Openness, Technology Capital, and Development

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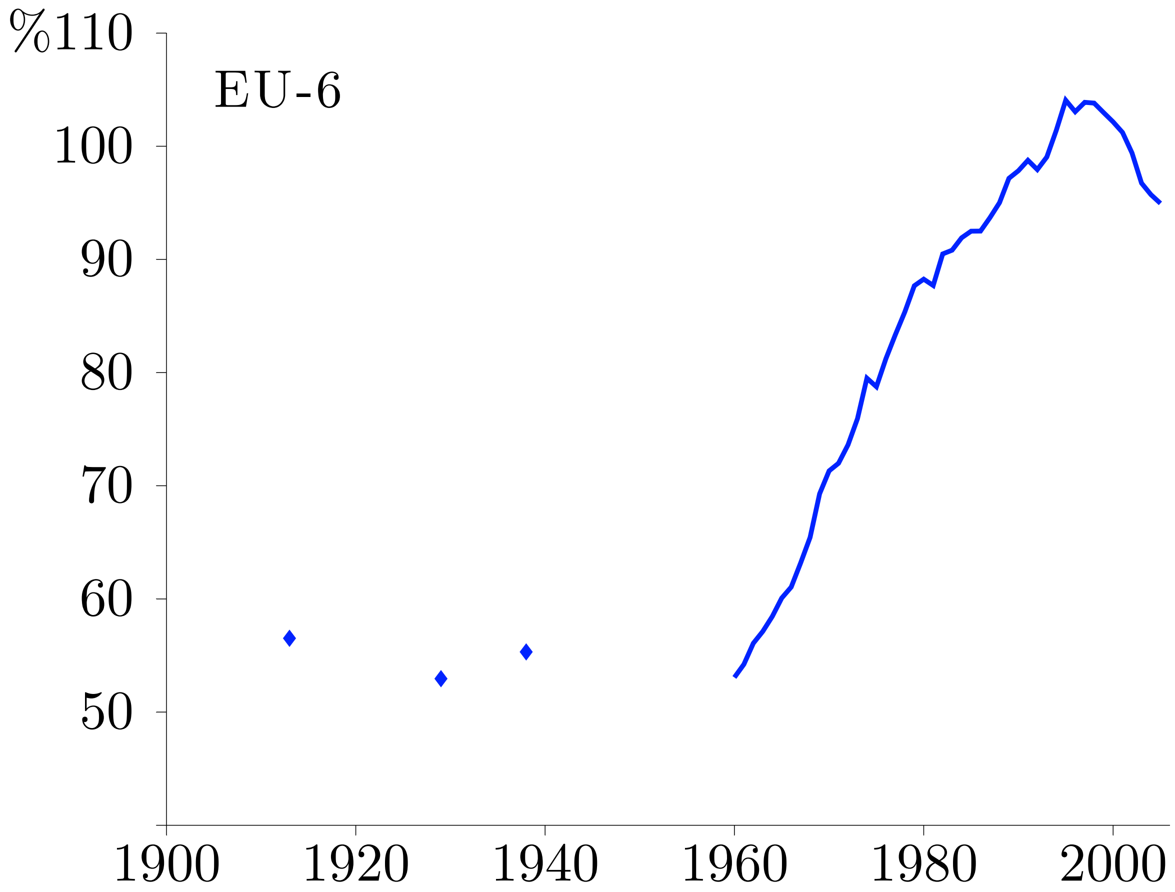
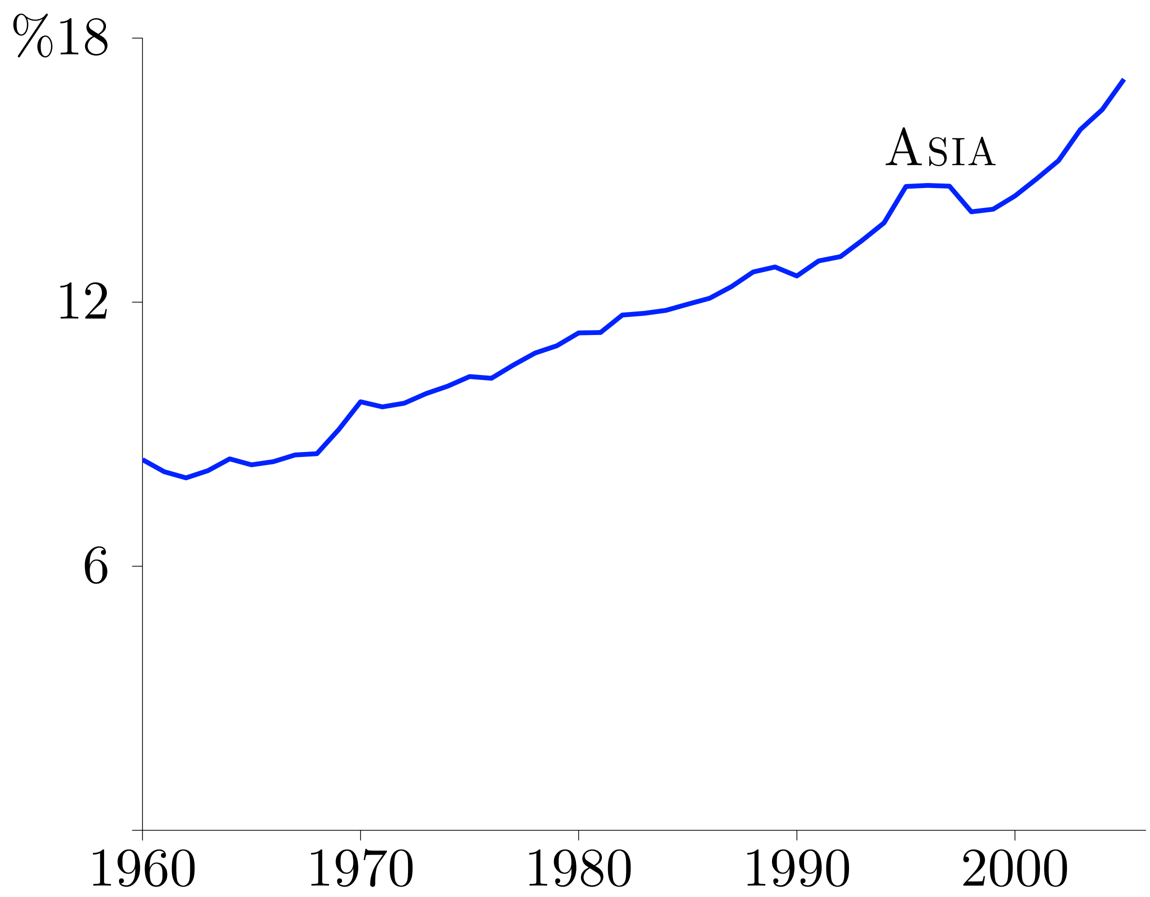
Why Did the EU-6 Catch Up?



