



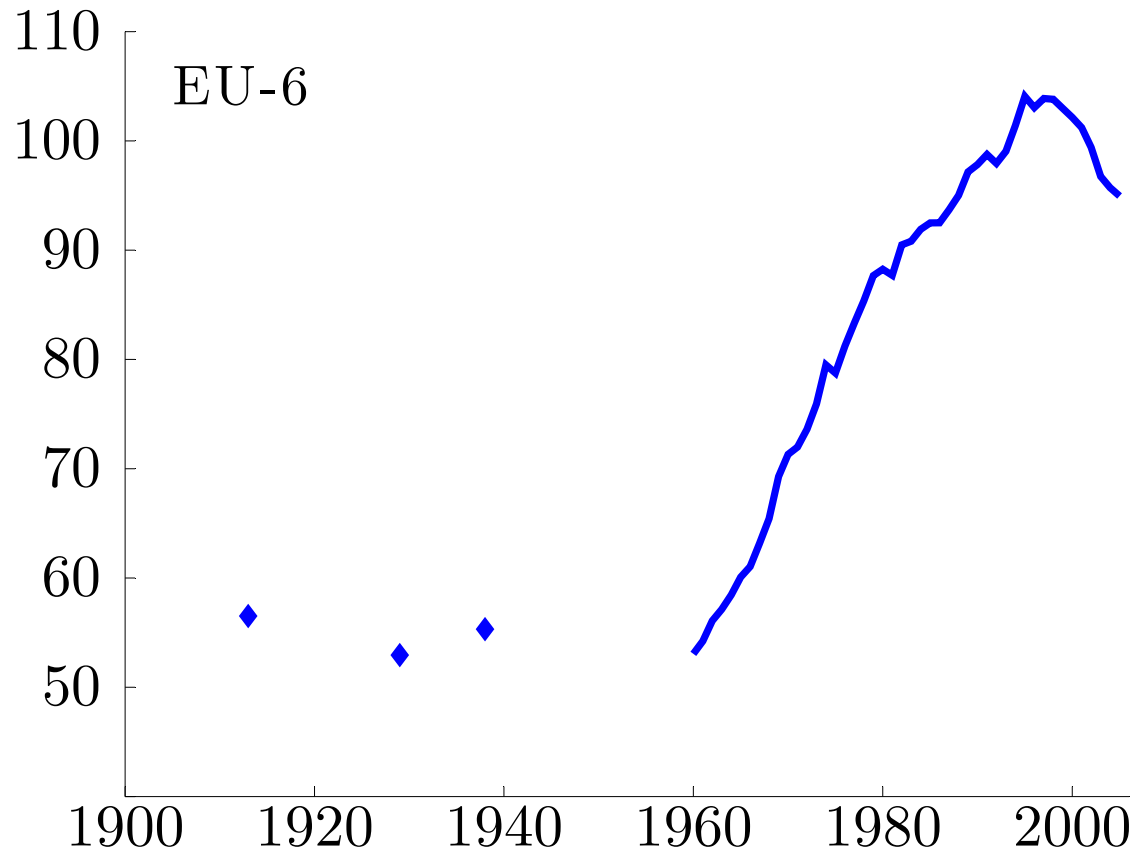
OPENNESS, TECHNOLOGY CAPITAL, AND DEVELOPMENT

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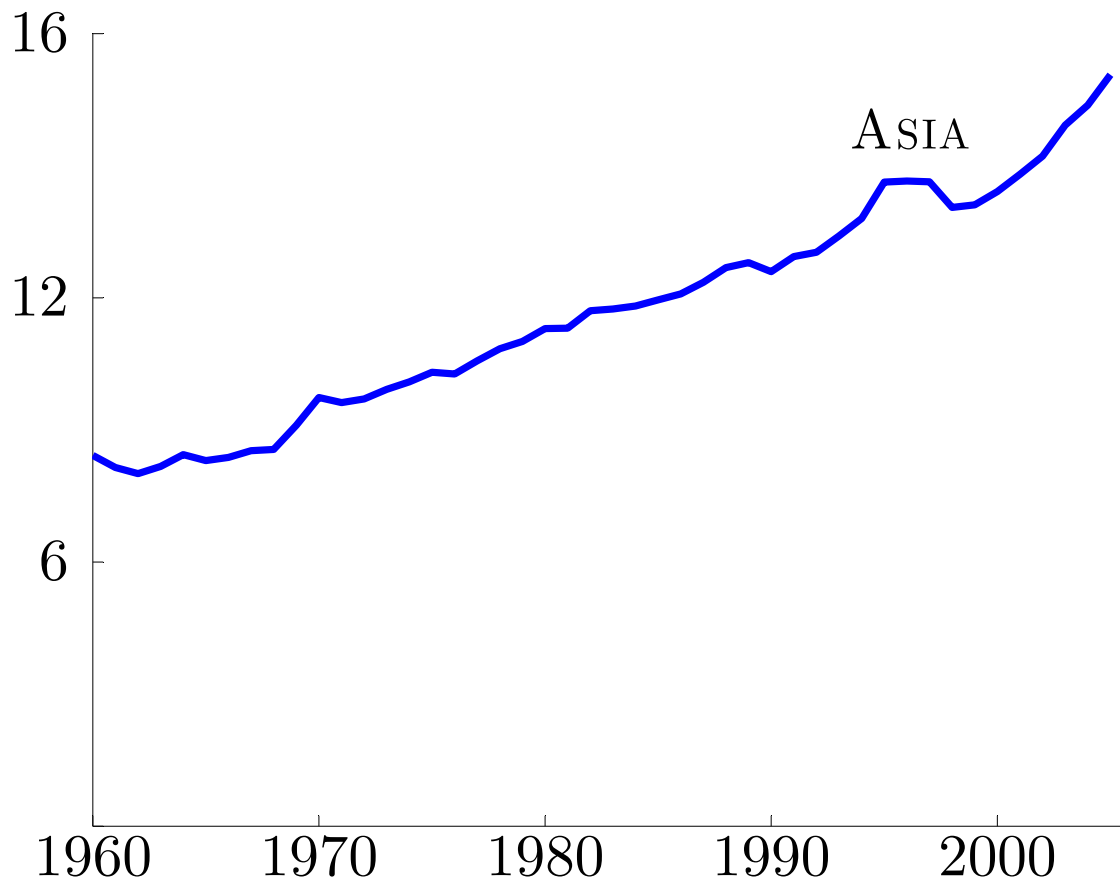
