The Dance of the Dynamics: The Interplay of Trade and Growth

Lei Ji
SKEMA & OFCE, Sciences Po

John Seater
Boston College

March 2016
Introduction

1. Use “2nd-generation” [i.e., latest vintage] fully endogenous growth model to study interaction of
   - Ricardian trade
   - Economic growth

2. Model built to be consistent with several facts from IO and trade literatures

3. Large number of results
   - A few confirm some conclusions from previous literature
   - Most are new
Motivation

Simple intellectual curiosity
- 2nd-gen growth model empirically successful
- Different predictions from its predecessors
- Not previously used to study trade and growth

Existing growth theory cannot explain several salient facts, such as:
- Systematic difference between industrialized and non-industrialized effects of 1980s globalization
- Persistent failure of sub-Saharan Africa to share in world-wide increases in growth rates
### Table 1

**Globalization & Growth**

(annualized per capita growth rates, percentage points)

<table>
<thead>
<tr>
<th>Region</th>
<th>Years</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>2.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Industrialized</td>
<td>3.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Non-industrialized</td>
<td>2.3</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Source: Bhalla (2002), Table 2.1
### Table 4
Rates of Growth of GDP/Capita
(annual avg. growth rates)

<table>
<thead>
<tr>
<th>Region</th>
<th>Years 1000-</th>
<th>Years 1500-</th>
<th>Years 1820-</th>
<th>Years 1870-</th>
<th>Years 1913-</th>
<th>Years 1950-</th>
<th>Years 1973-</th>
<th>Years 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1500</td>
<td>1820</td>
<td>1870</td>
<td>1913</td>
<td>1950</td>
<td>1973</td>
<td>1998</td>
<td></td>
</tr>
<tr>
<td>W. Eur.</td>
<td>0.13</td>
<td>0.15</td>
<td>0.95</td>
<td>1.32</td>
<td>0.76</td>
<td>4.08</td>
<td>1.78</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>0.36</td>
<td>1.34</td>
<td>1.82</td>
<td>1.61</td>
<td>2.45</td>
<td>1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.03</td>
<td>0.09</td>
<td>0.19</td>
<td>1.48</td>
<td>0.89</td>
<td>8.05</td>
<td>2.34</td>
<td></td>
</tr>
<tr>
<td>Asia\Jap</td>
<td>0.05</td>
<td>0.00</td>
<td>-0.11</td>
<td>0.38</td>
<td>-0.02</td>
<td>2.92</td>
<td>3.54</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.12</td>
<td>0.64</td>
<td>1.02</td>
<td>2.07</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

Source: Maddison (2001), Table B-22.
What This Paper Does

1. Extend 2nd-generation growth model to include Ricardian trade
2. Model is built to be consistent with several facts from IO and trade literatures, *not* to explain the foregoing facts
3. Derive many implications, most of which are new
4. Show that the model *does* explain the foregoing facts
5. Test other implications of the model
Relation to Other Trade Models

1. Melitz
   - Superficial similarity: Both emphasize economy’s IO structure
   - Aspects differ
     - Melitz: Cross-firm heterogeneity in TFP
       * Trade has only transitory growth effect
     - Ji & Seater: Nature of R&D and which firms do it
       * Trade has permanent growth effect

2. Eaton & Kortum
   - Richer trade dimensions (arbitrary numbers of countries and goods)
   - Weaker growth dimension (either static model or empirically-rejected growth models)
## Preview of Main Results

### Trade Affects Growth

1. Trade changes IO structure and so changes growth
2. Effect can be positive or negative: possible dynamic inefficiency
3. Effective technology transfer

### Growth Affects Trade

1. Full characterization of Ricardian corner: One country specializes, one does not
2. Endogenous changes in trading regimes: Can move out of Ricardian corner endogenously
Model Specification

IO Facts

1. **Number of firms and their market size are endogenous**
2. R&D drives technical progress, which drives growth
3. Virtually every country does R&D
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion
6. All three types of R&D **done mostly by incumbent firms**
7. Incumbents’ R&D devoted mostly to **quality improvement**
8. Remaining private R&D done mostly by outsiders to develop **new varieties** (*not* the usual “creative destruction” of 1st-generation endogenous growth theory)
Model Specification