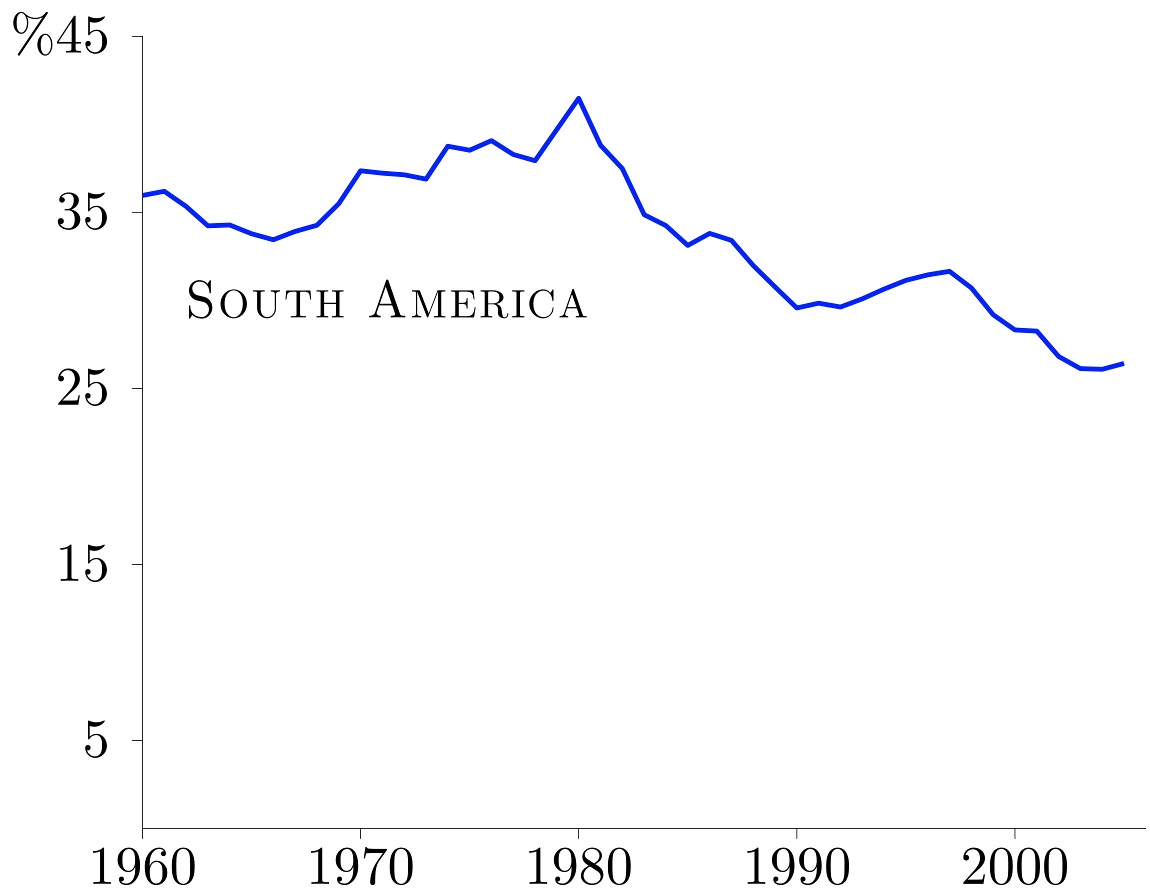
EU-6 Labor Productivity as % of US

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 Model of FDI

- Countries are measures of locations

- Technology capital can be used in multiple locations

- Doesn't require monopoly rents to finance innovation

New Avenue for Gains from FDI

- Opening implies bigger aggregate production sets

- In our model, gains arise

  - Without increasing returns

  - Without traditional factor endowment differences

  - Even with symmetric countries

Theory

Closed-Economy Aggregate Output

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

$M=$ units of *technology capital*

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

$N=$ number of production *locations*

$A=$ the technology parameter

$\phi=$ the income share parameter

which is the result of maximizing plant-level output

A Micro Foundation for Aggregation

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

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

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

We assume $g(z) = Az^{1-\phi}$, increasing and strictly concave

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$\Rightarrow$ organizational span of control limits

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

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

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

A Micro Foundation for Aggregation

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

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

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

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

Production in Open Economy

- The degree of openness of country i is σ_i

- Aggregate output in i is

$$\max_{z_d, z_f} \; M_i N_i A_i z_d^{1-\phi} + \sigma_i \sum_{j \neq i} M_j N_i A_i z_f^{1-\phi}$$

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

d, f indexes allocations to domestic and foreign operations

Production in Open Economy

- Aggregate output in i is

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

where

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

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

- Alternative interpretation of openness: fraction of M_j let in

Production in Open Economy

- Aggregate output in i is

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

- Key result provided $\omega_i > 0$:

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

Production in Open Economy

- Aggregate output in i is

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

- Key result:

  It is *as if* there were increasing returns,

  when in fact there are none.

Production in Open Economy

- Aggregate output in i is

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

- Key result:

  We partially endogenize measured TFP since locations and technology capital affect measured TFP.

Advantages to Our Technology

- Standard national accounting

- Standard parameter selection

- Standard welfare analysis

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Next, we describe the rest of the model

Introduce Population

- N_i = number of production locations in i

- $N_i \propto$ population in i

- Implication: Canada is like Taiwan, not China

Country i Household's Problem

$$\max \quad \sum_t \beta^t U(C_{it}/N_{it}, L_{it}/N_{it}) N_{it}$$

$$\text{s.t.} \qquad C_{it} + X_{ikt} + X_{imt} + NX_{it} = Y_{it}$$

Country i Household's Problem

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$$\text{s.t.} \quad C_{it} + X_{ikt} + X_{imt} + NX_{it} = Y_{it}$$

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

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

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$$N_{it} = (1+\gamma_N)^t N_{i0}$$

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$$X_{imt}, X_{ikt} \geq 0$$

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$$X_{imt}, X_{ikt} \geq 0$$

$K_{i0}; M_{i0}; \{A_{it}, \omega_{it}\}\ \forall i, t; \{M_{jt}\} \forall j \neq i, t; \{r_{it}^j\} \forall i, j, t$ given

How do Countries Differ?

Differences Across Countries

- Degree of openness

- Size $= \mathcal{A}_i N_i$
    - N_i is proprotional to population
    - $\mathcal{A}_i$ is augmenting labor & location $(= A_i^{\frac{1}{1-\alpha(1-\phi)}})$

Results depend only on product $\mathcal{A}_i N_i$

Steady State Analysis

A Steady State

- Common world interest rate determined by preferences
- Common K/Y ratio determined by interest rate
- Key result: Some M_i may be zero

Key Equilibrium Conditions

- K_i/Y_i same across i

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

- Combined with

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

$\Rightarrow$ System for which we apply Kakutani theorem

Three Lessons from Steady State Analysis

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Let's consider an example that illustrates 3 lessons ...

