Growth and Development

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Introduction to Economic Growth

Why are some countries rich?

What part of production - capital, productivity - is the reason some countries are rich?

$$Y_i = K_i^{\alpha}(A_i h_i L_i)^{1-\alpha}.$$

- K_i is physical capital
- A_i is productivity
- L_i is number of workers
- h_i is human capital per worker...this is new but hold on

GDP per capita

Write production as

$$Y_i = \left(\frac{K_i}{A_i h_i L_i} \right)^{\alpha} A_i h_i L_i, \tag{1}$$

let

$$\frac{K_i}{Y_i} = \frac{K_i}{K_i^{\alpha} (A_i h_i L_i)^{1-\alpha}} = \left(\frac{K_i}{A_i h_i L_i} \right)^{1-\alpha}.$$

and divide by population (N_i) to get

$$y_i = \left(\frac{K_i}{Y_i} \right)^{\alpha/(1-\alpha)} A_i h_i \frac{L_i}{N_i}. \tag{2}$$

is GDP per capita in country i

Human capital

Define human capital as

$$h_i = e^{\mu E_i}, \tag{3}$$

- E_i is years of education
- μ is the return to each year of education (e.g. $\mu \approx 0.10$)
- This conforms to typical labor market studies that each year of education raises wages by about 10%
- Schooling isn't the *only* aspect of human capital, but we can measure it

Comparing countries

Go back and compare some country i to a reference point (usually the US):

$$\frac{y_i}{y_{US}} = \left[\frac{(K/Y)_i}{(K/Y)_{US}}\right]^{\alpha/(1-\alpha)} \frac{A_i}{A_{US}} \frac{h_i}{h_{US}} \frac{(L_i/N_i)}{(L_{US}/N_{US})}. \tag{4}$$

We can assess why country i is richer or poorer than the US

- Different capital/output ratios
- Different productivity levels A_i/A_{US}
- Different human capital ratios
- Different labor force participation

Measuring productivity

How do you measure productivity in a country?

$$A_i = \frac{y_i}{\left(\frac{K_i}{Y_i}\right)^{\alpha/(1-\alpha)} h_i \frac{L_i}{N_i}}. \tag{5}$$

by re-arraning the equation for GDP per capita. Plug in and solve.

Doing the accounting

Country	GDP per capita $\frac{y_i}{y_{US}}$	Components of GDP per capita: Capital / output $\left[\frac{(K/Y)_i}{(K/Y)_{US}}\right]^{\frac{\alpha}{1-\alpha}}$	Human capital $\frac{h_i}{h_{US}}$	Labor force partic. $\frac{(L_i/N_i)}{(L_{US}/N_{US})}$	Prod. $\frac{A_i}{A_{US}}$
United States	1.000	1.000	1.000	1.000	1.000
Germany	0.818	1.175	0.971	1.115	0.643
Canada	0.797	1.153	0.989	1.072	0.652
United Kingdom	0.707	1.197	1.010	1.015	0.576
South Korea	0.675	1.204	1.006	1.087	0.512
Japan	0.634	1.205	0.940	1.147	0.489
Turkey	0.431	1.140	0.560	0.700	0.963
Mexico	0.299	1.141	0.643	0.896	0.455
Brazil	0.233	1.127	0.753	0.925	0.297
China	0.226	1.084	0.617	1.158	0.291
South Africa	0.200	1.071	0.688	0.662	0.411
Egypt	0.193	0.709	0.609	0.555	0.804
Indonesia	0.185	1.266	0.511	1.008	0.284
Vietnam	0.120	0.922	0.675	1.086	0.177
India	0.107	1.062	0.485	0.757	0.275
Nigeria	0.080	0.982	0.441	0.755	0.243
Kenya	0.068	0.869	0.523	0.991	0.150
Summary statistics over all countries:					
Mean	0.352	1.110	0.654	0.891	0.463
Std. Dev.	0.346	0.241	0.207	0.205	0.345
Coef. of Var.	0.983	0.217	0.316	0.229	0.746

What drives differences?

Differences across countries in GDP per capita depend on:

- Productivity - this is the main driver
- Human capital - this is somewhat important
- Labor force participation - in some cases
- Physical capital - limited explanatory power

Productivity differences

For developing countries, leading-edge R&D is limited

- Model productivity as diffusion or adoption rather than innovation
- Distance to frontier matters; bigger gaps mean more opportunities
- Human capital matters; additional channel allowing adoption

How does productivity evolve when diffusion drives growth?

Production setup

Production is like the Romer model with varieties

$$Y_t = (h_t L_t)^{1-\alpha} \int_0^{D_t} x_{jt}^{\alpha} dj. \tag{6}$$

Like Romer, each D_t variety uses similar amount of capital

$$\int_0^{D_t} x_{jt} dj = K_t.$$

GDP thus equals

$$Y_t = K_t^{\alpha} (D_t h_t L_t)^{1-\alpha}. \tag{7}$$

Everything about capital works as in the Solow/Romer.

