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The effects of human capital composition on technological convergence

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ABSTRACT

This paper empirically investigates whether the contribution of human capital to productivity growth depends on the composition of human capital and proximity to the technology frontier in a panel of 87 sample countries over the period 1970–2004. It tests the hypothesis that primary and secondary education is more suitable for imitation whereas tertiary education is more appropriate for innovation. The results show that the growth enhancing effects of higher education increase with proximity to the technology frontier only for high and medium income countries.

1. Introduction

Although human capital has been widely regarded as an important driver for innovative growth in the theories of endogenous growth (Romer, 1990; Aghion and Howitt, 1992, 1998; Acemoglu, 1996; Acemoglu et al., 2002), empirical findings regarding its direct contribution to growth are at best mixed.[1] On the other hand, building on the earlier work of Nelson and Phelps (1966) that suggests that a more educated workforce facilitates the adoption of new technologies, a number of recent studies have consistently found that human capital not only enhances the ability of a country to develop its own technological innovation but also increases its capacity to adopt technologies already developed elsewhere and thereby facilitates convergence (see Griffith et al., 2004; Benhabib and Spiegel, 2005; Kneller and Stevens, 2006; Madsen et al., 2010, among others).

However, despite finding a dual role for human capital in promoting growth, these studies do not resolve the empirical puzzle that human capital enhances growth only for those countries with the lowest level of education, as found by Krueger and Lindahl (2001). In an attempt to resolve this issue, Vandenbussche et al. (2006) argue that human capital does not affect innovation and imitation uniformly. In their model, unskilled human capital facilitates imitation or diffusion of existing technology, whereas skilled human capital promotes the innovation of new technology. Their theoretical model proposes that tertiary education should become increasingly important and primary and secondary education less important for growth as a country moves closer to the technology frontier.

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[1] For instance, Mankiw et al. (1992) find a positive and significant direct effect of human capital on growth, whereas Islam (1995) finds the reverse using a different estimator. Caselli et al. (1996) also obtain significant negative coefficients of human capital whereas Knowles and Owen (1995), Pritchett (2001) and Radelet et al. (2001) find insignificant associations between human capital and growth.

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Using aggregate data for 19 OECD countries over the period 1960–2000 and state level data for the US, the empirical analyses of Vandenbussche et al. (2006), henceforth VAM, and Aghion et al. (2009) find evidence in favor of the predictions of VAM's model. However, whether these predictions are valid for medium and low income developing countries remains untested. There are three reasons why it is important to test their hypothesis for developing countries. First, the VAM model so far has only been tested for high income countries. The sample countries typically have the highest levels of human capital accumulation in the world. Second, knowledge of the social returns to different categories of education is important from a budgetary perspective. If developing countries are mainly technology followers and thereby absorb foreign technologies by adapting them to local conditions and applying them to alternative uses, the social returns to lower skilled workers exceed those of higher skilled workers. Conversely, if human capital predominantly fosters technological innovations in developed countries and thereby generates income growth by making capital and labor more productive, the social returns to highly skilled workers may exceed those of lower skilled workers (Aghion et al., 2009). This suggests that the way human capital composition affects growth may vary depending on the developmental stage of a country, and therefore highlights the importance of segregating the sample into different income groups. Third, Caselli and Coleman (2006) argue that skilled and unskilled workers are imperfect substitutes and that the skill premium differs substantially between developed and developing countries. If this is the case, the sample of developing countries will give insight into the general validity of the model of VAM.

This paper contributes to the growth and development literature in three respects. First, the hypothesis of VAM is tested for low income, middle income and high income countries. Second, in addition to utilizing the widely used human capital datasets of Barro and Lee (2001), we also use the new educational datasets compiled by Cohen and Soto (2007) and Lutz et al. (2007). Third, only a few studies, if any, have made a cross-country analysis of the growth effects of human capital for various educational groups. *A priory* there is no reason why the growth effects of different categories of human capital are the same or that the social returns to human capital for different educational groups are the same as the private returns, as is often assumed when different educational groups are combined together in macroeconomic studies.

The next section establishes the empirical framework and Section 3 explains the data and construction of variables. The analysis is conducted based on a large panel of 87 countries (including 28 high, 37 middle and 22 low income countries) over the period 1970–2004 using the system GMM method. Section 4 presents the results and the last section concludes.

2. Empirical framework

The discussions above suggest that the composition of human capital has a direct effect on TFP growth: skilled human capital is important for innovation, whereas unskilled human capital is better suited for imitation. The effect of proximity (inverse of distance) to the technology frontier is expected to have a negative effect on TFP growth, following the prediction of the hypothesis of the advantage of backwardness by Gerschenkron (1962). That is, countries which are further behind the technology frontier should experience higher TFP growth due to lower effective costs of innovation, thereby allowing a more rapid catch-up to the technology frontier. The effects of skilled human capital on TFP growth should increase with proximity to the technology frontier since innovation is a skill-intensive activity. However, the contribution of unskilled human capital to TFP growth should decrease with proximity to the technology frontier since imitation requires mostly physical capital and less educated (or unskilled) human capital (VAM; Aghion et al., 2007, 2009).

Accordingly, the following empirical specification is adopted to test the above hypotheses (see VAM):

$$\Delta \ln A_{it} = \beta \ln\left(\frac{A_{i,t-1}}{A^{US}_{t-1}}\right) + \gamma' H_{i,t-1} + \delta' H_{i,t-1} \ln\left(\frac{A_{i,t-1}}{A^{US}_{t-1}}\right) + \theta' X_{it} + c_i + t_t + \varepsilon_{it} \quad (1)$$

where $\Delta \ln A$ is TFP growth, $\frac{A_{i,t-1}}{A^{US}_{t-1}}$ is the relative TFP gap between country i and the US (technology leader), which measures proximity to the technology frontier, H is a vector of human capital decomposed into different educational groups, X is a vector of control variables (which includes the rate of inflation, trade openness, the inflows of FDI, financial development and geographical location), c_i captures the time-invariant unobserved country-specific fixed effects, t_t captures the unobservable individual invariant time effects, and ε_{it} is the stochastic error term. The variables are measured as the average within the period that is covered by the differences.

The focus variables in the VAM model are human capital and the interaction between human capital and proximity to the frontier. The model predicts that the signs of the coefficients of these variables vary across educational groups. Importantly, VAM argues that the growth effects of the interaction between human capital and proximity are positive for tertiary education but negative for primary and secondary education. The interaction effect is negative for primary and secondary education because these educational groups imitate the innovations in the frontier country. The further the country is from the frontier the larger is the imitation effect because the effective costs of imitation are lower. Furthermore, the model predicts