Example: $I = 2$, Symmetric ω

- Country 1 is larger, $\mathcal{A}_1 N_1 > \mathcal{A}_2 N_2$

- Key equilibrium conditions imply a ω^* such that:

$$\text{Case 1: } M_1 > 0, M_2 > 0 \text{ if } \omega < \omega^*$$

$$\text{Case 2: } M_1 > 0, M_2 = 0 \text{ if } \omega > \omega^*$$

Lesson 1: Size Advantage ($\omega < \omega^*$)

- Country 1 is larger, $\mathcal{A}_1 N_1 > \mathcal{A}_2 N_2$

- If $\omega < \omega^*$, then $M_1, M_2 > 0$ and

$$\frac{Y_i}{N_i} \propto (M_i + \omega M_{-i})^{\frac{\phi}{1-\alpha(1-\phi)}} \mathcal{A}_i$$

What matters is effective technology capital, $M_i + \omega M_{-i}$

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$$\text{and} \quad \frac{Y_i}{N_i} \propto [(1+\omega)\mathcal{A}_i N_i]^{\frac{\phi}{(1-\alpha)(1-\phi)}} \mathcal{A}_i$$

Which is proportional to size

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and $$\frac{Y_i}{N_i} \propto [(1+\omega)\mathcal{A}_i N_i]^{\frac{\phi}{(1-\alpha)(1-\phi)}} \mathcal{A}_i$$

Implying an advantage to size when ω small

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$$\rightarrow \mathcal{A}_i \text{ as } \phi \rightarrow 0$$

As $\phi \rightarrow 0$, back to standard theory

LESSON 1: SIZE ADVANTAGE ($\omega > \omega^*$)

- Country 1 is larger, $\mathcal{A}_1 N_1 > \mathcal{A}_2 N_2$

- If $\omega > \omega^*$, then $M_2 = 0$ and

$$\frac{Y_1}{N_1} \propto (Y_1 + Y_2)^{\frac{\phi}{1-\alpha(1-\phi)}} \mathcal{A}_1$$

$$\frac{Y_2}{N_2} \propto (\omega(Y_1 + Y_2))^{\frac{\phi}{1-\alpha(1-\phi)}} \mathcal{A}_2$$

When $\omega > \omega^*$, small country uses M_1

Lesson 1: Size Advantage ($\omega > \omega^*$)

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Implying a disappearing advantage as $\omega \to 1$

Lesson 1: Size Advantage ($\omega > \omega^*$)

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- If $\omega > \omega^*$, then $M_2 = 0$ and

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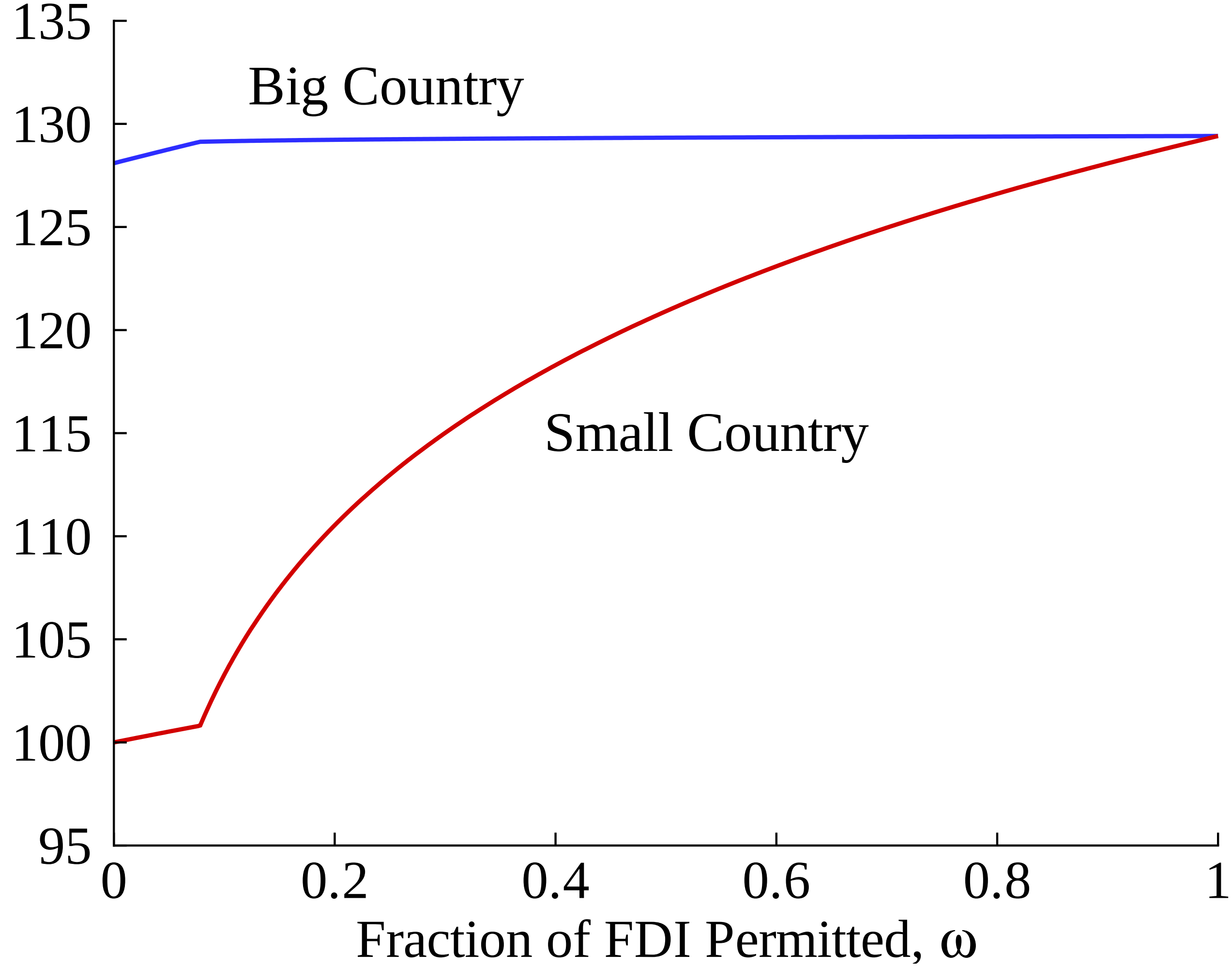
$$\frac{Y_2}{N_2} \propto (\omega(Y_1 + Y_2))^{\frac{\phi}{1-\alpha(1-\phi)}} \mathcal{A}_2$$