Diffusion dynamics

Diffusion of ideas/varieties happens according to

$$dD = \psi h A_t^{\gamma} D_t^{1-\gamma}. \tag{8}$$

- ψ is a scaling parameter
- A_t is the level of productivity in *leading* economies
- D_t is current level of varieties used
- γ dictates how important the leader is to diffusion
- Human capital, h, can increase diffusion

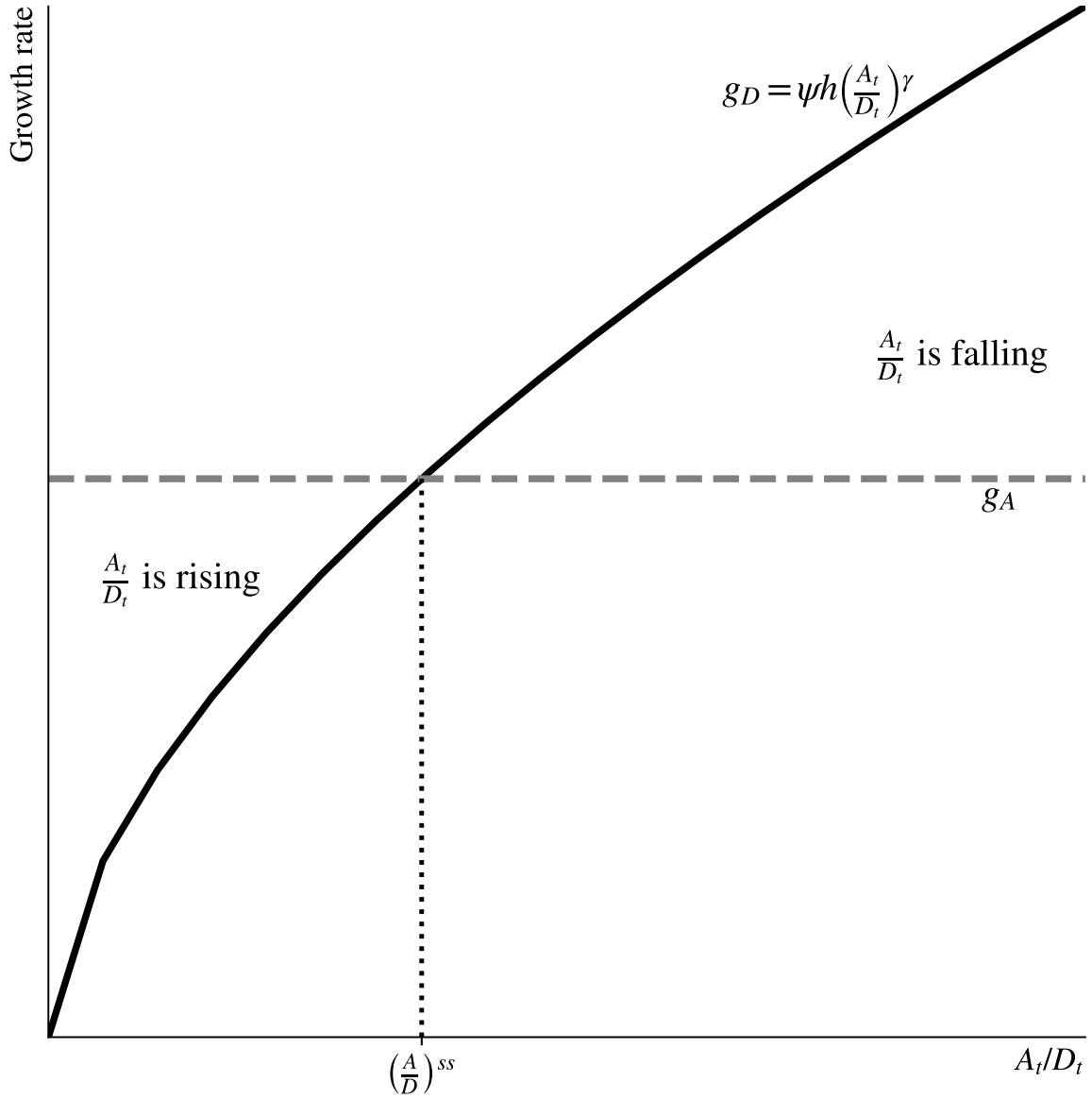
Diffusion dynamics

The growth rate of diffusion is therefore

$$g_D = \psi h \left(\frac{A_t}{D_t} \right)^{\gamma}. \tag{9}$$

- A/D ratio dictates pace of growth of varieties
- Similar to earlier models where ratio of stocks dictates a growth rate
- Note that as D goes up, g_D goes down, similar to Solow/Romer dynamics

