Overview of Growth Research in the Past Two Decades

by Pete Klenow

Stanford University and NBER

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FIGURE 1.1 Per Capita GDP in Seven Countries, 1870–2000
1950s  Solow (1956)

1960s  Nelson and Phelps (1966)

1970s  Dark Ages

1990s Explosion

Theory

- Romer (1990)
- Grossman and Helpman (1991)
- Stokey (1991)
- Aghion and Howitt (1992)
- Parente and Prescott (1994)
- Jones (1995)

Empirics

- Barro (1991)
- Mankiw, Romer and Weil (1992)
- Young (1994)
- Klenow and Rodriguez-Clare (1997)
- Hall and Jones (1999)
<table>
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<td>Barriers to Riches</td>
<td>Parente and Prescott (2000)</td>
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<td>Institutions</td>
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<td>Directed Technical Change</td>
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<td>Quantitative Theory</td>
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"Growth" actually divides into theories of ...

**Long Run Growth**
- Lucas (1988) human capital
- Romer (1990) technology

**Level Differences and Transition Dynamics**
- Barro and Sala-i-Martin (1992) physical capital
- Mankiw, Romer and Weil (1992) physical and human capital
- Parente and Prescott (1994) and Howitt (2000) technology
- Restuccia and Rogerson (2008) misallocation
What $\dot{X} = g X$ equation is the "engine" of growth?

$$Y(t) = K(t)^\alpha \left[ A(t) h(t) (1 - u) L(t) \right]^{1-\alpha}$$

- **Solow:** $\alpha < 1$, $u = 0$, exogenous $\dot{A} = gA$
- **Rebelo:** $\alpha = 1$, $u = 0$, $\dot{K} = sAK - \delta K$, endogenous $s = I/Y$
- **Lucas:** $\dot{h} = uh$, endogenous $0 < u < 1$
- **Romer:** $\dot{A} = uhL A$, endogenous $0 < u < 1$
Major role for physical and human capital

- Mankiw, Romer and Weil (1992)
- Manuelli and Seshadri (2007)
- Erosa, Koreshkova and Restuccia (2010)

Major role for residual TFP

- Klenow and Rodriguez-Clare (1997)
- Hall and Jones (1999)
- Hendricks (2002)
- Caselli (2005)
Rough ratios of 90th to 10th percentiles of countries in recent years:

\[
\frac{Y(i)}{\text{pop}(i)} = \frac{L(i)}{\text{pop}(i)} \left( \frac{K(i)}{Y(i)} \right)^{1-\alpha} \underbrace{h(i)}_{3} \underbrace{A(i)}_{4}
\]

Human capital, physical capital, and residual TFP are all important.
The K/Y ratio is about 3/4 at the 10th percentile.

It is about 3 at the 90th percentile (4 times as big).

The share of physical capital $\alpha \approx 1/3$.

$$\left( \frac{K(i)}{Y(i)} \right)^{\frac{\alpha}{1-\alpha}} \approx 4^{1/2} = 2$$
PPP Capital-Output Ratio in 1996

PPP GDP per worker relative to the U.S. in 1996
Schooling attainment is about 13 years at the 90th percentile.

It is about 3 years at the 10th percentile.

Across workers within the typical country, each year of schooling is associated with about 10% higher wages (see Mincer regressions).

Suppose each year of schooling is also associated with 10% higher human capital across countries. Then the ratio of human capital is:

\[ h(i) \approx \exp(0.1 \cdot 10) \approx 2.7 \]

This number is close to the answer from some more sophisticated quantitative theory (Erosa, Koreshkova and Restuccia, 2010).
**Human Capital**
- Acquired before, during, and after school age
- Includes any learning-by-doing
- Rival (if no externalities)

**Technology/Ideas**
- May be embodied in variety/quality of K/intermediates
- Or workers, managers, researchers (human capital)
- But the disembodied *idea* is non-rival
- Can be fully or only partially excludable
Why do we care what drives growth, level differences?