As $\phi \to 0$, back to standard theory

PRODUCTIVITIES VS. ω, $\mathcal{A}_1 N_1 = 10\mathcal{A}_2 N_2$



Lesson 2: Gain from Forming Unions

- I = number of equal-sized countries forming union

- Then, factor gain in productivity y for union is

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

- A union of small countries is like a large country

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- How large are the potential gains?

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

- If $\alpha = .3$, $\phi = .07$, then

$$\text{Gain} = 28\% \quad \text{if } I = 10$$

$$\text{Gain} = 64\% \quad \text{if } I = 100$$

Lesson 3: Gain from Unilaterally Opening

- I = number of equal-sized countries remaining closed

- Then, factor gain in productivity of I+1st opening is

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

- Countries gain when unilaterally opening

Lesson 3: Gain from Unilaterally Opening

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Lesson 3: Gain from Unilaterally Opening

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- Then, factor gain in productivity of $I+1$st opening is

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

- If $\alpha = .3$, $\phi = .07$, then

Gain = 25% if $I = 10$

Gain = 56% if $I = 100$

Bottom Line

- Gains to opening are large if ϕ not small

- To determine how large, need to know ϕ

Using US Accounts to Estimate ϕ

- If ϕ sizable, gains to opening are large
- In "Technology Capital and the US Current Account"
  - Chose ϕ, size, openness to match US
    - International accounts
    - National accounts
  - Needed $\phi = .07$ for consistency with accounts