Diffusion dynamics



Steady state

Given any initial ratio A/D

- The growth rate $g_D = g_A$
- Followers can only grow as fast as the leaders
- As they catch up they slow down
- The level of D determines how close to the frontier a country is

Steady state

What's the steady state A/D ratio?

$$\left(\frac{A}{D}\right)^{ss} = \left(\frac{g_A}{\psi h}\right)^{1/\gamma}. \tag{10}$$

This ratio is *smaller* and the follower is *closer* when

- h is high. More HC means easier to adopt new technologies
- g_A is low. If the leader grows slowly, it's easier to keep up

BGP

At any given point in time the level of D_t is

$$D_t = \left(\frac{\psi h}{g_A}\right)^{1/\gamma} A_t, \tag{11}$$

which means the BGP for GDP per capita in the follower is

$$y_t^{BGP} = \left(\frac{s_I}{g_A + g_L + \delta}\right)^{\frac{\alpha}{1-\alpha}} h \left(\frac{\psi h}{g_A}\right)^{1/\gamma} A_t. \tag{12}$$

and the follower runs “parallel” to the BGP of the leader.

Human Capital

Note that with this BGP

$$y_t^{BGP} = \left(\frac{s_I}{g_A + g_L + \delta}\right)^{\frac{\alpha}{1-\alpha}} h \left(\frac{\psi h}{g_A}\right)^{1/\gamma} A_t. \tag{13}$$

- Human capital is more important than just via skills (h)
- The $h^{1/\gamma}$ term influences diffusion
- Development accounting may understate importance of human capital

Importing ideas

Think of international trade as a way of importing ideas via varieties.

$$Y_t = (h_t L_t)^{1-\alpha} \int_0^{D_t+M_t} x_{jt} dj. \tag{14}$$

where D_t are the domestic varieties and M_t are imported varieties. Trade can raise GDP by adding new types of goods.

Domestic production

On the domestic side,

$$D_t z_t = K_t.$$

The country uses K_t in capital to produce z_t units of the D_t varieties they can make.

$$K_t - D_t x_t = D_t(z_t - x_t) = M_t x_t. \tag{15}$$

But the country only *uses* x_t units of those varieties, leaving $D_t(z_t - x_t)$ for export, which are traded for $M_t x_t$ units of foreign varieties.

Trade balance

Interpreting the trade:

- You can think of $D_t(z_t - x_t)$ as a literal amount of goods shipped to foreign countries.
- You can think of $M_t x_t$ as the amount of goods imported from those countries
- OR you can think of $D_t(z_t - x_t)$ as capital that is owned by the domestic country in a foreign country (outward FDI)
- and then $M_t x_t$ is amount of capital owned by a foreign country in the domestic country (inward FDI)

This assumes balanced trade at all times. Adding deficits or surpluses involves additional work on consumption side.

