III Economic Growth (continued)

H Endogenous Growth and Finance: Aghion et al (2005, QJE)

1 Introduction

- The "great divergence" between rich and poor countries: The proportional gap between the richest group of countries and the poorest increased from 3 in 1820 to 19 in 1998 (Maddison, 2001).
- Reasons for divergence: Technology appears to be the central factor underlying divergence (e.g. Easterly and Levine, 2001).
- Financial development and technology: Financial constraints present poor countries from taking full advantage of technology transfer.
- Three elements of the proposed theory: (i) Technology transfer requires investment; (ii) the size of investment required rises as the global technology frontier advances; and (iii) innovators' access to external finance is limited due to the agency problem.
- Predictions: Countries above some threshold level of financial development will all converge to the same long-run growth rate and all other countries will have strictly lower long-run growth rates (club convergence).
- Empirical evidence: Evidence supports the predictions of the theory.

2 Theoretical Framework

There are m countries (with a fixed population $P = 1$) that do not trade goods or factors, but make use of each other's technological ideas. Each country has three productive activities: "general" good production (perfect competition), intermediate goods production (monopolistic competition) and R&D (perfect competition).

- Consumers: 2-period lived consumers are endowed with 2 units of labor services in the first period and none in the second period. They all share an identical utility function: $U = c_1 + \beta c_2$, where $0 < \beta < 1$.

- General Good Production: Final goods are produced using labor P and intermediate goods $x_t(i)$. Output is given by

$$Z_t = P^{1-\alpha} \int_0^1 A_t(i)^{1-\alpha} x_t(i) di \quad 0 < \alpha < 1, \tag{1}$$

  where $P(=1) =$ labor employment in the general sector, $x_t(i) =$ the quantity of the latest version of intermediate good i and $A_t(i) =$ the productivity parameter associated with intermediate good i.

  Assuming perfect competition in the final goods sector, we have the first-order condition:

$$p_t(i) = \alpha \left(\frac{x_t(i)}{A_t(i)} \right)^{\alpha - 1}.$$

  The general good is used as numeraire.

- Intermediate Good Production: For each intermediate good i, there is one innovator (the ith innovator in $t-1$ and the ith incumbent in t if he succeeds). Let

$$A_t(i) = \bar{A}_t \ \ (\text{resp. } A_{t-1}(i)) \ \text{ with prob } \ \mu_t(i) \ \ (\text{resp. } 1 - \mu_t(i))$$

where $\bar{A}_t$ is the world technology frontier growing at the constant rate $g > 0$. In each intermediate sector, the incumbent is able to produce an intermediate good using the general good with 1 unit of the general good producing one unit of any intermediate good. There is also an unlimited number of people who can use $\chi(> 1)$ units of the general good to produce 1 unit of an intermediate good (the latest version). As a result,

$$p_t(i) = \chi,$$

$$x_t(i) = (\alpha/\chi)^{\frac{1}{1-\alpha}} A_t(i).$$

- Aggregate Behavior: Define the country's "average productivity" A_t as

  $$A_t = \int_0^1 A_t(i)di,$$

  then we have gross output of the general good

  $$Z_t = \zeta A_t,$$

  where $\zeta = (\alpha/\chi)^{\frac{\alpha}{1-\alpha}}$.

  In equilibrium, $\mu_t(i) = \mu_t$ for all i, so

  $$A_t = \mu_t \bar{A}_t + (1 - \mu_t) A_{t-1}.$$

  Define the country's normalized productivity a_t (an inverse measure of the country's distance to the technological frontier, or the "technology gap") as

  $$a_t = A_t / \bar{A}_t.$$

The gap a_t evolves according to

$$a_t = \mu_t + \left(\frac{1-\mu_t}{1+g}\right) a_{t-1}.$$

Value added in the general sector is wage income (w_t) and value added in the intermediate sectors is profit income ($\mu_t \pi_t$). Per capita GDP is the sum of these two:

$$Y_t = w_t + \mu_t \pi_t = (1-\alpha)\zeta A_t + \mu_t \pi \bar{A}_t.$$

- Innovations: Investing N_{t-1} units of the general good gives an innovation with probability μ_t. The cost function of R&D is given by

$$N_{t-1} = \tilde{n}(\mu_t)\bar{A}_t = (\eta\mu_t + \delta\mu_t^2/2)\bar{A}_t, \quad \eta, \delta > 0,$$

where multiplying $\tilde{n}$ by $\bar{A}_t$ reflects the "fishing-out" effect: the further ahead the frontier moves, the more difficult it is to innovate. This cost function leads to the probability of a successful innovation:

$$\tilde{mu}(n) = \tilde{n}^{-1}(n) = \left[(\eta^2 + 2\delta n)^{1/2} - \eta\right)/\delta,$$

where $\eta < \beta\pi < \eta + \delta$ is assumed to give $\mu_t \in (0,1)$.

