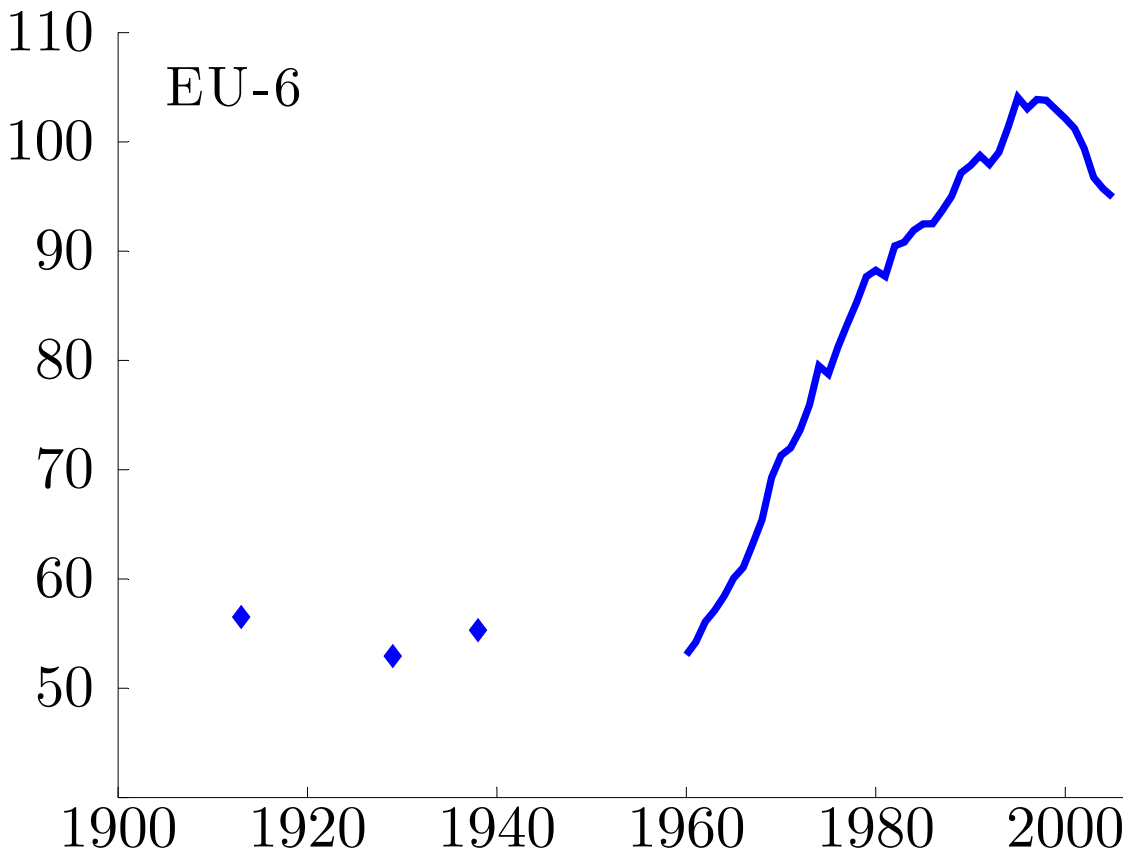
Openness, Technology Capital, and Development