Economies in Transition

In Transitions

- Allow for

  - Labor to be elastically supplied with

$$u(c, l) = \log c + \psi \log(1 - l)$$

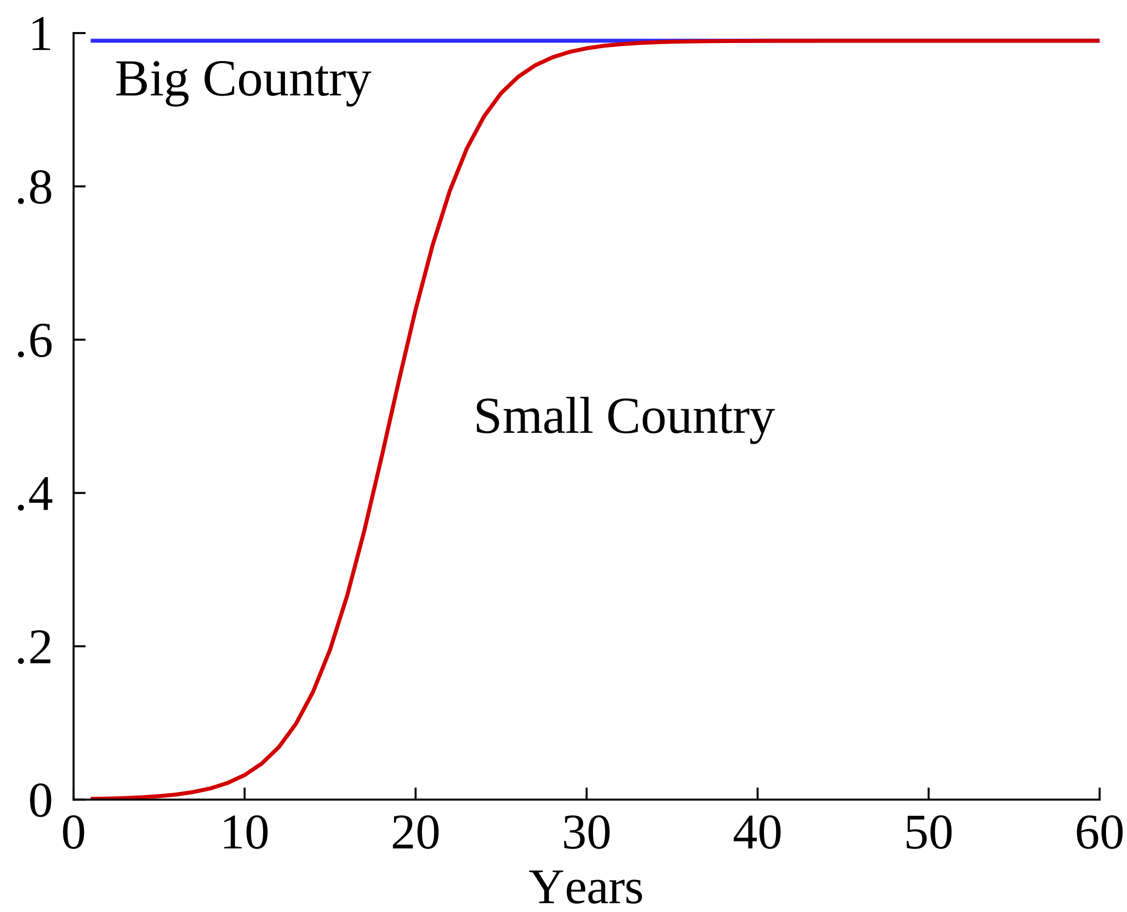
  - Growth in population γ_N and technology $\gamma_{\mathcal{A}}$ so