IO Facts

1. Number of firms and their market size are endogenous
2. R&D drives technical progress, which drives growth
3. Virtually every country does R&D
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion
6. All three types of R&D done mostly by incumbent firms
7. Incumbents’ R&D devoted mostly to quality improvement
8. Remaining private R&D done mostly by outsiders to develop new varieties (*not* the usual “creative destruction” of 1st-generation endogenous growth theory)
Model Specification

IO Facts

1. Number of firms and their market size are endogenous
2. R&D drives technical progress, which drives growth
3. Virtually every country does R&D
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion
6. All three types of R&D done mostly by incumbent firms
7. Incumbents’ R&D devoted mostly to quality improvement
8. Remaining private R&D done mostly by outsiders to develop new varieties (*not* the usual “creative destruction” of 1st-generation endogenous growth theory)
Model Specification

IO Facts

1. Number of firms and their market size are endogenous
2. R&D drives technical progress, which drives growth
3. Virtually every country does R&D
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion
6. All three types of R&D done mostly by incumbent firms
7. Incumbents’ R&D devoted mostly to quality improvement
8. Remaining private R&D done mostly by outsiders to develop new varieties (*not* the usual “creative destruction” of 1st-generation endogenous growth theory)
Model Specification

IO Facts

1. Number of firms and their market size are endogenous
2. R&D drives technical progress, which drives growth
3. Virtually every country does R&D
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion
6. All three types of R&D done mostly by incumbent firms
7. Incumbents’ R&D devoted mostly to quality improvement
8. Remaining private R&D done mostly by outsiders to develop new varieties (*not* the usual “creative destruction” of 1st-generation endogenous growth theory)
Model Specification

**IO Facts**

1. Number of firms **and** their market size are endogenous.
2. R&D drives technical progress, which drives growth.
3. Virtually every country does R&D.
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country.
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion.
6. All three types of R&D **done mostly by incumbent firms**.
7. Incumbents’ R&D devoted mostly to quality improvement.
8. Remaining private R&D done mostly by outsiders to develop **new varieties** (*not* the usual “creative destruction” of 1st-generation endogenous growth theory).
Model Specification

IO Facts

1. Number of firms and their market size are endogenous.
2. R&D drives technical progress, which drives growth.
3. Virtually every country does R&D.
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country.
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion.
6. All three types of R&D done mostly by incumbent firms.
7. Incumbents’ R&D devoted mostly to quality improvement.
8. Remaining private R&D done mostly by outsiders to develop new varieties (*not* the usual “creative destruction” of 1st-generation endogenous growth theory).
Model Specification

IO Facts

1. Number of firms and their market size are endogenous
2. R&D drives technical progress, which drives growth
3. Virtually every country does R&D
4. R&D by multinationals small percentage of total and nearly exclusively specific to host country
5. Three broad classes of R&D: (a) quality improvement, (b) cost reduction, (c) variety expansion
6. All three types of R&D done mostly by incumbent firms
7. Incumbents’ R&D devoted mostly to quality improvement
8. Remaining private R&D done mostly by outsiders to develop new varieties (*not* the usual “creative destruction” of 1st-generation endogenous growth theory)
Underlying Facts, Continued

Trade Facts

1. About 3/4 of international trade is in factors of production (physical capital and intermediate goods).
2. Some firms or industries shut down in the face of foreign competition - a property of most Ricardian trade models because that's what specialization means.
Production

Competitive sectors

Final Goods

\[ Y = X_1^\epsilon X_2^{1-\epsilon} \]

where \( Y \equiv \) final output, \( X_i \equiv \) \( i \)th processed good

Processed Goods

\[ X_1 = \int_0^{N_1} G_{1j}^\lambda \left( Z_{1j}^\delta Z_1^\gamma Z_2^{1-(\delta+\gamma)} l_{1j} \right)^{1-\lambda} dj, \quad 0 < \lambda, \gamma, \delta < 1 \]

\[ X_2 = \int_0^{N_2} G_{2j}^\lambda \left( Z_{2j}^\delta Z_2^\gamma Z_1^{1-(\delta+\gamma)} l_{2j} \right)^{1-\lambda} dj, \quad 0 < \lambda, \gamma, \delta < 1 \]

where \( N_i = \) number of varieties of type \( i \) intermediate, \( G_{ij} = \) quantity of \( ij \) variety, \( Z_{ij} = \) quality of \( ij \) variety, \( Z_i = \) average quality of all type \( i \) intermediates, \( l_{ij} = \) labor assigned to good \( G_{ij} \)
Monopolistically competitive sector