Ellen McGrattan and Edward Prescott

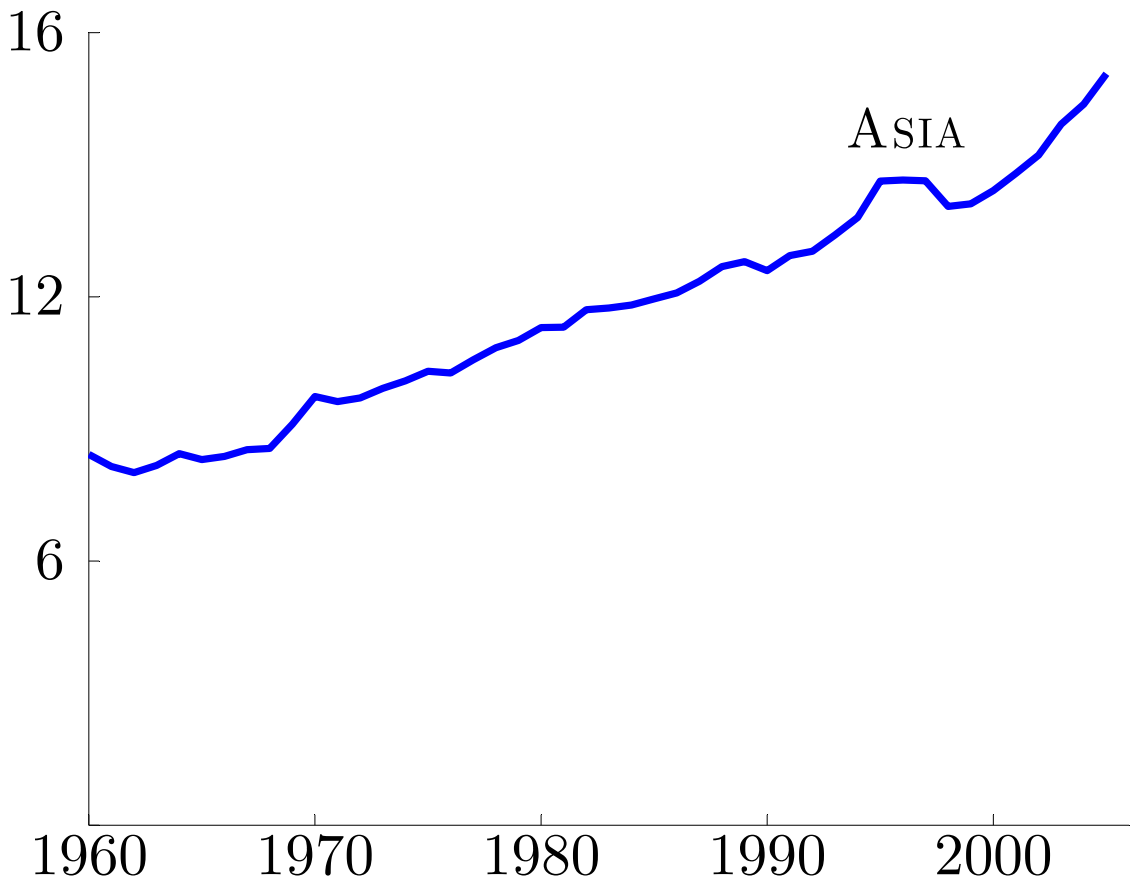
April 2007

Why Did the EU-6 Catch Up?