$$\gamma_Y = [(1 + \gamma_{\mathcal{A}})(1 + \gamma_N)]^{(1-\alpha(1-\phi))/((1-\alpha)(1-\phi))} - 1$$

- What happens to a country joining an open EU?

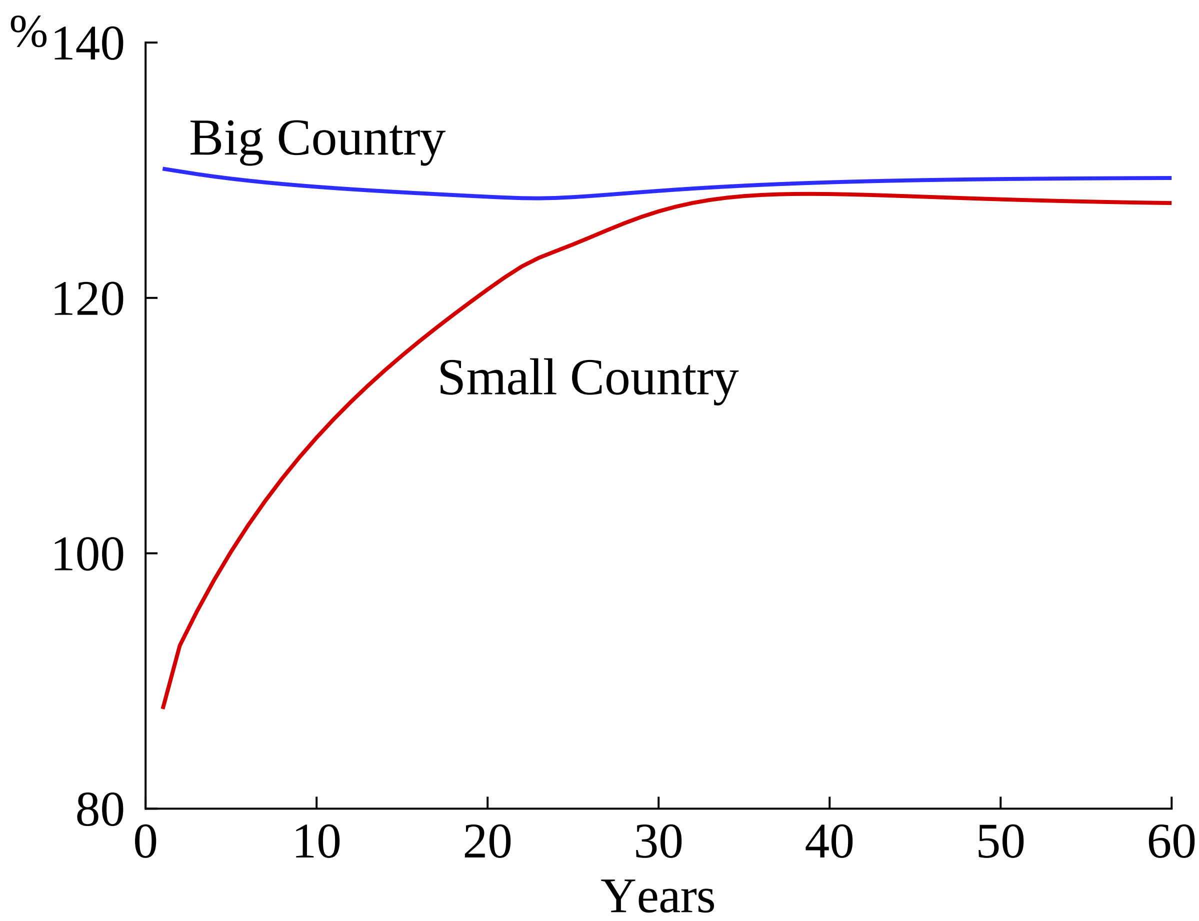
Small Country ($\mathcal{A}N = 1$) Opens to Big ($\mathcal{A}N = 10$)

