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Endogenous TFP and cross-country income differences ☆

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ABSTRACT

Using a class of endogenous growth models that exhibit international spillovers, we show that most of the cross-country differences in output per worker are explained by barriers to the accumulation of rival factors (physical and human capital) rather than by barriers to the accumulation of knowledge. This is shown theoretically, by comparing models with exogenous and endogenous TFP, and quantitatively by using a carefully calibrated version of the model. The main finding is that barriers to the accumulation of physical and human capital explain up to 64% of income gaps relative to the US.

1. Introduction

In his classic study of the mechanics of economic growth and development, Lucas (1988) famously asks: "Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, *what*, exactly? If not, what is it about the 'nature of India' that makes it so?" Seminal papers by Parente and Prescott (1994), Klenow and Rodríguez-Clare (1997), and Hall and Jones (1999) have shown that differences in total factor productivity, or TFP, are key for understanding income differences, and Prescott (1998) has called for a theory of TFP. These studies suggest that differences in physical capital per worker and human capital cannot account for income differences. Their main policy implication, which constitutes an answer to Lucas' question, is that the elimination of barriers to accumulation of knowledge is key for economic development.

In the last 10 years, a new generation of endogenous growth models has been proposed (Parente and Prescott, 1994; Eaton and Kortum, 1996; Howitt, 2000; Klenow and Rodríguez-Clare, 2005, among others). These models are consistent

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with a number of empirical regularities on growth and development. Notably, countries seem to share a common long-term growth rate, while their relative income levels, as well as their investment rates in physical capital, human capital and research are persistently different. These facts suggest that the international diffusion of knowledge is a key piece in understanding development. More importantly, in these models long-term growth rates are determined worldwide, while country policies and specific conditions affect relative income levels. This new generation of growth models provides the needed theory of relative TFPs.

This paper explores the theoretical and quantitative implications of this new generation of growth models for cross-country income differences. A key insight of endogenous growth models is that "income gaps" are caused by "object gaps" and "idea gaps" (Romer, 1990). More precisely, these models regard long-term income differences as the result of two types of distortions or frictions: distortions associated with the accumulation of rival factors of production, the objects, such as distortional taxes on capital and labor, as well as risks of expropriation, confiscation, thievery, squatting, extortion, kidnapping, etc.; and distortions associated with the accumulation of nonrival factors of production, the ideas, such as taxes on innovation and adoption activities, costly patent application and patent protection, limited intellectual property rights, and overall, risk of imitation and copying. The main issue addressed in this paper is the relative importance of each type of friction in explaining cross-country income differences. The fundamental frictions in our model are two rates of expropriation, one affecting physical capital, and the other affecting ideas via limited patent protection.

The main finding of the paper is that income differences are primarily explained by distortions to the accumulation of rival factors rather than distortions to the accumulation of ideas. This finding is surprising in light of the results of Klenow and Rodríguez-Clare (1997)—KR (1997) hereafter—and Hall and Jones (1999)—HJ henceforth—who, using models of exogenous TFP, suggest instead that income differences are primarily explained by barriers to the accumulation of knowledge. We show analytically that frictions to the accumulation of rival factors are magnified when TFP is endogenous. A carefully calibrated version of the model shows that this amplification is large. In fact, our quantitative findings are closer to those of Mankiw et al. (1992)—MRW hereafter—than to KR (1997) or HJ, but the mechanism and policy implications are completely different.

Our model builds on Howitt (2000), and particularly on Klenow and Rodríguez-Clare (2005)—KR (2005) henceforth. They extend a quality-ladder model of growth to include international diffusion of knowledge, and eliminate scale effects at the country level. A key component of these models is the "catch-up" externality, one that captures the idea that lagging behind the world technology frontier facilitates technological progress via adoption. This externality determines the speed of technological diffusion. In contrast with the two papers above, we use Romer's (1990) and Barro and Sala-i-Martin's (2003) variety approach instead of the Shumpetarian approach. This alternative formulation is analytically more tractable and yields closed-form results that are easy to compare to other findings in the literature. For example, we show that the standard model of exogenous TFP is a particular case of our model when the speed of diffusion is infinite. It is also shown analytically that distortions to the accumulation of rival factors are amplified as the speed of diffusion decreases. Our closed-form solutions allow us to perform exact variance decompositions analogous to those of KR (1997), and therefore we can compare our results directly to theirs. Finally, it is documented that this added tractability of the varieties model comes at no major cost because the quantitative results are similar to those of quality-ladder models.

For the quantitative assessment, we calibrate the key parameter of our model—the elasticity that governs the international diffusion of knowledge—following Howitt's (2000) suggestion of using the speed of convergence as a matching target. Since the object of study is cross-country data, we provide discipline to the calibration by relying on different data. Two alternative calibrations are used. The first one is the speed of convergence among 13 Asian countries estimated by Evans and Kim (2005) at around 2.5%. Second, Parente and Prescott (1994) suggest a higher speed of convergence for Japan of between 2% and 4% per year depending on how far Japan was from its balance growth income. Our answer to Lucas' (1988) question is that the long-term growth rate of India is likely tied to the worldwide growth rate, but India's income level is tied to India's distortions. According to our calculations, India's barriers to the accumulation of physical and human capital explain up to 64% of the income gap relative to the US, and the remaining 36% is explained by distortions to the accumulation of knowledge. These figures suggest that an Indian government with the will and power to reduce the income gap must focus on eliminating barriers to the accumulation of rival factors rather than nonrival ones.

The paper is organized as follows. Section 2 reproduces benchmark results obtained in a framework of exogenous TFP using our database for 1996. Section 3 presents the main results of the paper using an extended Solow model with endogenous TFP, but exogenous saving rates and R&D investment rates. The section summarizes analytical results, the calibration of the model, and the main quantitative findings. Section 4 endogenizes savings rates and R&D investment rates using a version of Romer's (1990) and Barro and Sala-i-Martin's (2003) variety model. It is shown that the steady state of this model maps exactly into the Solow model of Section 3, but provides additional equations to determine savings rates and R&D investment rates. In Section 5 we check the robustness of our results by allowing TFP to affect human capital accumulation. Section 6 concludes.

2. Exogenous TFP models

The neoclassical growth model has been the workhorse of most existing attempts to quantify the sources of cross-country differences of output per worker. Prominent examples of these attempts have arrived at opposite conclusions. On