Intermediate Goods

1. Incumbents
   - Output:
     \[
     G_{ij} = A_i^{-1} Y_{ij}
     \]
   - Quality improvement:
     \[
     \dot{Z}_{ij} = \alpha_i R_{ij}
     \]
   where \( R_{ij} \) is R&D expenditure
Intermediate Goods, Continued

2. Entrants

- Dividend paid by intermediate goods firm:

\[ D_{ij} = G_{ij} (P_{Gij} - A_i) - \phi_i - R_{ij} \]

where \( \phi_i \) is fixed operating cost, which we assume has the form \( \phi_{ij} = \theta_i Z_i^2 / Z_k \)

- Value of intermediate goods firm:

\[ V_{ij}(t) = \int_t^\infty D_{ij}(\tau) e^{-\int_t^\tau r(s)ds} d\tau \]

- Costless entry induces entry until: \( V_{ij} = 0 \)

\[ \Rightarrow D_{ij} = 0, \quad \Rightarrow R_{ij} = G_{ij} (P_{Gij} - A_i) - \phi_i \]
Summary of Types of Goods

1. Final good \( Y \)
2. Processed goods \( X_1 \) and \( X_2 \)
3. Intermediate goods:
   - \( N_1 \) varieties of Type-1 goods \( G_{1j} \) with quality \( Z_{1j} \)
   - \( N_2 \) varieties of Type-2 goods \( G_{2j} \) with quality \( Z_{2j} \)
Households

Maximize

\[ U(t) = \int_t^\infty \log(c) e^{-\rho t} \]

subject to

\[ 0 = \int_0^\infty \left( \int_0^{N_1} D_1 j dJ + \int_0^{N_2} D_2 j dJ + wL - C \right) e^{-\int_t^\tau r(s) ds} dt \]
Two countries, Home and Foreign

Two sets of tradable goods, $G_{1j}$ and $G_{2j}$

Countries are “large” because intermediate goods industries set prices, not take them as given

Final good $Y$ not tradable (see companion paper by Kane, Ji, & Seater for tradable $Y$)

$Y_H$ is the numeraire: $P_{Y_H} \equiv 1$
Comparative Advantage

1. Comparative advantage determined by relative quality-adjusted prices

2. Arbitrarily assume Home and Foreign have comparative advantages in $G_1 j$ and $G_2 j$, respectively:

\[
\frac{P_{G_{H1}}}{Z_{H1}^{\lambda}} \leq \frac{P_{G_{F1}}}{Z_{F1}^{\lambda}} \quad \text{and} \quad \frac{P_{G_{H2}}}{Z_{H2}^{\lambda}} \geq \frac{P_{G_{F2}}}{Z_{F2}^{\lambda}}
\]

3. Equivalent to

\[
\frac{A_{H2}}{A_{F2}} \left( \frac{Z_{F2}}{Z_{H2}} \right)^{(\delta + \gamma)(1-\lambda)} \geq P_{Y_F} \geq \frac{A_{H1}}{A_{F1}} \left( \frac{Z_{F1}}{Z_{H1}} \right)^{(\delta + \gamma)(1-\lambda)}
\]

4. $P_{Y_F}$ must be in this closed interval because otherwise one country tries to import both goods from the other country.
Intermediate goods prices are constant markups over marginal cost:

\[ P_{Gij} = \frac{A_i}{\lambda} \equiv P_{Gi} \]

Symmetry across firms within an industry implies same R&D expenditure for each firm in that industry:

\[ R_{ij} = R_i \]

Other main properties of the solution depend on whether the economy is in the Ricardian interior (each country specializes in producing one group of intermediate goods) or the corner (one country specializes but the other does not)
Cobb-Douglas technology and trade balance imply

\[ P_{YF} = \left[ (1 - \epsilon) \frac{L_H}{\epsilon L_F} \right]^{1-\lambda} \]