Openness Parameters (σ)



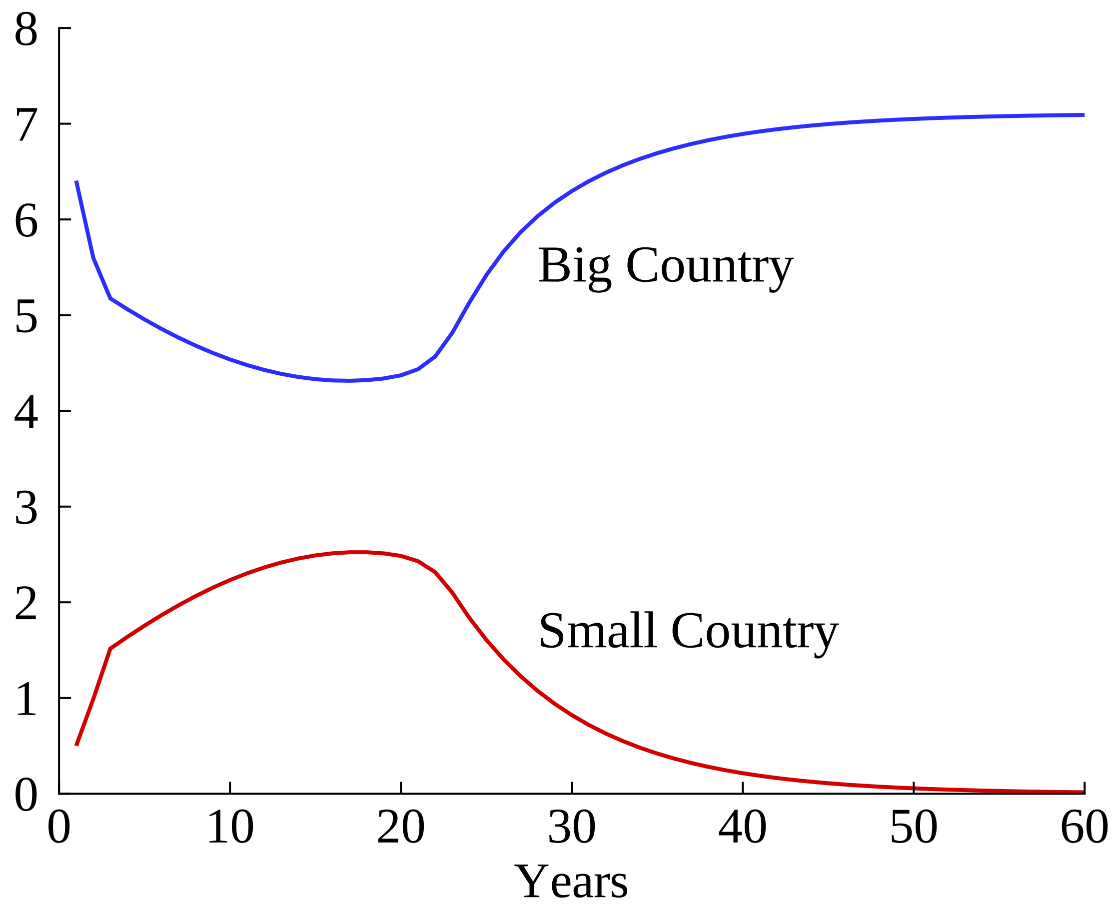
Small Country Opens to Big

Consumption/ $C_{2,0}(1+\gamma_Y)^t$



Small Country Opens to Big

Technology Capital/ $Y_{2,0}(1+\gamma_Y)^t$



Small Country Opens Gradually – Recap

- Initially, small country
  - Takes advantage of new markets in big country
  - Invests more in technology capital
  - Experiences a decline in measured productivity
  - Scares observers at the World Bank
- Eventually exploits big country's technology capital stock