WHY DID THE EU-6 CATCH UP?



EU-6 LABOR PRODUCTIVITY AS % OF US



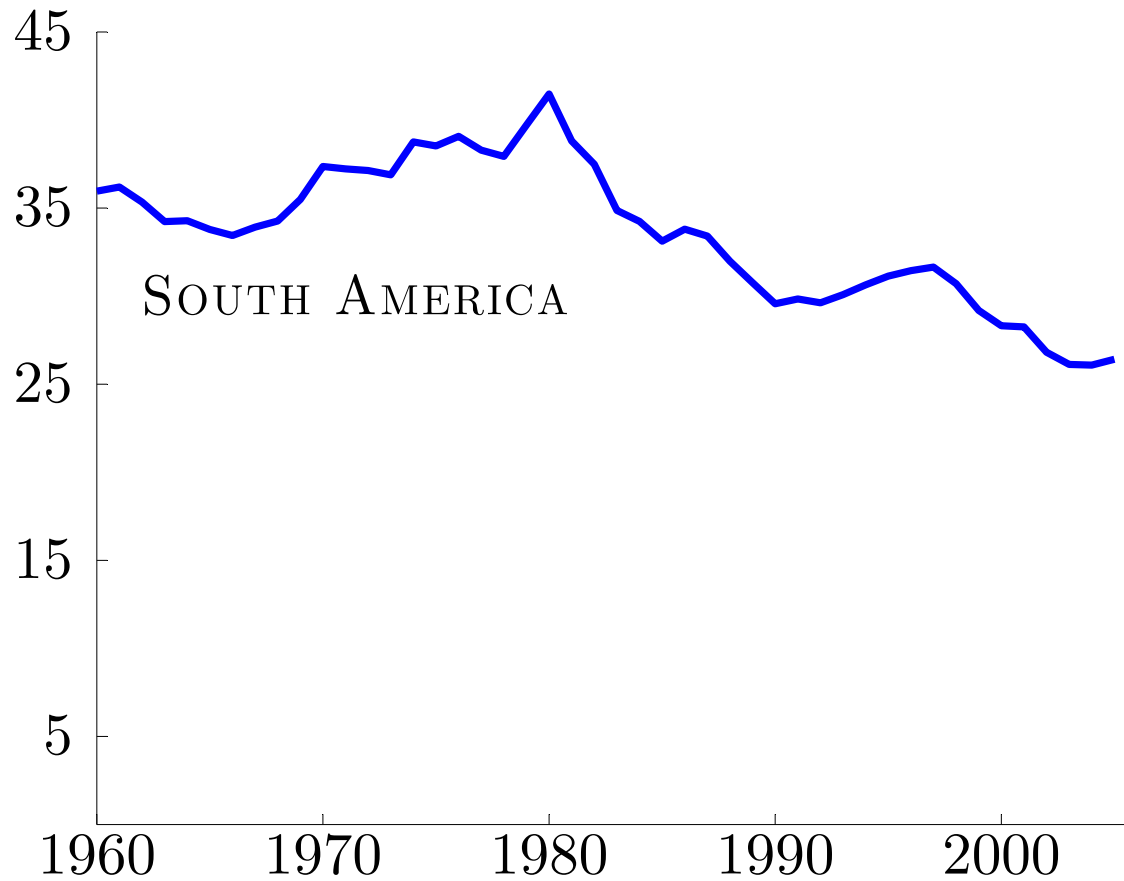
WHY IS ASIA STARTING TO CATCH UP?