Substitution into comparative advantage expression gives

\[ \frac{A_{H2}}{A_{F2}} \left( \frac{Z_{F2}}{Z_{H2}} \right)^{\frac{(\delta+\gamma)(1-\lambda)}{\lambda}} > \left[ \frac{(1 - \epsilon) L_H}{\epsilon L_F} \right]^{1-\lambda} > \frac{A_{H1}}{A_{F1}} \left( \frac{Z_{F1}}{Z_{H1}} \right)^{\frac{(\delta+\gamma)}{\lambda}} \]

where the strict inequalities are equivalent to complete specialization

Home shuts down its \( G_2 \) industry, and Foreign shuts down \( G_1 \), so Home and Foreign also shut down the associated R&D programs

Growth of \( Z_{H2} \) and \( Z_{F1} \) stops

\[ \Rightarrow \] complete specialization is dynamically stable
No Aggregate Market Size Effects

Rate of return to R&D depends on market size per intermediate goods firm, not aggregate market size:

\[ r_{H1} = \Omega_{r1}^H \left\{ \left[ A_1^\epsilon A_2^{(1-\epsilon)} \right]^{-\lambda/(1-\lambda)} I_{H1} \right\} \]

\[ = \Omega_{r1}^H \left\{ \left( \sim \frac{G_{H1}}{\text{worker}} \right) \left( \text{workers using } G_{H1} \right) \right\} \]

\[ = \Omega_{r1}^H \{ \text{total demand for } G_{H1} \} \]

where

\[ I_{H1} = L_H/N_{H1} \]

\[ N_{H1} = \Omega_{N1}^H \left\{ \left[ A_1^\epsilon A_2^{(1-\epsilon)} \right]^{-\lambda/(1-\lambda)} L_H \right\} \]

\[ \Rightarrow r_{H1} = \Omega_{r1}^H/\Omega_{N1}^H \]
Level Effect

$$Y^{\text{Autarky}}_H = \kappa'_H \left[ \left( \frac{Z^{\delta+\gamma}_H}{P^{\lambda}_{G_H}} \right) Z^{1-(\delta+\gamma)}_H \epsilon \right]^{1-\epsilon}$$

$$\bullet \left[ \left( \frac{Z^{\delta+\gamma}_H}{P^{\lambda}_{G_H}} \right) Z^{1-(\delta+\gamma)}_H (1 - \epsilon) \right] L_H$$

$$Y^{\text{Trade}}_H = \kappa'_H \left[ \left( \frac{Z^{\delta+\gamma}_H}{P^{\lambda}_{G_H}} \right) Z^{1-(\delta+\gamma)}_H \epsilon \right]^{1-\epsilon}$$

$$\bullet \left[ \left( \frac{Z^{\delta+\gamma}_H}{P^{\lambda}_{G_H}} \right) Z^{1-(\delta+\gamma)}_H (1 - \epsilon) \right] L_H$$
Balanced Growth Rate

1. Everything grows at same rate:

\[
g^* = \frac{\dot{Z}_1}{Z_1} = \frac{\dot{Z}_2}{Z_2} = \frac{\dot{Y}}{Y} = \frac{\dot{C}}{C} = \frac{\dot{X}_1}{X_1} = \frac{\dot{X}_2}{X_2} = \frac{\dot{G}_1}{G_1} = \frac{\dot{G}_2}{G_2} = \frac{\dot{w}}{w}
\]

2. Autarkic growth rates differ across countries:

\[
(g_k^*)^{Autarky} = \frac{\delta}{1 - \delta} \sqrt{\alpha_{k1}\theta_{k1}\alpha_{k2}\theta_{k2}} - \frac{1}{1 - \delta \rho}
\]

3. Trade growth rate:

\[
(g_{H}^*)^{Trade} = (g_{F}^*)^{Trade} = \frac{\delta}{1 - \delta} \sqrt{\alpha_{H1}\theta_{H1}\alpha_{F2}\theta_{F2}} - \frac{1}{1 - \delta \rho}
\]
Transition Growth Rate

\[(g_H)^{Trade} = (g_F)^{Trade} = \Gamma \frac{\dot{Z}_{H1}}{Z_{H1}} + (1 - \Gamma) \frac{\dot{Z}_{F2}}{Z_{F2}}\]

where

\[\Gamma \equiv [1 - (\delta + \gamma)] + \epsilon [2(\delta + \gamma) - 1]\]
1. Recall comparative advantage conditions

\[ \frac{A_{H2}}{A_{F2}} \left( \frac{Z_{F2}}{Z_{H2}} \right)^{\frac{(\delta + \gamma)(1 - \lambda)}{\lambda}} \geq P_{YF} \geq \frac{A_{H1}}{A_{F1}} \left( \frac{Z_{F1}}{Z_{H1}} \right)^{\frac{(\delta + \gamma)(1 - \lambda)}{\lambda}} \]

