I. Introduction

• NGT and Jone’s facts
  • EGT
• Empirical works
• Theoretical works
Jones Facts (1998)*

1. Large variation in per capita income across economics

2. Countries can move from being poor to being rich and vice-versa
   For instance: Hong Kong, South Korea and vice-versa: Argentina

3. Growth in output and growth in trade volume are closely related

*Jones, C. I. (1998), Introduction to Economic Growth, W.W. Norton, New York, Chapters 1 - 5, 8, 9 and Appendix A.
Neoclassical Growth Theory (NGT)

• No autonomous engine of growth
• Growth dies off in the long-run without exogenous trend
  – 1. No theory of determinants of long-run growth
  – 2. No theory of determinants of long-run cross-country differences in growth rates
  – 3. Policies do not affect long-run growth
Can NGT explain the facts?  
Numerical example

• Differences in parameters could explain Jones fact 1.

\[ \frac{Y_t}{L_t} = A_t \cdot y_t^* = A \left( \frac{s}{n + g + \delta} \right)^{1-\alpha} \]

\[ \alpha = 1/3; \quad g = 0.02; \quad \delta = 0.05; \]
\[ 0.01 < s < 0.08; \quad 0.00 < n < 0.05. \]
\[ \Rightarrow y_{\text{low}}^* = 0.29A_t; \quad y_{\text{high}}^* = 1.07A_t \]

But, difference in income levels only 3~4 fold
Questions:

(a) Why large differences in growth rates?
(b) Why persistent differences (productivity differences)?
(c) What drives growth in the world overall?
Endogenous Growth Theory (EGT): sources of TFP growth

“This great increase of the quantity of work which, in consequence of the division of labor, the same number of people are capable of performing, is owing to three different circumstances; first to the increase of dexterity in every particular workman; secondly, to the saving of the time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labor, and enable one man to do the work of many”. Smith (1776), Book1, Chapter 1, Section 1.1.5.
Endogenous Growth Theory (EGT): sources of TFP growth

- Positive spillovers in capital stock $\uparrow$, but labor supply $\uparrow$ leads to negative spillovers
- Let $Y = A(K, L)K^{1-\alpha}L^{\alpha}$
- $= (K/L)^{\gamma}K^{\alpha}L^{1-\alpha} = K^{\beta}L^{1-\beta}$
- where $\beta = \alpha + \gamma$.
- Note that $\alpha$ is the share of labor predicted by the neoclassical model. The spillover definition of technology now allows the contribution of capital to be $\beta > \alpha$ as required.
Endogenous Growth Theory (EGT): sources of TFP growth

• In the late 80’s and throughout the 90’s, NGT came under the center of criticism
  – Paul Romer, Gene Grossman and Elhanan Helpman
  – originated a new body of theoretical and empirical work

• The new theory has moved from two main objections to the traditional approach: empirical and theoretical standpoints.
1. Empirical standpoint

• NGT is argued to fail to explain in a satisfactory way the enormous disparities of level and growth rates of per capita income across countries
Cobb-Douglas Augmented Solow Model
Mankiw, Romer and Weil (1992)

• Marginal extension to the neoclassical model – include human capital (H) as a distinct factor of production.
• K and H are allowed to vary together across countries and arrive at decent results for the example discussed earlier.
• The workhorse model of long-run macro
Cobb-Douglas Augmented Solow Model
Mankiw, Romer and Weil (1992)

• MRW starting with this model:

\[ Y_j = K_j^\beta H_j^\alpha (A_j L_j)^{1-\alpha-\beta} \Rightarrow y_j = A_j k_j^\beta h_j^\alpha \]

\[ \alpha, \beta \geq 0, \alpha + \beta \leq 1 \]

\[ y \equiv Y / L, \ k \equiv K / AL, \ h \equiv H / AL \]

Y: total output
H: human capital
L: labor
A: labor-augmenting technological change
Cobb-Douglas augmented Solow model: assumptions and s.s.