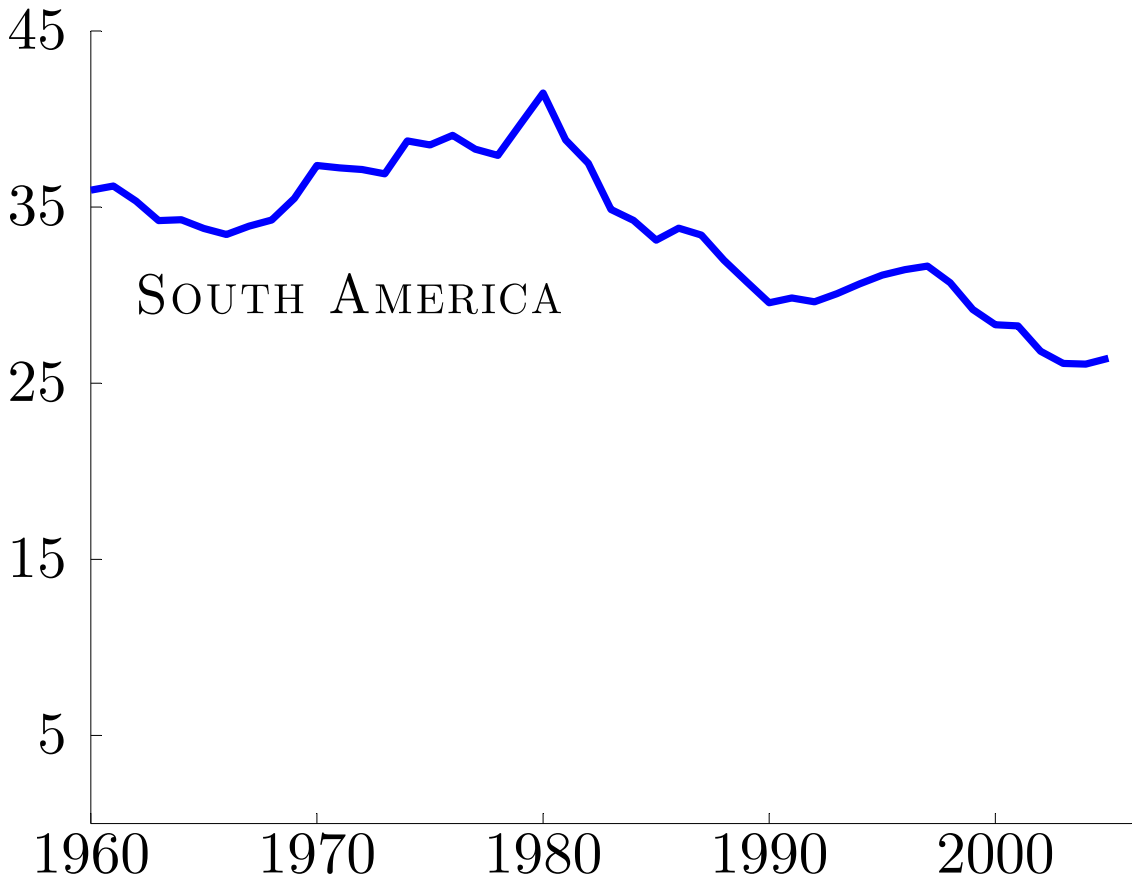
EU-6 Labor Productivity as % of US

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

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

which is the result of maximizing plant-level output

A Micro Foundation for Aggregate Function

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

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

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

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

A Micro Foundation for Aggregate Function

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

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

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

$\Rightarrow$ optimal to split Z evenly across location-technologies

A Micro Foundation for Aggregate Function

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

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

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

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

A Micro Foundation for Aggregate Function

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

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

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

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

Production in Open Economy

- The degree of openness of country i is σ_i

- Aggregate output in i is

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

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

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

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

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

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

- 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

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

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

Need a Measure of Size

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

Guts of the Theory

- $\{Y_i, M_i\}$ satisfy

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

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

- 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+1st opening is

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

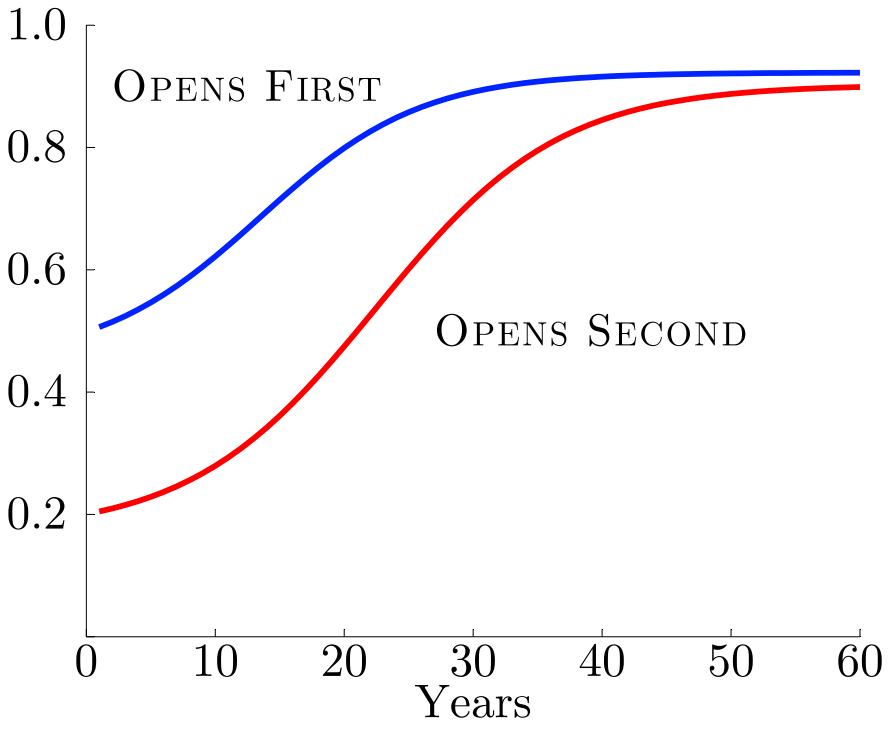
- For example, if $\alpha = .3$, $\phi = .94$,

  gain = 21% if $I = 10$

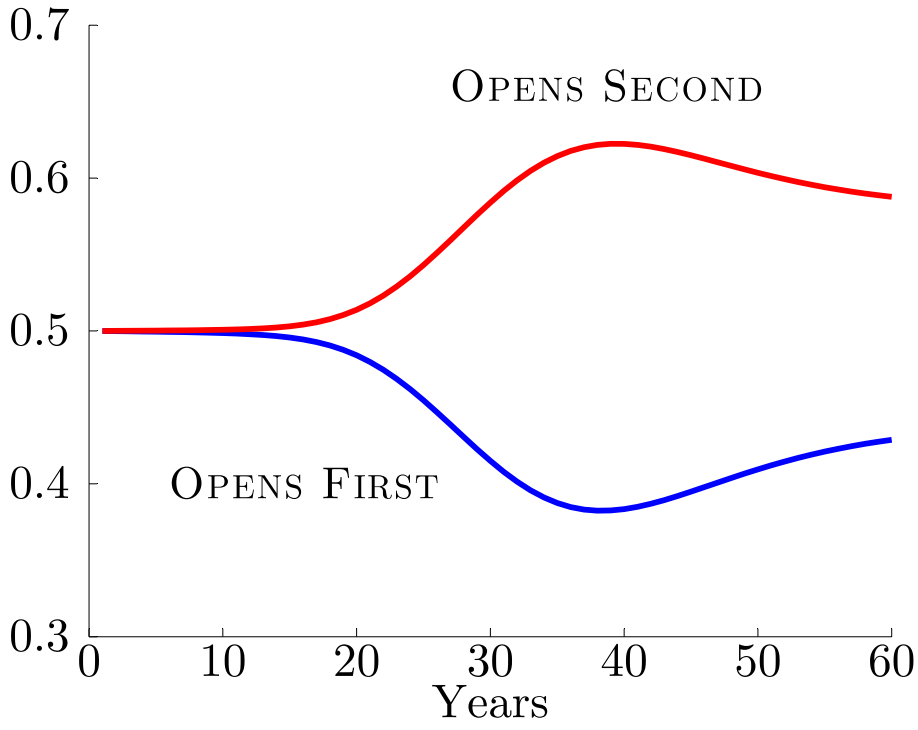
  gain = 47% if $I = 100$

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. net asset position