2. In the interior, also have

\[ P_{YF} = \left[ (1 - \epsilon) \frac{L_H}{\epsilon L_F} \right]^{1-\lambda} \]

3. Nothing guarantees that \( \left[ (1 - \epsilon) \frac{L_H}{\epsilon L_F} \right]^{1-\lambda} \) is inside the comparative advantage bounds

4. When it isn’t, we have a corner solution, such as

\[ \left[ (1 - \epsilon) \frac{L_H}{\epsilon L_F} \right]^{1-\lambda} > \frac{A_{H2}}{A_{F2}} \left( \frac{Z_{F2}}{Z_{H2}} \right)^{\frac{(\delta + \gamma)(1 - \lambda)}{\lambda}} \]

\[ > \frac{A_{H1}}{A_{F1}} \left( \frac{Z_{F1}}{Z_{H1}} \right)^{\frac{(\delta + \gamma)(1 - \lambda)}{\lambda}} = P_{YF} \]
1. Level effects essentially the same as under complete specialization

2. Balanced growth rates:

\[ g_i^*T = \frac{\delta}{1 - \delta} \sqrt{\alpha_{H1} \theta_{H1} (\alpha_{H2} \theta_{H2})^\eta (\alpha_{F2} \theta_{F2})^{1-\eta}} - \frac{\rho}{1 - \delta} \]

3. Transition growth rates differ in general:

\[ g_H^T = \Gamma \frac{\dot{Z}_{H1}}{Z_{H1}} + \{\eta \epsilon [1 - (\delta + \gamma)] + (\delta + \gamma) (1 - \epsilon)\} \frac{\dot{Z}_{H2}}{Z_{H2}} \]

\[ + \{(1 - \eta) [1 - (\delta + \gamma)] \epsilon\} \frac{\dot{Z}_{F2}}{Z_{F2}} \]

\[ g_F^T = \Gamma \frac{\dot{Z}_{H1}}{Z_{H1}} - (\delta + \gamma) \epsilon \frac{\dot{Z}_{H2}}{Z_{H2}} + \{[1 - (\delta + \gamma)] \epsilon + \delta\} \frac{\dot{Z}_{F2}}{Z_{F2}} \]
Transition Dynamics, Continued

Three phases in the region of \( \{Z_{H1}, Z_{H2}, Z_{F2}\} \) space:

1. Saddle-path stable steady state (the balanced growth rate given on previous slide)
2. Phase that reaches the boundary of the interior and crosses into it in finite time, converting the world to complete specialization
3. Phase where world remains incompletely specialized forever and countries growth rates approach constant difference

\[
(g_H - g_F) \to \left( \delta + \frac{\delta^2}{\eta \epsilon [1 - (\delta + \gamma)] + \gamma} \right) \alpha_{H2} \theta_{H2} \left( \frac{Z_{H2}}{Z_{H1}} \right)^* 
\]
Comparative advantage determines:

1. Trade pattern - who trades what for what
2. Specialization pattern - who produces what

IO structure:

1. Prevents aggregate market size effects through proper treatment of entry
2. Determines which firms do R&D

Comparative advantage and IO structure interact to determine:

1. Cross-country R&D pattern
2. Countries’ and world’s growth rates
How Trade Affects Growth

\[(g^{*})^{Trade} = \frac{\delta}{1-\delta} \sqrt{\alpha_{H1}\theta_{H1}\alpha_{F2}\theta_{F2}} - \frac{1}{1-\delta} \rho\]

\[(g)^{Trade} = \Gamma \frac{Z_{H1}}{Z_{H1}} + (1 - \Gamma) \frac{Z_{F2}}{Z_{F2}}\]

where \(\Gamma \equiv [1 - (\delta + \gamma)] + \epsilon [2(\delta + \gamma) - 1]\)