An innovator chooses μ_t to maximize the expected net payoff

$$\beta\mu_t \pi \bar{A}_t - \tilde{n}(\mu_t)\bar{A}_t$$

subject to credit constraints.

- Equilibrium Innovation under Perfect Credit Markets: Suppose innovators can borrow unlimited quantities at the interest rate $r = 1/\beta - 1$ subject to a binding commitment to repay, then

μ_t will be chosen to maximize the net expected payoff without credit constraints:

$$\mu_t = \mu^* = (\beta\pi - \eta)/\delta,$$

so the equilibrium R&D expenditure is

$$N_{t-1} = \tilde{n}(\mu^*)\bar{A}_t = n^*\bar{A}_t.$$

The technology gap evolves according to

$$a_{t+1} = \nu^* + \left(\frac{1-\mu^*}{1+g}\right) a_t \equiv H_1(a_t),$$

which converges in the long run to the steady-state value

$$a^* = \frac{(1+g)\mu^*}{g+\mu^*} \in (0,1).$$

Per capita GDP in the steady state is

$$Y_t^* = [(1-\alpha)\zeta a^* + \mu^*\pi]\bar{A}_t,$$

which grows at the same rate as the technology frontier $\bar{A}_t$.

- Credit Constraints: Suppose that credit markets are imperfect. An innovator can pays a cost cN_t to defraud his creditors. So the innovator can borrow an amount less than νw_t, where $\nu \in [1,\infty)$. The credit constraint is binding if $n^*\bar{A}_{t+1} > \nu w_t$, which is equivalent to

  $$n^* > a_t\omega, \quad \omega \equiv \frac{\nu(1-\alpha)\zeta}{1+g}.$$

  Innovators in more advanced countries with $a_t > n^*/\omega \equiv \underline{a}(\omega)$ will invest $n^*\bar{A}_{t+1}$ in R&D and innovate with probability μ^*, while innovators in less advanced countries with $a_t < n^*/\omega \equiv$

$\underline{a}(\omega)$ will invest $\nu w_t = a_t \omega \bar{A}_{t+1}$ and innovate with probability $\tilde{\mu}(a_t \omega) < \mu^*$.

With credit constraints, the technology gap will follow

$$a_{t+1} = \tilde{\mu}(\omega a_t) + \left[\frac{1 - \mu(\omega a_t)}{1+g}\right] a_t \equiv H_2(a_t).$$

- The World Growth Rate: Assuming that the growth rate g of the global technology frontier is determined by innovations in the leading countries without credit constraints and that there is only one leader (country 1), then

$$g = \sigma \mu_1^* = \sigma \left(\frac{\beta_1 \pi_1 - \eta_1}{\delta_1}\right),$$

where $\sigma > 0 =$ the spillover coefficient.

3 Theoretical Implications

- Three Dynamic Patterns:

$$a_{t+1} = H(a_t) \equiv \min\{H_1(a_t), H_2(a_t)\}.$$

1. Convergence in growth rate, no marginal effect of financial development ($\omega \geq n^*/a^*$): Growth rate $G_t \to g$ and Technology gap $a_t \to a^*$ (Figure I).

2. Convergence in growth rate with a level-effect of financial development ($\eta g/(1+g) \leq \omega < n^*/a^*$): $G_t \to g$ and $a_t \to \hat{a} < a^*$ (Figure II).

3. Divergence in growth rate, with a growth-effect of financial development ($\omega < \eta g/(1+g)$): $G_t \to (1+g)\omega/\eta \in (0, g)$ and $a_t \to 0$ (Figure III).

- Two main implications:

  1. The likelihood that a country will converge to the frontier growth rate increases with its level of financial development.

  2. In a country that converges to the frontier growth rate, financial development has a positive but eventually vanishing effect, ceteris paribus, on the steady-state level of per-capita GDP relative to the frontier.

4 Empirical Evidence

- Empirical evidence supports the predictions of the proposed theory.
- Empirical findings are robust.