ASIAN LABOR PRODUCTIVITY AS % OF US



WHILE SOUTH AMERICA IS LOSING GROUND?



SOUTH AMERICAN LABOR PRODUCTIVITY AS % OF US



QUESTIONS

- Why did the EU-6 catch up?
- Why is Asia starting to catch up?
- Why is South America losing ground?

Answer: Open countries gain, closed countries lose



OUR NOTION OF OPENNESS

- Openness can mean many things
- We mean foreign multinationals' *technology capital* permitted
- We find big gains to openness



TECHNOLOGY CAPITAL

- Is accumulated know-how from investments in
 - R&D
 - Brands
 - Organization know-how

which can be used in as many *locations* as firms choose



NEW AVENUE FOR GAINS

- Countries are measures of locations
- Technology capital can be used in multiple locations
- Implying gains to openness
 - Without increasing returns
 - Without factor endowment differences



THEORY



WHAT'S NEW?

- Adding locations to the neoclassical growth model
- This extension
 - Permits introduction of technology capital
 - Doesn't require monopoly rents to finance innovation



CLOSED-ECONOMY AGGREGATE OUTPUT

$$Y = A(NM)^{1-\phi} Z^{\phi}$$

M = units of *technology capital*

Z = composite of other factors, $K^{\alpha} L^{1-\alpha}$

N = number of production *locations*

A = the technology parameter

ϕ = the income share parameter



A MICRO FOUNDATION FOR AGGREGATE FUNCTION

- $n \in \{1, \dots, N\}, m \in \{1, \dots, M\}$

$$F(N, M, Z) = \max_{z_{nm}} \sum_{n,m} g(z_{nm})$$

$$\text{subject to } \sum_{n,m} z_{nm} \leq Z$$

We assume $g(z) = Az^\phi$, increasing and strictly concave



A MICRO FOUNDATION FOR AGGREGATE FUNCTION

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$$F(N, M, Z) = \max_{z_{nm}} \sum_{n,m} g(z_{nm})$$

$$\text{subject to } \sum_{n,m} z_{nm} \leq Z$$

\Rightarrow optimal to split Z evenly across location-technologies



A MICRO FOUNDATION FOR AGGREGATE FUNCTION

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$$F(N, M, Z) = \max_{z_{nm}} \sum_{n,m} g(z_{nm})$$

subject to $\sum_{n,m} z_{nm} \leq Z$

$$\Rightarrow F(N, M, Z) = NMg(Z/NM) = A(NM)^{1-\phi} Z^\phi$$



A MICRO FOUNDATION FOR AGGREGATE FUNCTION

- $n \in \{1, \dots, N\}, m \in \{1, \dots, M\}$

$$F(N, M, Z) = \max_{z_{nm}} \sum_{n,m} g(z_{nm})$$

$$\text{subject to } \sum_{n,m} z_{nm} \leq Z$$

$$\Rightarrow F(N, \lambda M, \lambda Z) = \lambda F(N, M, Z)$$



PRODUCTION IN OPEN ECONOMY

- The degree of openness of country i is σ_i
- Aggregate output in i is

$$\max_{z_d, z_f} M_i N_i A_i z_d^\phi + \sigma_i \sum_{j \neq i} M_j N_i A_i z_f^\phi$$

$$\text{subject to } M_i N_i z_d + \sum_{j \neq i} M_j N_i z_f \leq Z_i$$

d, f indexes allocations to domestic and foreign operations



PRODUCTION IN OPEN ECONOMY

- The degree of openness of country i is σ_i
- Aggregate output in i is

$$Y_i = A_i N_i^{1-\phi} (M_i + \omega_i \sum_{j \neq i} M_j)^{1-\phi} Z_i^\phi$$

where

$$Z_i = K_i^\alpha L_i^{1-\alpha}$$

$$\omega_i = \sigma_i^{\frac{1}{1-\phi}} = \text{fraction of foreign T-capital permitted}$$



PRODUCTION IN OPEN ECONOMY

- The degree of openness of country i is σ_i
- Aggregate output in i is

$$Y_i = A_i N_i^{1-\phi} (M_i + \omega_i \sum_{j \neq i} M_j)^{1-\phi} Z_i^\phi$$

- Key result:

Each i has constant returns, but summing over i results in a *bigger* aggregate production set.



