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Innovation, public capital, and growth ☆

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ABSTRACT

This paper studies interactions between innovation, public capital, and human capital in an OLG model of endogenous growth. Public capital affects growth not only through productivity, but also through innovation capacity and human capital accumulation. Numerical simulations, based on a calibrated version of the model, are used to illustrate these channels. Panel data regressions are presented next; they show that higher innovation performance promotes growth directly, whereas public capital has both direct and indirect growth effects by promoting human capital accumulation and innovation capacity. Elasticity estimates derived from simultaneous equation techniques show that the general equilibrium effects of public capital on steady-state output per capita (which account for indirect effects) are significantly higher than those derived from single equation methods.

1. Introduction

The link between human capital, innovation, and growth has been the subject of numerous analytical and empirical contributions. Starting from the seminal contributions of Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992), a number of studies have proposed integrated models in which R&D and human capital accumulation are engines of growth, by emphasizing the complementarity between these two factors for the process of development; these studies include Redding (1996), Arnold (1998), Funke and Strulik (2000), Strulik (2005), Grossmann (2007), Iacopetta (2010), Gómez (2011), Sequeira (2011), Chen and Funke (2013), and Gómez and Sequeira (2013).

At the same time the link between *public* capital, innovation, and growth has not received much attention in the literature. In one of the few existing contributions, Schiffbauer (2007) developed a Romer-type model in which government spending on infrastructure reduces transportation costs associated with intermediate goods. However, he does not discuss public policy, and the potential trade-offs associated with the provision of infrastructure and other services by the government. Yet, this is a critical issue; if governments have access to limited resources to cover their expenditure, different types of government interventions may entail dynamic trade-offs at the macroeconomic level—even though at the microeconomic or sectoral level these interventions are largely complementary. In addition, different types of government intervention may

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generate spillover effects on other sectors, which may have an indirect impact on innovation capacity. If indeed lack of infrastructure or low quality of tertiary education are key constraints on research and development activities, increasing spending on infrastructure or universities may ultimately prove to be more efficient to stimulate innovation than, say, subsidies to research activities in the private sector.

To address these issues, this paper develops an overlapping-generations (OLG) model in which education, public capital, and innovation are all determinants of long-run growth. In the model, public capital affects the economy in a number of ways—through productivity in the production of final goods (in the standard Barro (1990) tradition), but also through innovation capacity and the economy's ability to produce human capital. This last channel is consistent with a number of studies that have documented a positive impact of infrastructure services on educational attainment (Agénor, 2012). As a consequence of these various channels, the trade-offs involved in the allocation of public spending are more involved; depending on production elasticities, the best way to foster innovation activity in the private sector is not necessarily through direct public subsidies.

Our analytical framework delivers several important testable implications with respect to the effects of public infrastructure and public R&D spending on economic growth. The former operates both directly and indirectly (through the capacity to innovate and the accumulation of human capital) while the latter depends on the way R&D spending is financed. Moreover, the impact of infrastructure may operate, both directly and indirectly, in a nonlinear fashion. We test these implications by using a sample of 38 industrial and developing countries for the period 1981–2008 with a variety of econometric procedures and alternative definitions of the key variables.

To preview our empirical results, we find that higher innovation performance is conducive to per capita income growth while the stock of public capital has both direct and indirect growth effects by raising both human capital and the capacity to innovate. We also find evidence of quality effects of infrastructure and empirical support for the "critical mass" hypothesis of public capital, in line with several recent contributions (see Röller and Waverman (2001), Kellenberg (2009), Agénor (2010), and Czernich et al. (2011)). Taking proper account of the government's budget constraint, and the joint determination of the key endogenous variables, our estimates also suggest that public spending on R&D contributes to growth by fostering innovation. Further, we use the coefficient estimates to calculate various elasticity parameters, thus offering a direct link to the theoretical model developed. Elasticity estimates derived from simultaneous equation techniques suggest that the general equilibrium effects of public capital on growth are significantly higher than those derived from single equation methods. Indeed, while our direct estimates are close to the average of 0.17 reported in the review by Bom and Ligthart (2014), which focuses on studies based on single equation techniques, our estimate based on simultaneous equation techniques is in the range of 0.2–0.4, depending on the type of infrastructure.

The paper continues as follows. Section 2 presents the model. In doing so we pay particular attention to the production functions for goods, human capital, and ideas, given that our estimation methodology is directly related to them and the parameters that characterize the externalities associated with public capital. Section 3 defines the equilibrium growth rate and discusses an experiment involving an increase in infrastructure investment. Section 4 presents our econometric methodology and findings. Section 5 offers some concluding remarks.

2. The economy

We consider an OLG economy where individuals live for two periods, adulthood and old age. Each individual is endowed with one unit of time in each period of life. In adulthood time is allocated to market work, whereas in old age time is allocated entirely to leisure. Savings can be held only in the form of physical capital, whose initial stock is the endowment of an initial old generation. In adulthood, each individual has one child; total population is thus constant and the size of each cohort is set to $\bar{N}$.

In addition to individuals, the economy is populated by firms and a government. There are four sectors in the economy: the first produces a final good, the second intermediate inputs, the third human capital, and the fourth conducts research and development (R&D). Labor moves freely across sectors.

2.1. Individuals

Let c^t_{t+j} denote consumption at period $t+j$ of a person born at the beginning of period t, with $j = 0, 1$. The discounted utility of an individual born at t is given by

$$U_t = \eta_C \ln c^t_t + \frac{\ln c^t_{t+1}}{1+\rho}, \tag{1}$$

where $\rho > 0$ is the subjective discount rate and $\eta_C > 0$.

The period-specific budget constraints are given by

$$c^t_t + s_t = (1-\tau)e_t w_t, \tag{2}$$

$$c^t_{t+1} = (1 + r_{t+1})s_t, \tag{3}$$