- Constant saving rates for K and H: \( s_j^k; s_i^h \)
- Constant population growth rate: \( n_j \)
- Common exogenous technological growth rate: \( g \)

\[
\begin{align*}
  k_j^* &= \left( \frac{s_j^k}{n_j + g + \delta^k} \right)^{1-\alpha} \left( \frac{s_j^h}{n_j + g + \delta^h} \right)^{\alpha} \frac{1}{1-\alpha-\beta} \\
  h_j^* &= \left( \frac{s_j^k}{n_j + g + \delta^k} \right)^{\beta} \left( \frac{s_j^h}{n_j + g + \delta^h} \right)^{1-\beta} \frac{1}{1-\alpha-\beta}
\end{align*}
\]
Cobb-Douglas augmented Solow model: MRW growth regression

- Substituting (2) back into (1), taking logs

\[
\ln y_j = \ln A_j + gt + \frac{\alpha}{1-\alpha-\beta} \ln \left( \frac{s_j^h}{n_j+g+\delta^h} \right) + \frac{\beta}{1-\alpha-\beta} \ln \left( \frac{s_j^k}{n_j+g+\delta^k} \right)
\]

- Estimate (3) if we have cross-country data \(\delta^h, \delta^k, n_j, s_j^k\) and \(s_j^h\)

- What MRW do?
  - \(s_j^k\): investment rate
  - \(s_j^h\): fraction of working age population enrolled in school
  - Standard depreciation rate: \(\delta^h=\delta^k\)
  - Common technology: \(A_j=A\)
Cobb-Douglas augmented Solow model: MRW growth regression

- $\alpha \sim 1/3; \beta \sim 1/3; R^2 \sim 0.78$

- Strong support for the augmented Solow model
  - $\alpha \sim$ capital share of 1/3 in national income
  - $R^2 \sim$ almost 80 percent of the differences in income per capita can be explained by investment decisions (human and physical capital differences)
Cobb-Douglas Augmented Solow Model: Problems with the MRW

• The common technology assumption is too strong.
  – When $A_j$ varies across countries, $A_j = \varepsilon_j A$, it will be correlated with measures of $s_j^k$ and $s_j^h$.
  – There will be an omitted variable bias leading to overestimates of $\alpha$ and $\beta$ as well as an exaggeration of $R^2$. 
Cobb-Douglas Augmented Solow Model: Problems with the MRW

• Coefficient on \( s_j^h \) is difficult to explain
  – SCHOOL: the average percentage of the working-age population in secondary school for the period 1960-1985. It ranges from under 1 to over 12 in the sample of countries

• If saving and growth are strongly related, and technology and growth are also positively related, error term is correlated with saving rate \( \rightarrow \) biased estimates of coefficients
Mankiw, Romer and Weil (1992)

• *Romer* concludes that the data analysis carried out by researchers above does not require abandoning the neoclassical framework, only extending it.

• Also, looking at growth models only to explain convergence distracts attention from other important elements of growth.

• A different perspective on models of growth as well as different type and quality of data are required.
Why do some countries produce so much more output per worker than others?
Hall and Jones (1999)

• International differences in output per worker across 127 countries in 1988 are fundamentally determined by variations in a country's "social infrastructure".
Hall and Jones (1999)

• Social infrastructure ~ the institutions and government policies creating the climate for enhanced output levels

• They provide an environment that supports productive activities and encourages capital accumulation, skill acquisition, invention and technology transfer.
Hall and Jones (1999)

“Countries with corrupt government officials, severe impediments to trade, poor contract enforcement, and government interference in production will be unable to achieve levels of output per worker anywhere near the norms of western Europe, northern America, and eastern Asia. Our contribution is to show, quantitatively, how important these effects are.” (p.86, QJE)
Production function-productivity analysis
Hall and Jones (1999)

• $Y = A K^\alpha (AH)^{1-\alpha}$

  $H = e^{\phi(E)} L$
  $h \equiv H / L = e^{\phi(E)}$

• $Y/L = A \times h \times (K/Y)^{\alpha/(1-\alpha)}$
Growth Accounting
Hall and Jones (1999)