PRODUCTION IN OPEN ECONOMY

- The degree of openness of country i is σ_i
- Aggregate output in i is

$$Y_i = A_i N_i^{1-\phi} (M_i + \omega_i \sum_{j \neq i} M_j)^{1-\phi} Z_i^\phi$$

- Key result:

It is *as if* there were increasing returns,
when in fact there are none.



ADVANTAGES TO OUR TECHNOLOGY

- Standard welfare analysis
- Standard national accounting
- Standard parameter selection



THE REST OF THE MODEL

- Households in i
 - Own K_i and M_i
 - Solve standard utility maximization
- Resource constraint in i

$$Y_{it} = C_{it} + X_{ikt} + X_{imt} + NX_{it}$$

where $X_{ikt} = K_{i,t+1} - (1 - \delta_k)K_{it}$

$$X_{imt} = M_{i,t+1} - (1 - \delta_m)M_{it}$$



PREDICTIONS OF THEORY



USE THEORY TO MAKE 4 POINTS

1. There is an advantage to size when world closed;
2. The gains of forming larger unions are large;
3. Opening unilaterally benefits the country opening;
4. Seemingly similar countries can have different M 's.



NEED A MEASURE OF SIZE

- Assume
 - N_i is proportional to population
 - A_i is augmenting labor & location ($= A_i^{\frac{1}{1-\phi\alpha}}$)
- Then, results depend only on product $A_i N_i$



NEED A MEASURE OF SIZE

- Assume
 - N_i is proportional to population
 - A_i is augmenting labor & location ($= A_i^{\frac{1}{1-\phi\alpha}}$)
- Then, results depend only on product $A_i N_i$
- This is our measure of *size*.



GUTS OF THE THEORY

- $\{Y_i, M_i\}$ satisfy

$$Y_i = \psi \mathcal{A}_i N_i (M_i + \omega_i \sum_{j \neq i} M_j)^{\frac{1-\phi}{1-\alpha\phi}}$$

$$\sum_j \partial Y_j / \partial M_i \leq \rho + \delta_m, \text{ with equality if } M_i > 0$$

- Implying
 - $Y_i / (\mathcal{A}_i N_i)$ depends positively on the M_j
 - For some values of $(\mathcal{A}_i N_i)$ & ω_i , some constraints bind



SIZE ADVANTAGE WHEN CLOSED

- $\omega_i = 0$ for all i
- Then, output per effective person increasing in size,

$$y_i \propto (\mathcal{A}_i N_i)^{\frac{1-\phi}{\phi(1-\alpha)}}$$



BIG GAINS FROM FORMING UNIONS

- I = number of equal-sized countries forming union
- Then, productivity gain for I in union is

$$y(I)/y(1) = I^{\frac{1-\phi}{\phi(1-\alpha)}}$$

- For example, if $\alpha = .3$, $\phi = .94$,

$$\text{gain} = 23\% \quad \text{if } I = 10$$

$$\text{gain} = 52\% \quad \text{if } I = 100$$



BIG GAINS FROM UNILATERALLY OPENING

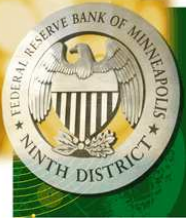
- I = number of equal-sized countries remaining closed
- Then, productivity gain of $I+1$ st opening is

