**Beyond the Basic Solow Growth Model, Part 2**

**Agenda**
- Extending the Basic Solow Growth Model.
  - Accounting for Differences in A.
  - Conditional Convergence.
- Endogenous Technological Change.
  - New Growth Theory.
- Policy Implications.

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**Extending the Basic Solow Growth Model**

**Accounting for A and a-dot:**
- Differences in Technology,
- Differences in Economic Attributes,
- Differences in Institution, and
- Differences in Quality of Labor Force.

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**Extending the Basic Solow Growth Model**

- Countries do NOT have similar “Technology”
  - Composition of Capital Stock,
  - Quality of Capital Stock,
  - Infrastructure, and
  - Business Organization and Management.

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**Extending the Basic Solow Growth Model**

- Countries do NOT have similar “Economic Attributes”
  - Topography and climate,
  - Geographic size,
  - Population size,
  - Cultures, …

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**Extending the Basic Solow Growth Model**

- Countries do NOT have similar “Economic Attributes” (more)
  - Composition of output, and
  - Existence of local monopolies.
  - Closed economies,
  - Tariffs, quotas, and
  - Business regulations.

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**Extending the Basic Solow Growth Model**

- Countries do NOT have similar “Institutions”
  - Institutions are the
    - Formal rules,
    - Customs,
    - Practices, and
    - Patterns of behavior that govern economic action.
Extending the Basic Solow Growth Model

• Countries do NOT have similar “Institutions”
  - Limited, honest government,
  - Honest and competent institutions,
  - Rule of Law,
  - Property Rights,
  - Free Markets,
  - Government regulations of business,
  - Efficient systems of schooling, and
  - Efficient systems of public health.

• Countries do NOT have the similar “Quality of Labor”
  - Size of the labor force,
    • Including labor force participation rates,
  - Educational levels and job skills,
  - Work ethics, work hours, and labor market flexibility, and
  - Health of the workforce.

Differences in A

Conditional Convergence

Extending the Basic Solow Growth Model

• Differences in technology, economic attributes, institutions, and/or quality of labor imply a different production function.
  - And a different steady state Y/N.

• Conditional Convergence
  - Basic Solow Growth Model predicts “absolute” convergence.
  - Extended Solow Growth Model recognizes “conditional” convergence.
    • Y/N will eventually converge for countries with similar economic attributes.
    • This is the conditional convergence hypothesis.
      - Real world observations support this proposition.
Endogenous Technological Change

• Increasing the Long-run Growth Rate.
  ➢ To permanently increase y-dot, must permanently increase a-dot.
  • From the growth accounting formula.
  • In the basic Solow Growth Model, y-dot can only be increased during a transition period.
  ➢ The only way to always be in a transition period is for A to keep increasing, i.e., a-dot > 0.

Endogenous Technological Change

• So we need an explicit theory of technological change.
  ➢ If a-dot = 0, then y-dot = n-dot and y-dot is exogenous because n-dot is exogenous.
  ➢ If a-dot = a > 0, then y-dot > n-dot but y-dot is still exogenous because a is exogenous.
  ➢ To endogenize y-dot we must endogenize a-dot, i.e., provide an explanation for technological change.

New Growth Theory

• Is an attempt to explain A and a-dot within the model.
  ➢ Focuses on the determinants of A and a-dot and integrates A back into the production function.

A Production Function for Technology

• Technology, and its production, encompasses so many aspects that it is difficult to formulate a simple theory.
  • Start with a production function for technology, i.e.,
    ➢ Technology is the result of a process that transforms inputs into technology.

A Production Function for Technology

• Suppose
  ➢ $\Delta A = f (K_A, N_A, A, E)$
  ➢ where
    • $A$ = technological innovation.
    • $K_A$ = capital devoted to technological innovation.
    • $K_A < K$
    • $N_A$ = labor input devoted to technological innovation.
    • $N_A < N$
    • $E$ = economic environment in which technological innovation takes place.
    ➢ The degree of monopoly power.