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- Initially, small country
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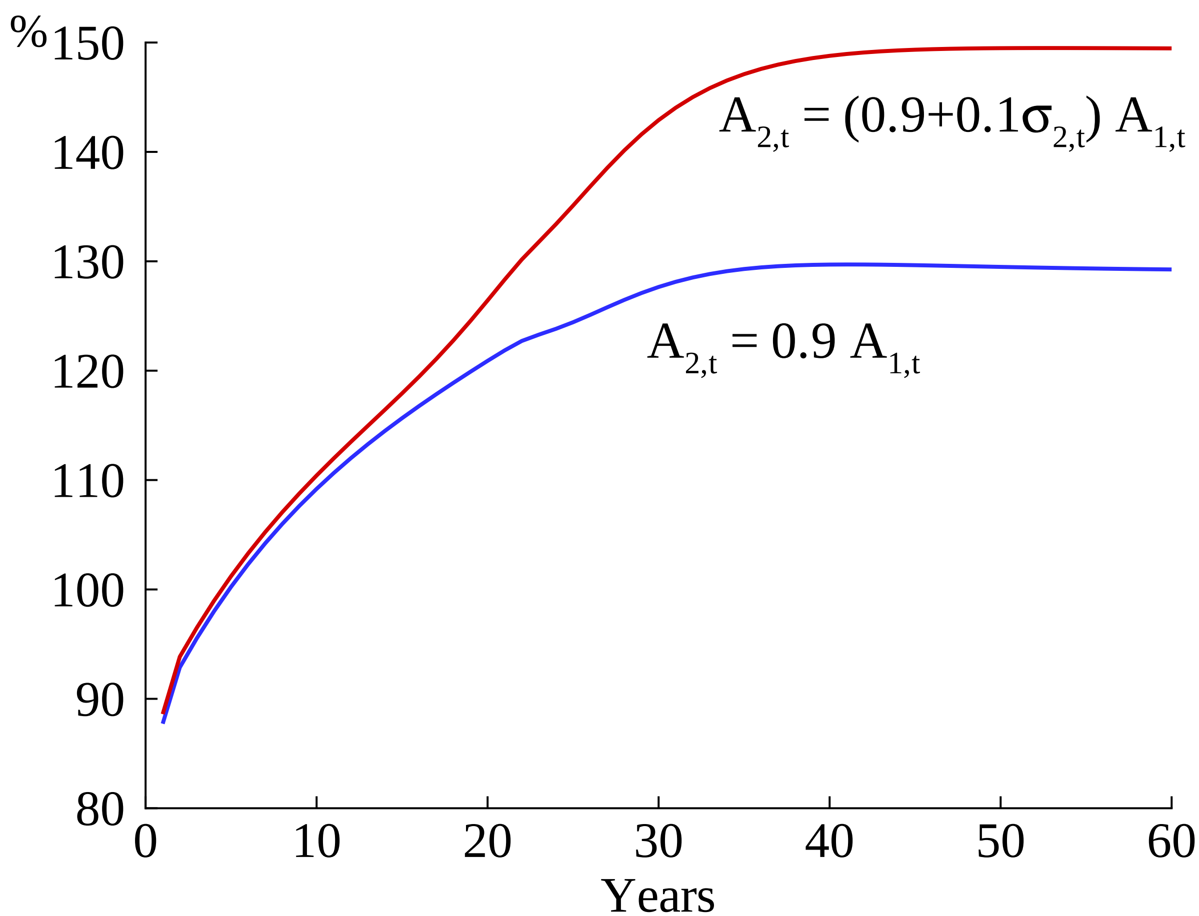
- Eventually exploits big country's technology capital stock
- What if there is diffusion of knowlege?

Gains from Opening with Diffusion

- Compare small country's consumption in 2 cases:
  - Without diffusion ($A_{2t} = .9A_{1t}$)
  - With diffusion ($A_{2t} = A_{1t}(.9 + .1\sigma_{2,t})$)

Gains from Opening with Diffusion

Consumption/ $C_{2,0}(1+\gamma_Y)^t$



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 account