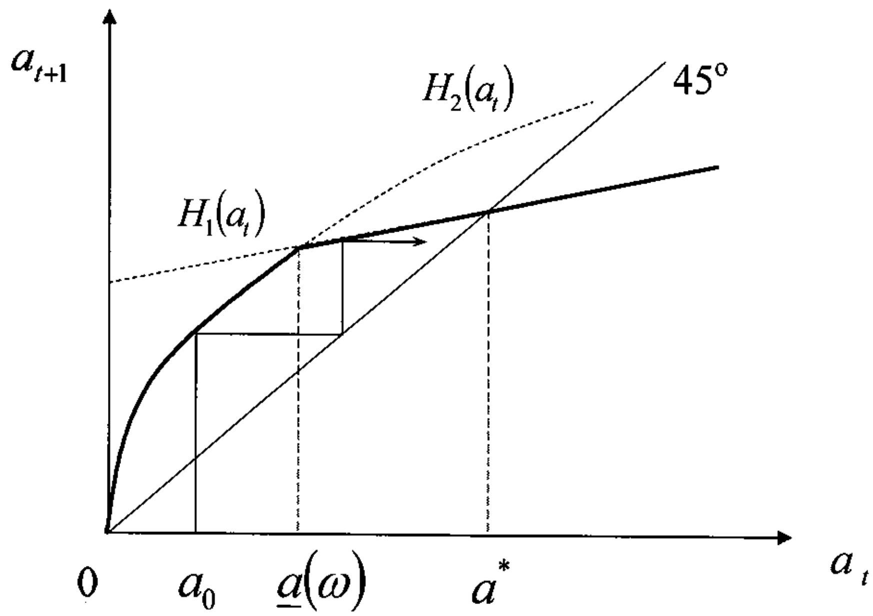

FIGURE I

A Country with the Highest Level of Financial Development

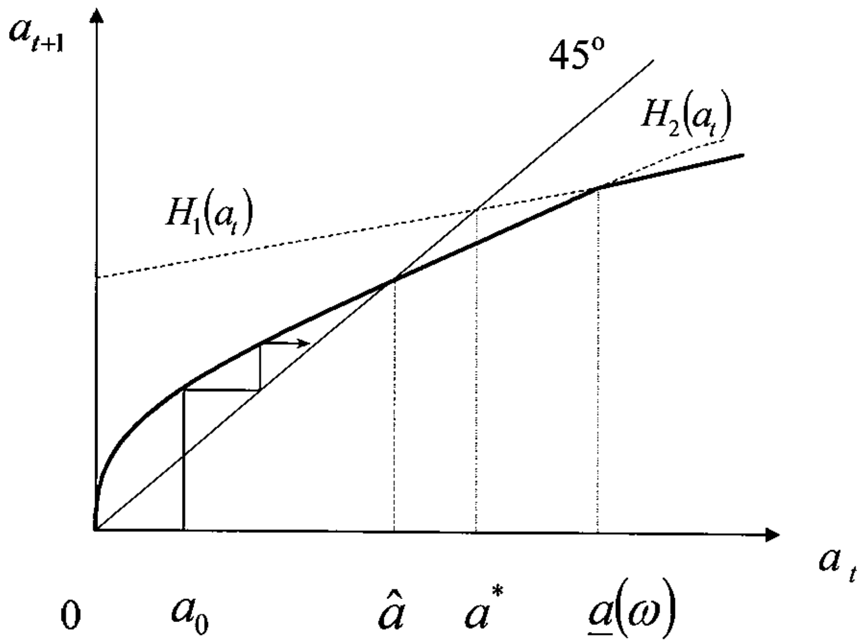

FIGURE II

A Country with a Medium Level of Financial Development

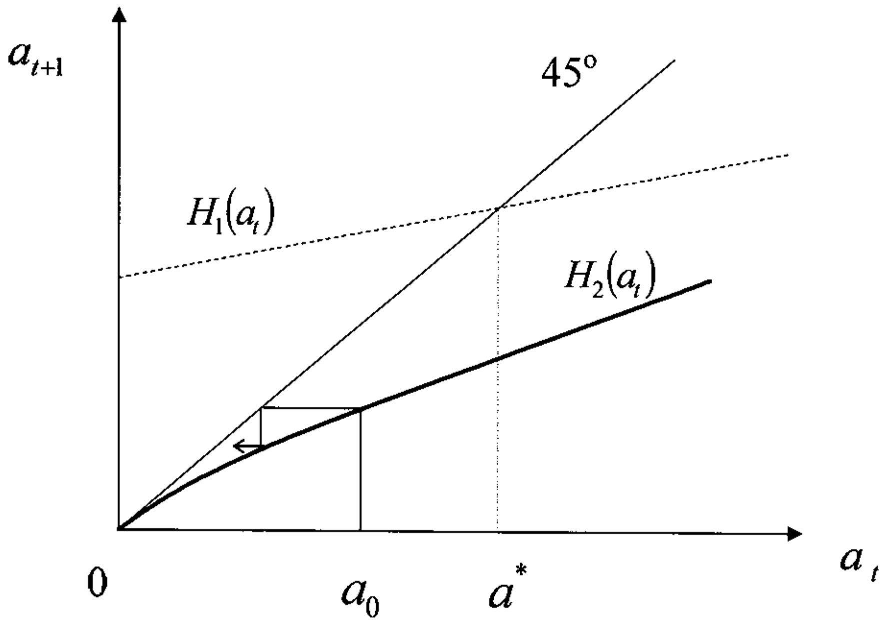

FIGURE III

A Country with the Lowest Level of Financial Development