A Production Function for Technology

• Determinants of Technological Innovation
  ➢ Capital and Labor.
    • $K_A$ and $N_A$ are the $K$ and $N$ used in research and development.
    • Increases in $A$ come from research and development.
      ➢ Countries that invest more in research and development will grow faster.
      • $K_A$ and $N_A$ can be influenced by policy choices.
      ➢ This makes A endogenous.
### A Production Function for Technology

**Determinants of Technological Innovation**

<table>
<thead>
<tr>
<th>Economic Environment</th>
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<tbody>
<tr>
<td><strong>Stable government.</strong></td>
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<tr>
<td><strong>Protection of property rights.</strong></td>
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<tr>
<td><strong>Openness to trade.</strong></td>
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<td><strong>Enforcement of patent and copyright laws.</strong></td>
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<td><strong>Public good can be used without diminishing the amount available to others.</strong></td>
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<tr>
<td><strong>Technology is generally a public good.</strong></td>
</tr>
<tr>
<td>« One idea/process can be used over and over again without diminishing it, i.e., it is “non-excludable.”</td>
</tr>
<tr>
<td>« Unless it can be protected by patents, copyrights, or trade secrets which attempt to make technology excludable.</td>
</tr>
</tbody>
</table>

### Determinants of Technological Innovation

**Technology.**

- \( \Delta A \) is also dependent on A.
  - Technology is used to develop new(er) technology.
    - The methods and tools used to come up with new ideas and new, more efficient ways to produce goods and services.
    - There are important spillover effects from A.
    - i.e., new ideas spawn other new ideas.

**Economic Environment.**

- Need an environment in which entrepreneurs and innovators thrive and create new ideas.
  - Stable government.
  - Protection of property rights.
  - Openness to trade.
  - Enforcement of patent and copyright laws.

**Public Goods and Patents.**

- Non-patented ideas/processes are public goods.
  - Have the highest payoff for economic growth.
  - But no incentive to create.
- If A is patented, then its public good element is reduced.
  - But the incentive to develop A is increased.

**Technological developments can also be differentiated by how broadly they can be applied.**

- General purpose technologies (rather than specific purpose technologies) have the strongest effects on growth.
A Production Function for Technology

- Determinants of Technological Innovation
  - Economic Environment.
    - Public Goods and Patents.
      - In assigning copyrights, patents, and property rights, policy makers are making compromises between the incentives to create and economic growth.
        - Patent protection is for a limited amount of time.
        - Then the idea/process becomes public good.

Endogenous Technological Change

- Identifying Causes of Technological Growth
  - Technological development is a complicated process.
    - Difficult to generalize.
    - Difficult to capture in a model.
  - Some economists argue that the growth process is too difficult to generate into a model.

Not-so-New Growth Theory

- #1: Basic Ideas for Growth.
  - Maintain a stable government.
    - Good governance,
    - Anti-corruption, and
    - Competent institutions.
  - Enact sound social policies.
    - Adequate public health,
    - Adequate education, and
    - Basic infrastructure.

- #2: Specialization and the Market
  - Profit incentive will lead to specialization and endogenous technological innovation.
    - Increase competitive pressures.
    - Open the economy to international trade.
- #3: The Role of the Entrepreneur
  - Waves of innovation.

Not-so-New Growth Theory

- #1: Basic Ideas for Growth.
  - Enact sound economic policies.
    - Create competitive markets.
      - Give them freedom to operate.
    - Reform tax codes and spending to promote growth.
    - Save and invest.
    - Maintain low and stable inflation.
Policy Implications

• Basic Solow Growth Model:
  ➢ Increase $v$ to increase $I$ to increase $K$.
  ➢ Increase research and development and economic incentives to boost $A$.

• Expanded Solow Growth Model:
  ➢ Educate the labor force and improve its job skills.
  ➢ Create/change economic attributes and institutions to be more growth compatible.

Policies Implications

• Faster growth has accrued to those who:
  ➢ Have higher levels of K-to-L.
  ➢ More educated labor force.
  ➢ Institutions that foster innovation.

• Faster growth has also accrued to those who:
  ➢ Reduce protectionism.
  ➢ Privatize government controlled activities.
  ➢ Adopt industrial policies.

Conclusions

• Don’t have a really good explanation for technological change or, therefore, growth.

• Models are not irrelevant.
  ➢ They help understand the growth process.
  ➢ They are used as guides for policy.
    • But cannot be used mechanistically.