1. Growth driven entirely by quality improvement, not variety expansion
2. Growth depends on
   - R&D efficiencies \(\alpha_{ij}\) and fixed cost parameters \(\theta_{ij}\)
   - but not quality levels \(Z_{ij}\) or unit costs \(A_{ij}\) of producing \(G_{ij}\)
3. Technology transfer has no effect on balanced growth and only quantitative effects on transitional growth
4. Effective technology transfer has a central effect on both balanced growth and transitional growth
How Trade Affects Growth, Continued

**Effective Technology Transfer**

1. Generalizes Acemoglu & Ventura (2002): growth rates equal everywhere in Ricardian interior, not just on BGP
2. Can explain observed negative “forward spillovers” in importing country
3. Offers alternative explanation for apparent technology transfer with trade (Coe & Helpman 1995)

**Growth Rate Behavior**

2. No country takes over all R&D, consistent with observation and contrary to G&H (1991, Ch9)
Dynamic Inefficiency

1. Trade may reduce growth through a dynamic inefficiency arising from a cross-functional externality
   - Trade today depends on comparative advantage, which depends on relative quality-adjusted price
   - Growth depends on R&D, which is independent of comparative advantage but does depend on which industries survive

2. Different from other (counterfactual) explanations of negative growth effect:
   - Redding (1999)
     - exogenous growth
     - no R&D
     - independent R&D sector
     - growth falls only if resources devoted to R&D fall
Melitz and Eaton-Kortum

\[(g^*)^{Trade} = \frac{\delta}{1-\delta} \sqrt{\alpha H_1 \theta H_1 \alpha F_2 \theta F_2} - \frac{1}{1-\delta} \rho\]

1. Melitz heterogeneity
   - Affects average efficiency of production = $A_{ij}^{-1}$
   - Irrelevant to long-run growth
   - Recent evidence (Harrison et al., 2013) finds Melitz heterogeneity has only transitional effects

2. Eaton-Kortum
   - Very rich
   - Extensions to growth limited to (counterfactual) 1st-generation endogenous growth and semi-endogenous growth models
   - Don’t know what would happen if combined with 2nd-generation approach
Incomplete Specialization

Three sub-regions

1. F grows faster than H
   - eventually F becomes “technologically big enough” to satisfy all of H’s needs
   - world enters the Interior
   - growth rates become equal

2. H grows faster than F
   - H and F go asymptotically to constant difference in growth rates
   - Remain in Ricardian corner forever
   - F’s share of world output goes asymptotically to zero

3. Saddle-path stable balanced growth
   - H and F have same growth rate
   - Remain in Ricardian corner forever with incomplete specialization
Terms of Trade

1. Terms of trade are relative quality-adjusted prices

\[ TOT \equiv \left( \frac{P_{GH1}}{(\delta + \gamma)(1 - \lambda)} \right) \left( \frac{P_{GF2}}{(\delta + \gamma)(1 - \lambda)} \right)^{-1} = \frac{P_{GH1}}{P_{GF2}} \left( \frac{Z_{F2}}{Z_{H1}} \right)^{(\delta + \gamma)(1 - \lambda)} \]

2. Can show there is no necessary relation between growth and change in TOT

3. Sharp contrast to Acemoglu & Ventura (2002), where change in TOT is positively related to growth rate
How Growth Affects Trade

1. Growth can move world from Ricardian corner to Ricardian interior endogenously
2. Theory explains the conditions required for this to happen or not happen
3. Brings the two cases together in a unified treatment
Welfare

\[
\log \frac{u^T_H(t)}{u^A_H(t)} = (1 - \epsilon) \log \left[ \frac{Z_{F2}^{\delta + \gamma}(0)}{P_G^{\lambda} G_{F2}} - \frac{Z_{H2}^{\delta + \gamma}(0)}{P_G^{\lambda} G_{J2}} \right] \\
+ \epsilon (1 - \delta - \gamma) \left[ \log Z_{F2}(0) - Z_{H2}(0) \right] \\
+ \left\{ \Gamma \int_0^\infty \left[ g_{H1}^T(s) - g_{H1}^A \right] ds \\
+ (1 - \Gamma) \int_0^\infty \left[ g_{F2}(s) - g_{H2}^A \right] ds \right\}
\]

