Does human capital stimulate investment in physical capital? Evidence from a cost system framework

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ABSTRACT

The direct effect of human capital on economic growth has been widely analysed in the economic literature. This paper, however, focuses on its indirect effect as a stimulus for private investment in physical capital. The methodological framework used is the duality theory, estimating a cost system aggregated with human capital. Empirical evidence is given for Spain for the period 1980–2000. We provide evidence on the indirect effect of human capital in making private capital investment more attractive. Among the main explanations for this process, we observe that higher worker skill levels enable higher returns to be extracted from investment in physical capital.

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1. Introduction

The role that human capital plays as a stimulus for technical progress and for investment in physical capital has been stressed in the economic literature. It can be argued that the stock of human capital in an economy favours the generation and absorption of technology but that, at the same time, technical progress will increase the incentive to invest in education. In this way, if technology is linked to investment in physical capital, there will be a positive relationship between the two types of capital. Additionally, by stimulating the production structure to shift from sectors with lower to higher capitalisation ratios, another link between educational and physical capital can be deduced (Tamura, 2002). In fact, this relationship has been used in some empirical studies to justify the limited impact of human capital on the estimation of growth regressions that control for the accumulation of physical capital. Barro (1991), for instance, argues that a significant part of the effect of human capital is channeled through an increase in the investment rate for physical capital. The same result is obtained by Sianesi and Van Reenen (2003) and Krueger and Lindahl (2001). Even with more disaggregated evidence in the same line, Van de Walle (2003) finds that the net marginal benefit of investment in an irrigation system in Vietnam depends on the farmers' educational level.

On the other hand, one could argue that the accumulation of human capital could offset the neoclassical mechanism of decreasing returns to the accumulation of physical capital. In this sense, Barro (1998) argues that an economy with an initially low ratio of physical capital to human capital (as after a war or catastrophe, or after a period of quick accumulation of human capital for non-economic reasons) will tend to grow rapidly due to increases in the stock of physical capital until the ratio between the two types of capital is equilibrated. This circumstance can be deduced from the growth models in which the physical capital to human capital ratio is constant in the long run. So, if there is disequilibrium in the economy at any moment – for instance, due to an

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abundant stock of human capital in relation to physical capital – equilibrium will be reached again through greater investment in the stock of the capital which was initially less abundant (Barro and Sala-i-Martin, 1995).

As a consequence of the reasons set out above, we believe that it is interesting to check whether the accumulation of education in an economy does indeed stimulate physical capital. Previous contributions in the literature have put the emphasis on the so-called capital–skill complementary hypothesis. The seminal paper by Griliches (1969) stated this hypothesis and using US data obtained empirical evidence that "*skill* or *education* is more complementary with capital than unskilled or unschooled labour". Since then, cross-section studies and time-series studies have provided empirical evidence on the complementary hypothesis for different sets of economies and time periods (e.g. Berman et al 1994; Doms et al., 1997; Flug and Hercowitz, 2000). The empirical support has been shown to be robust to alternative specifications of the production function (Bergström and Panas, 1992), though it seems to be far from uniform across industries and economies. For instance, the results in Rice (1989) supported complementarity for the US but advised of substantial industry heterogeneity, while Papageorgiou and Chmelarova (2005) obtained heterogeneous evidence for different samples of countries that is shown to be related to the initial level of development and human capital endowment. In the same vein, Duffy et al. (2004) estimated a CES production function for a sample of countries in which the assumption of constant elasticities of substitution between factors is relaxed, and a positive relationship could not be found between the educational level and physical capital. However, the authors recognise that this could be due to the high heterogeneity of the sample of countries – i.e. they have economies with very different development levels – which they have used to check the assumption in line with the argument made by Goldin and Katz (1998), according to which the relationship between the two types of capital depends on the development level.

Therefore, although the direct effect of human capital on economic growth has been widely analysed in the economic literature, its indirect effect through the stimulation of private investment in physical capital has not received much attention. This paper aims at providing further stimulating evidence on the issue. Specifically, apart from the analysis of the direct effect of human capital on output, we focus on checking whether the accumulation of human capital stimulates investment in physical capital. This being the case, the paper tries to shed some light on the reasons behind such a relationship. In this sense, our prior assumption is that a higher worker skill level may enable a higher return to be earned from investment in physical capital. In other words, a high endowment of human capital in an economy makes it more attractive for firms to locate, especially for highly capitalised, productive activities which require a highly skilled workforce. This paper will test that hypothesis.

From a methodological point of view, a novelty in the paper is the use of the framework established by duality theory, using a cost system in which we incorporate human capital as a factor that can shift the cost function.[1] The main advantage of using the dual approach in this paper arises from the possibility of computing the elasticity of physical capital to human capital and then analysing the indirect effect that human capital has on economic growth through its influence on the optimum stock of physical capital. That measure cannot be obtained by the standard practice of estimating a production function with human capital as an additional input.[2]

The above-mentioned methodology is applied to a comprehensive dataset for the Spanish economy in the last few decades. The situation in Spain could be paradigmatic since there has been a spectacular increase in educational attainment and this has coincided with a virtually uninterrupted process in which the country has opened up and become exposed to competition, with the ensuing modernisation of production and institutional structures. It seems therefore that the situation in Spain is ideal for assessing the impact of human capital and its relationship with physical capital. In addition, homogeneous, high-quality data on aggregate output and input quantities and prices, and educational human capital is available for a long time span for Spain as a whole and for each of its regions. This makes it possible to obtain robust estimates of the direct and indirect effects of human capital, in contrast with the evidence provided in most of the previous literature, which is based on information from samples of heterogeneous economies.

The rest of the paper is organised as follows. In the second section we present the model based on the duality theory that includes human capital stock as a factor that influences production technology in an economy, and we describe the empirical specification from which the effect of human capital on physical investment can be obtained. The third section describes the dataset and the major variables in the empirical analysis, paying special attention to the accumulation of human and physical capital in Spain over the last few decades. The results are reported in the fourth section and, in the last section, we put forward our conclusions.

2. Theoretical and empirical framework

2.1. Cost function expanded with human capital

Consider a production function, where Y is the output and X_i ($i = 1, ..., r$) the ith input:

$$Y = F(X_1, ..., X_r) \tag{1}$$

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[1] Morrison and Siegel (1997) is, to the best of our knowledge, the only study to analyse effects of human capital endowment on production activity by adopting this approach in the more general sense of studying the effects of knowledge accumulation without analysing the stimulus that human capital may give to investment in physical capital.

[2] The use of a cost function to analyse the effect of human capital must be understood therefore as parallel to the common practice in the economic growth literature of using a production function aggregated with the stock of human capital (see for instance Topel, 1999). Both frameworks rest on the same idea that a higher endowment of human capital in the economy may imply higher productivity growth.