Trade and GDP

Whatever the interpretations we have

$$K_t = x_t(D_t + M_t),$$

which allows us to write GDP as

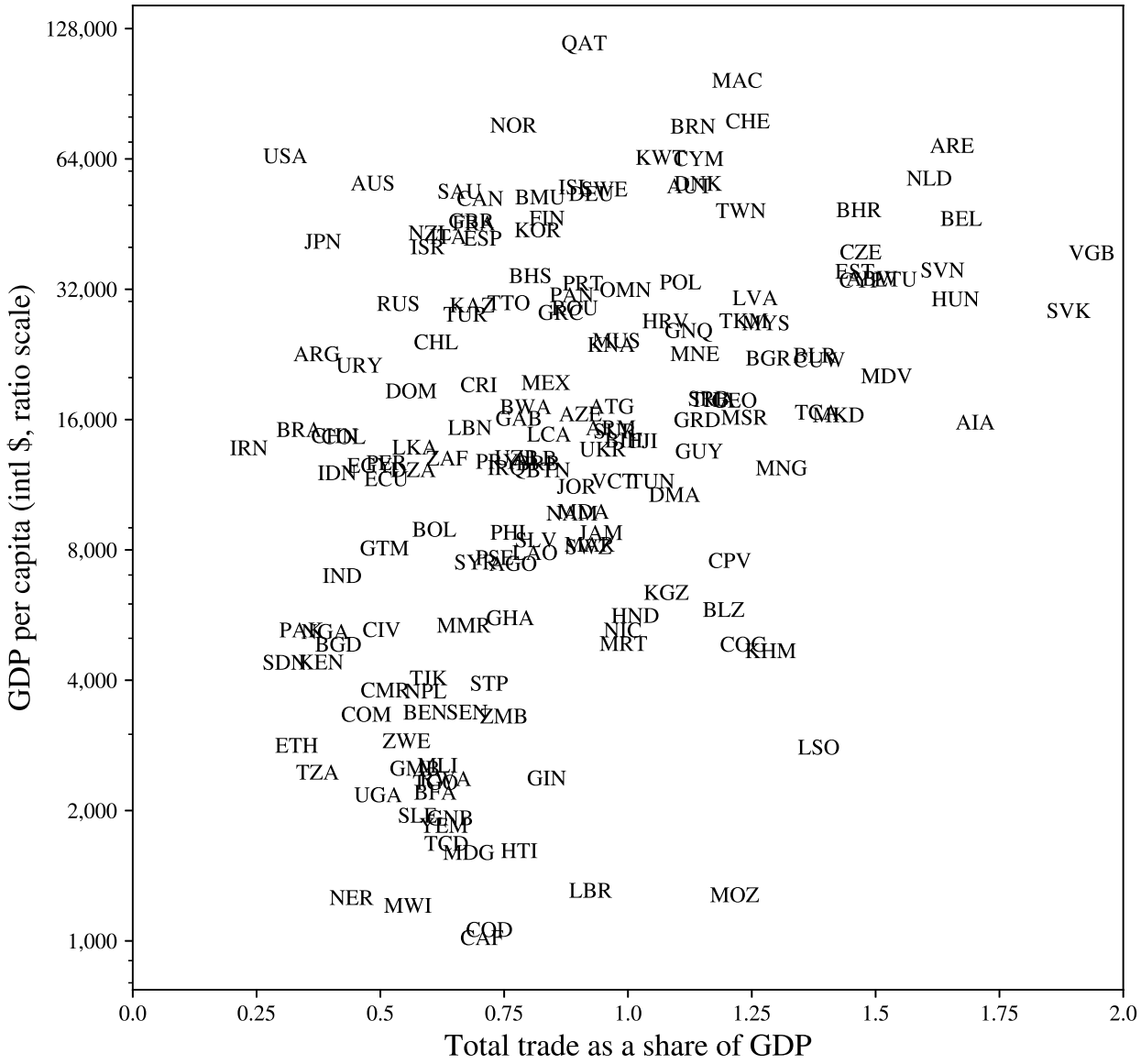
$$Y_t = K_t^{\alpha}(D_t h_t L_t)^{1-\alpha}\left(1 + \frac{M_t}{D_t}\right)^{1-\alpha}.$$

Domestic varieties act like a productivity term. But we also have this M_t/D_t ratio which can boost productivity. Note that

$$\frac{\text{Imports}}{\text{GDP}} = \frac{M_t x_t}{Y_t} = \frac{M_t}{D_t + M_t}\frac{K_t}{Y_t} \tag{16}$$

so if imports/GDP go up, GDP should be higher. Trade is unequivocally good for GDP in this setup due to varieties.

Trade and GDP



Factor use

Alternative way to think about productivity differences is via allocations.

- In Romer model, we assumed each variety was "equal" in terms of allocation
- Each used K/A of the capital stock, because each was equally productive, $x_i = K_i$
- But what if some firms/varieties get more capital and some less?
- Lower overall GDP because the marginal product of the varieties would differ
- This would show up in measurement as lower aggregate A given the factors used

Marginal product

Let production look like this

$$Y = L^{1-\alpha} \int_0^D x_j^\alpha dj. \tag{17}$$

where D are the number of varieties, as usual. What's the marginal product of any given variety?

$$MP_j = L^{1-\alpha} \alpha x_j^{\alpha-1} \tag{18}$$

and as each variety uses capital, $x_j = K_j$, the marginal product is

$$MP_j = L^{1-\alpha} \alpha K_j^{\alpha-1} = \left(\frac{L}{K_j} \right)^{1-\alpha} \tag{19}$$

Compare marginal products

Take two varieties, i and j. If $K_i > K_j$ then

- $MP_i < MP_j$ because MP declines with capital used
- Move one unit of capital from i to j. You lose MP_i, you gain MP_j. Net increase in GDP.
- If we can raise GDP just be re-allocating capital (not accumulating it) then there is a mis-allocation
- Mis-allocations - different MPs - make GDP lower for a given set of K, L
- Therefore mis-allocations must show up as lower measured A

Why mis-allocations?

If there are mis-allocations and $MP_i \neq MP_j$, why?

- Capital isn't substitutable. We're wrong that K_i could be used as K_j (office building versus a drill press)
- Policies (taxes, subsidies) favor one variety over the other. State-owned enterprises may get cheaper capital, for example.
- Transport and relocation costs. It's not possible move an entire factory from Ohio to Alabama.
- Differences in market power. i faces competitors, j is a monopolist?