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Physical capital accumulation in Asia 12: Past trends and future projections[☆]

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ABSTRACT

The pace of capital accumulation in East Asia has simply been stunning. In this paper, we investigate sources of this fast accumulation and make projections for the future. We estimate a "convergence" equation for physical capital per capita, which is derived from an open economy growth model, using a pooled cross-country, across-decade sample of the entire world. We also conduct projections for the next two decades. We find that an economy with a low level of capital stock per capita tends to experience faster accumulation subsequently. Asian economies have certainly benefited from this "convergence effect". But on the other hand, other factors such as a low rule of law score and high investment goods prices have worked against them. Our projection shows that, if those economies wish to maintain their current pace of fast capital accumulation, the keys would be to reduce distortions in the domestic market and to improve the quality of institutions.

1. Introduction

In this paper, we investigate sources of historical trends in physical capital accumulation for what we shall call "Asia-12" in this report, defined as China, Hong Kong, India, Indonesia, Korea, Malaysia, Pakistan, the Philippines, Singapore, Taiwan, Thailand, and Vietnam. We also make projections for the future. We propose a new projection approach based on estimation of a "convergence" equation for the investment rate. This equation, in turn, is based on an open economy growth model with capital mobility subject to convex adjustment costs. Using a pooled cross-country, cross-decade sample of the entire world, we identify major determinants of the growth rate of capital per capita. Based on those estimates, we decompose historical growth in the Asia-12 and make projections for the future. We will also investigate determinants of the investment rate for those countries. We study carefully the role of the saving rate.

The rest of the report is organized as follows. In Section 2, we develop our empirical model based on a theoretical open economy growth model. Section 3 provides an overview of past trends physical capital per capita (K/Pop) and the investment rate (I/Y). In Section 4, as a preliminary step, we study data properties of the investment rate in details. In Section 5, we estimate our convergence equation for physical capital per capita, and analyze sources of past growth. Section 6 uses the same model to make projections for the future. Section 7 concludes.

2. Theoretical background

In this section, we will develop a theoretical foundation for our projection method, which is an open economy growth model (although a formal exposition of the model will be left to Appendix A). The theory will help us identify key determinants of the physical capital–population ratio. We employ an open economy model primarily because most of the Asian economies are highly open economies.

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Consider a small open economy. Capital is assumed to be freely mobile across countries. Capital flow is determined primarily by the country's after-tax marginal product of capital (hereafter MPK). Here, "tax" should be interpreted to include such elements as country risks (quality of government and institutions, openness to external transactions) and efficiency of internal capital market. Investors are assumed to have access to the world capital market in which the world real interest rate is determined exogenously. The steady state condition is thus:

$$(1-\tau)\mathrm{MPK} = r^w, \tag{1}$$

where r^w is the world real interest rate which is considered to be exogenous, and τ is the tax rate broadly defined. Next, we study how this MPK is determined.

2.1. Steady state: simple case with no long run growth

We first consider a simple case without population growth or technological progress. Assume that the production function takes a Cobb–Douglas form:

$$Y = AK^{\alpha}L^{1-\alpha}, \tag{2}$$

where Y is output, A is a positive constant, K is physical capital and L is labor. Also, α takes a value between 0 and 1. Then we have

$$\mathrm{MPK} = \alpha AK^{\alpha-1}L^{1-\alpha} = \alpha A\left(\frac{K}{L}\right)^{\alpha-1} = \alpha\frac{Y}{K} \tag{3}$$

Hence, for the capital–output ratio, we obtain the following steady state condition:

$$\frac{K}{Y} = \frac{(1-\tau)\alpha}{r^w}. \tag{4}$$

Thus the tax rate becomes the primary determinant of this ratio. Note that TFP does not enter Eq. (4). On the other hand, for the capital–labor ratio, we get

$$\frac{K}{L} = \left[\frac{(1-\tau)\alpha A}{r^w}\right]^{1/(1-\alpha)}. \tag{5}$$