$$y_o/y_c = I^{\frac{1-\phi}{1-\phi\alpha}}$$

- For example, if $\alpha = .3$, $\phi = .94$,

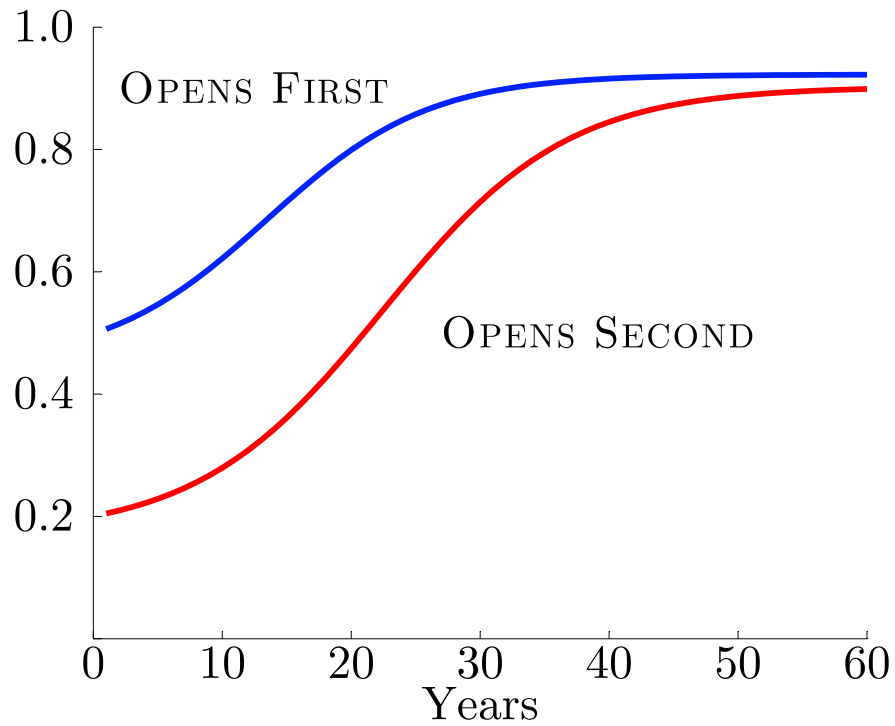
$$\text{gain} = 21\% \text{ if } I = 10$$

$$\text{gain} = 47\% \text{ if } I = 100$$

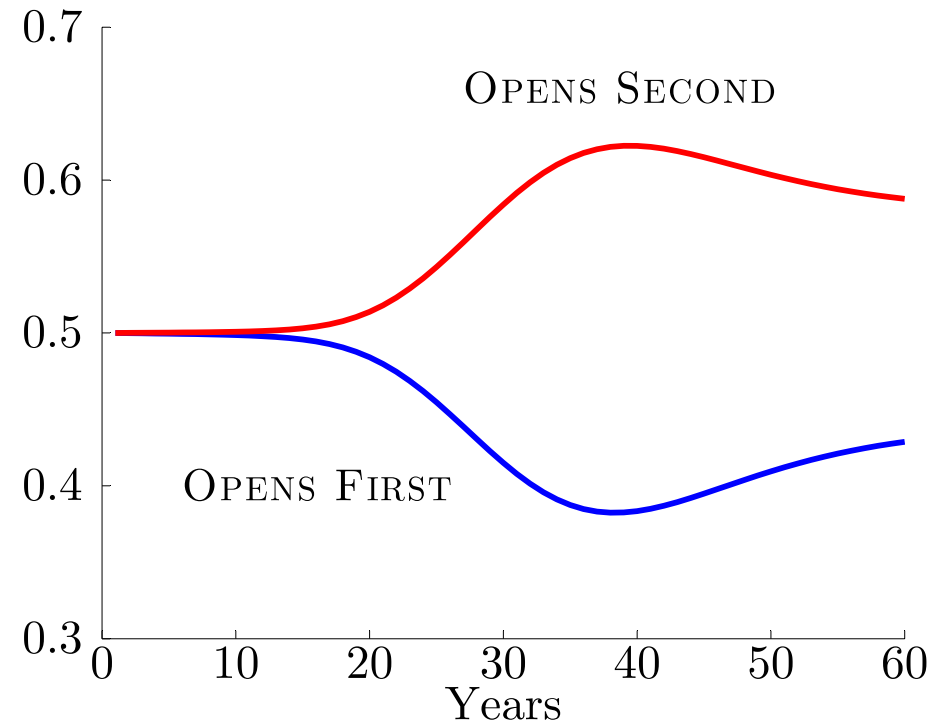


SEEMINGLY SIMILAR BUT DIFFERING T-CAPITAL

OPENNESS PARAMETERS



T-CAPITAL/ $Y_{2,0}(1+\gamma_Y)^t$



Motivated by experience of EU and US



SUMMARY

- Paper extends neoclassical growth model by adding
 - Locations
 - Technology capital
- Use new theory to assess the gains from openness
- Elsewhere, use theory to study U.S. current accounts



Not everything that counts can be counted, and
not everything that can be counted counts.

– ALBERT EINSTEIN