- \( Y/L = A \times h \times (K/Y)^{\alpha/(1-\alpha)} \)

This equation decomposes differences in output per worker into differences in capital intensity, human capital per worker, and productivity,

- To measure productivity, they use data on output, labor input, average educational attainment, and physical capital for the year 1988.

\[
\ln(A) = \ln(Y/L) - \phi(E) - [\alpha/(1-\alpha)] \ln(K/Y)
\]
Reflections
Hall and Jones (1999)

• What are the major differences between Hall and Jones and Mankiw, Romer, and Weil [1992]?
• “Accounting for the differences in productivity across countries is a promising area of future research.”
• “The central hypothesis of this paper is that the primary, fundamental determinant of a country’s long-run economic performance is its social infrastructure.”
Econometric method
Hall and Jones (1999)

\[ \ln(Y / L) = \alpha + \beta S + \varepsilon \]

1. endogeneity: \( S = \gamma + \delta \ln(Y / L) + X'\theta + \eta \)

2. measurement error: \( S = \tilde{S} - \nu \)

\[ \Rightarrow \ln(Y / L) = \alpha + \beta \tilde{S} + \tilde{\varepsilon} \]

\[ \tilde{\varepsilon} = \varepsilon - \beta \nu \]

\[ E(X'\tilde{\varepsilon}) \neq 0 \Rightarrow IV \]

The coefficient \( \beta \) will be identified by the orthogonality conditions \( E(X'\tilde{\varepsilon}) = 0 \).
Main findings

• “Paralleling the growth accounting literature, levels accounting finds a large residual that varies considerably across countries.”

• “Differences in social infrastructure across countries cause large differences in capital accumulation, educational attainment, and productivity, and therefore large differences in income across countries.”
Main findings

• Why different countries have adopted different social infrastructures?

• They have been influenced by Western Europe. Using distance from the equator and language data, they conclude that differences in social infrastructure cause large differences in income is robust to measurement error and endogeneity concerns.
2. Theoretical standpoint

• NGT fails to explain the determinants of technological advancement, which is the most important factor to understand the long-run performance of modern economies.

• No simple extensions: it is necessary to abandon the environment in which traditional theory was developed, i.e. perfect competition.
Endogenous growth theory

Two strands of this literature:
(I) Growth can continue indefinitely through capital accumulation
(II) Technological progress can be explained by economic forces and is endogenous

The endogenous growth literature has been exciting, particularly for policy makers. If economic growth is not exogenous then the government may be able by appropriate policy to boost the growth of the economy.
The AK model (Rebelo, 1991)

- One way of getting continued growth is to rule out decreasing marginal product of capital; that is rule out the idea of a steady state
- AK production function
  \[ Y = A \times K \rightarrow \text{constant MPK} \]
- Change in Capital Stock:
  \[ \frac{\dot{K}}{K} = sA - \delta \]
  which is constant and, under certain assumptions, always positive – endogenous growth
Is constant MPK plausible?

Obviously an empirical proposition but two motivations

i) **Broad Conception of Capital**
   - Capital is not just machines and buildings but also human capital
   - Human capital and physical capital may interact to create constant returns

ii) **Externalities**
   - When one firm discovers something, other firms will take advantage of it as well
Productivity of capital increases with higher human capital.

Encourages education/training.

Higher capital stock increases return to human capital.

Encourages capital investment.

New machines & new knowledge → grow indefinitely through capital accumulation.

Productivity of capital increases with higher human capital.
An Alternative to Perfect Competition

• The Neoclassical model of growth ignores the fact that firms own these innovations and charge monopoly rents for them.

• The question then was how to augment or change the existing growth literature to allow for monopoly rents to be exploited.
An Alternative to Perfect Competition

• Romer’s contribution was the combination of monopolistic competition and increasing returns to technological advances.

• His concept of positive spillovers to R&D led to the creation of models where growth could be sustained in a framework of endogenously determined variables crucial to the growth process.