Hence, in this case, TFP does show up on the right hand side. These features will be important when we interpret our estimation results later. For the level of investment, denoted I, as the steady state requires

$$I = \delta K, \tag{6}$$

where δ is the depreciation rate, we have a one-to-one correspondence between I and K. Thus, for example, if we would like to predict the long run investment rate, we could utilize the relationship:

$$\frac{I}{Y} = \delta\frac{K}{Y} = \delta\frac{(1-\tau)\alpha}{r^w}. \tag{7}$$

2.2. Steady state: introducing population growth and technological change

Now consider introducing population growth and technological progress. We introduce a labor-augmenting technological term into the production function in the previous sub-section:

$$Y = AK^{\alpha}(X\cdot L)^{1-\alpha}, \tag{8}$$

where X is the level of technology. We assume

$$\frac{\dot{L}}{L} = n, \quad \frac{\dot{X}}{X} = x, \tag{9}$$

where both n and x are constants. We can write down the "per efficiency unit" production function as:

$$\hat{y} = A\hat{k}^{\alpha}, \text{ where } \hat{y} \equiv \frac{Y}{XL} \text{ and } \hat{k} \equiv \frac{K}{XL}. \tag{10}$$

In this case, we have

$$\mathrm{MPK} = \alpha A\hat{k}^{\alpha-1} = \alpha\frac{\hat{y}}{\hat{k}} = \alpha\frac{Y}{K}. \tag{11}$$

Note that this expression is the same as in the simpler case with no growth. Thus, again, we obtain the following steady state condition:

$$\frac{K}{Y} = \frac{(1-\tau)\alpha}{r^w}. \tag{12}$$

On the other hand, for the capital–labor ratio, we get

$$\frac{K}{L} = X\cdot\left[\frac{(1-\tau)\alpha A}{r^w}\right]^{1/(1-\alpha)}. \tag{13}$$

Hence, even in the steady state, this variable will be growing at the rate x. For investment, we note

$$\dot{K} = I - \delta K \Rightarrow \frac{\dot{K}}{K} = \frac{I}{K} - \delta. \tag{14}$$

Note that, in the steady state, we must have

$$\frac{\dot{K}}{K} = n + x.$$

Thus, we get, in the steady state,

$$\frac{I}{K} = \delta + n + x \text{ or } \frac{I}{Y} = (\delta + n + x)\cdot\frac{(1-\tau)\alpha}{r^w} \tag{15}$$

must hold. Thus, population growth rate (or, more realistically, labor force growth rate) and the rate of technological change enter as important determinants for the steady state I/Y ratio.

2.3. Steady state under capital-skill complementarity

Now we consider a possible role of human capital. Simply introducing "H" into the above Cobb–Douglas production function in a labor augmenting way would not change anything fundamentally, as "H" would act just like "X" in the above analysis. Things are a little different when we consider the more interesting case of K–H complementarity.

$$Y = A(K^{\rho} + H^{\rho})^{\alpha/\rho}(X\cdot L)^{1-\alpha}, \tag{16}$$

where H is the level of human capital. Note that, in this setup, α should be considered as the share of "capital broadly defined": its realistic value would be closer to 0.6 or 0.7 rather than 0.3 or 0.4. In this case, we have

$$\mathrm{MPK} = \alpha\frac{Y}{K}\cdot\frac{K^{\rho}}{K^{\rho}+H^{\rho}} = \alpha\frac{Y}{K}\cdot\frac{(K/Y)^{\rho}}{(K/Y)^{\rho}+(H/Y)^{\rho}} \tag{17}$$

Hence, the long run capital–output ratio will be dependent on the country's level of human capital (relative to GDP), unless ρ is equal to zero.

2.4. Modeling transition

We assume that there is a quadratic cost of adjustment for investment. This would imply a gradual adjustment toward the steady state. The full model is developed and solved in the appendix. It is shown that the model solution exhibits a tendency toward gradual convergence to the steady state in terms of capital