growth. With this initial condition we can solve (6) for the transitional growth path:[2]

$$g_A \mid_{\phi<1} = \frac{e^{nt} n}{-1 + 20n + \phi + (1-\phi)e^{nt}}. \tag{7}$$

We can plot this equation which is shown in figure 1 (in addition the balanced growth path for the case of $\phi = 1$ and of $\phi < 1$, both which are constant, are depicted).

Figure 1 shows that after the initial increase due to the increase in s, the rate of efficiency growth will adjust slowly towards the long run equilibrium. A decade after the policy shock, the gap between the actual (transitional) rate of growth and the long run equilibrium is still 82% of the gap initially after the shock. After the second decade the gap will be 70% (again compared to the initial situation). It will take nearly four decades to bridge half of the

[2]Equation (6) is a Bernoulli equation. Define $z(t) = g_A^{-1}$. Thus, $\dot{z}(t) = (-1)g_A^{-2}\dot{g_A}$. Using this, we can rewrite (6), $\dot{z}(t) = nz(t) + (\phi - 1)$, which can readily be solved for z. Substituting back gives the solution to (6), see e.g. Gandolfo (1997).

initial gap. This is similar to the value Steger (2003) finds for the more sophisticated Segerstrom (1998) model.

Since phases of transition are fairly long in "second generation" growth models, the policy effects on the transitional growth path are important. Moreover, results derived in otherwise similar "first generation" models are reasonable approximations for the transitional behaviour of "second generation" models and hence, for real world growth processes.

4 Conclusion

Within a simple endogenous growth framework we have shown that the effects of a change in the amount of resources devoted to R&D on the rate of efficiency growth are independent of whether we consider a "first" or a "second generation" endogenous growth model. This is true, when considering the impact effect. After the shock, the growth rate in the "second generation" model will move towards its (unchanged) balanced path. However, since phases of transition are long, the results derived in "first generation" models are also a good description of the quantitative and qualitative effects of policy changes in second generation models.

"First generation" models, hence, offer a convenient approximation of the transitional behaviour of "second generation" models. Thus, comparative static results, although derived in various applications of "first generation" models, are relevant for real world policy.

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