1. 1st term is static gain from trade
2. 2nd term also a static term reflecting externality due to quality spillover across industries
3. 3rd term is the welfare change from change in growth rate
Table 1
Globalization & Growth
(annualized per capita growth rates, percentage points)

<table>
<thead>
<tr>
<th>Region</th>
<th>Years</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>2.5 2.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Industrialized</td>
<td>3.3 1.6</td>
<td>-1.7</td>
</tr>
<tr>
<td>Non-industrialized</td>
<td>2.3 2.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Source: Bhalla (2002), Table 2.1
Our theory reconciles competing views

2. Rodriguez & Rodrik (2000): trade has no systematic effect on growth
### Table 4
Rates of Growth of GDP/Capita
(annual avg. growth rates)

<table>
<thead>
<tr>
<th>Region</th>
<th>Years</th>
<th>1000-</th>
<th>1500-</th>
<th>1820-</th>
<th>1870-</th>
<th>1913-</th>
<th>1950-</th>
<th>1973-</th>
<th>1998-</th>
</tr>
</thead>
<tbody>
<tr>
<td>W. Eur.</td>
<td></td>
<td>0.13</td>
<td>0.15</td>
<td>0.95</td>
<td>1.32</td>
<td>0.76</td>
<td>4.08</td>
<td>1.78</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td></td>
<td>0.36</td>
<td>1.34</td>
<td>1.82</td>
<td>1.61</td>
<td>2.45</td>
<td>1.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td></td>
<td>0.03</td>
<td>0.09</td>
<td>0.19</td>
<td>1.48</td>
<td>0.89</td>
<td>8.05</td>
<td>2.34</td>
<td></td>
</tr>
<tr>
<td>Asia\Jap</td>
<td></td>
<td>0.05</td>
<td>0.00</td>
<td>-0.11</td>
<td>0.38</td>
<td>-0.02</td>
<td>2.92</td>
<td>3.54</td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td></td>
<td>-0.01</td>
<td>0.01</td>
<td>0.12</td>
<td>0.64</td>
<td>1.02</td>
<td>2.07</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

Source: Maddison (2001), Table B-22.
Our theory can explain

1. Asia’s catch-up
   - Japan 1870-1950
   - Japan 1950-1998 (?)

2. Africa’s failure to catch up

3. Quah’s (1997) “twin peaks”
Tests

We perform three simple tests

1. Terms of trade and growth
2. Globalization and growth
3. Trade and growth differences among growth leaders and followers
### Tests: Terms of Trade & Growth

#### Table 5
Growth rates of income and of the terms of trade

<table>
<thead>
<tr>
<th></th>
<th>Growth rate of income per worker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff.</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>0.01975</td>
</tr>
<tr>
<td><strong>Growth rate of TOT</strong></td>
<td>0.01161</td>
</tr>
<tr>
<td><strong>Adj R-squared</strong></td>
<td>-0.0111</td>
</tr>
</tbody>
</table>
Refine Bhalla’s test by seeing how many advanced and laggard economies had an increase or decrease in growth rates after 1980.

**Table 6**

**Globalization and Growth Rates**

<table>
<thead>
<tr>
<th></th>
<th>Change in growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rise</td>
</tr>
<tr>
<td>Member OECD</td>
<td>1</td>
</tr>
<tr>
<td>Non-member OECD</td>
<td>15</td>
</tr>
<tr>
<td>Developed</td>
<td>0</td>
</tr>
<tr>
<td>Underdeveloped</td>
<td>16</td>
</tr>
</tbody>
</table>
Howitt & Mayer-Foulkes (2005) prediction:

Increase in technology transfer caused by trade raises leaders’ growth rates and reduces laggards’ growth rates to zero

Our prediction:

Trade and effective technology transfer raise laggards’ growth rates

Our test:

- Compare change in growth rates in two sets of countries
  - initially more than 1 percentage point above world average
  - initially more than 1 percentage point below world average
- Of the 20 countries in Low group, 19 had growth rates higher in last 5 years of sample than in first 5 years
Conclusion

1. Built model on IO and trade facts
2. Theory delivers many results either new or contrary to existing literature
3. Theory’s predictions consistent with several observations and three simple tests
4. Work for the future: Generalize to many countries and many goods