**Human capital**
- Quality, subsidies, financing of education
- Progressivity of tax rates on individual earnings
- Perhaps no scale effects

**Technology/Ideas**
- Intellectual Property Rights
- R&D tax credits, government funding of basic research
- Barriers to technology adoption
- Scale effects and openness to goods, FDI, ideas

**Misallocation**
- Barriers to equalization of marginal products in x-section
World Technology Frontier

- Technological change drives growth
- Most of it is embodied in physical capital
- Usually skill-biased
- Endogenous to R&D done mostly in the OECD
- Scale effects at the world level

See Jones and Romer (2010)

Distance from the World Technology Frontier

- Most countries share a long run growth rate
- For these countries, policy differences have level effects
Investing in ideas
R&D spending by region, 2006, %

- North America: 43.7%
- Europe: 28.9%
- Japan: 21.5%
- Rest of Asia: 4.8%
- China & India: 0.6%
- Other: 0.5%

Total: $478bn

Source: Booz Allen Hamilton database
FIGURE 3.1 Economic Growth over the Very Long Run in Six Countries
Industrial Revolution?

How do countries transition from the Malthusian Trap to growth?

**Demographic Transition**
- Fundamental in Lucas (2002)
- Incidental in Hansen and Prescott (2002)

**Structural Transformation**
Proximate vs. Fundamental Causes

Geography, Luck

\[ \Downarrow \]

Institutions, Policies

\[ \Downarrow \]

\[ L/popl, K/Y, h, A \]

\[ \Downarrow \]

\[ Y/popl \]
Geographical Determinism = Montesquieu, Sachs

Case against:

- East vs. West Germany
- North vs. South Korea
- Hong Kong vs. China
- Singapore vs. Malaysia
- Nogales vs. Nogales (Arizona/Mexico)
- El Paso vs. Juarez (Texas/Mexico)
- Botswana and South Africa vs. rest of southern Africa
Steady State in the Neoclassical Growth Model

\[ Y(t) = K(t)^\alpha [A(t)L(t)]^{1-\alpha} \]

\[ \dot{A}(t)/A(t) = g_A, \quad \dot{L}(t)/L(t) = g_L \]

\[ K(t) = I(t) - \delta K(t) \]

If the investment rate settles down to a steady state level \((I/Y)^{ss}\):

\[ (K/Y)^{ss} = \frac{(I/Y)^{ss}}{g_A + g_L + \delta} \]

\[ (Y/L)^{ss} = A(t) [(K/Y)^{ss}]^{\frac{\alpha}{1-\alpha}} \]
Per capita production:

\[ y(i, t) = k(i, t)^\alpha \left[ Z(t) A(i) \ell(i) \right]^{1-\alpha} \]

If \( Z(t) \) grows at a constant rate \( g_Z \), then:

\[ g_y(i, t) \approx g_Z - \beta \left[ \ln y(i, t) - \ln y(i, t)^{ss} \right] \]

\[ y(i, t)^{ss} = Z(t) A(i) \ell(i) \left[ (K(i)/Y(i))^{ss} \right]^{\frac{\alpha}{1-\alpha}} \]
σ Convergence

• When the S.D. of $ln y(i, t)$ across $i$ is falling over $t$
• Not true of "East" vs. "West" 1820-1950
• Not true for all countries 1960-2000, unless weight by population

Unconditional $\beta$ Convergence

• When richer countries exhibit slower growth
• See OECD since World War II, U.S. states 1880-1980
• In principle, can have $\beta$ convergence without $\sigma$ convergence

Conditional $\beta$ Convergence

• When richer countries exhibit slower growth conditional on $y^{ss}$
• Seen over all countries 1960-2000, if condition on schooling
FIGURE 5.8 Growth Rates in the OECD, 1960–2000
FIGURE 5.9 Growth Rates around the World, 1960–2000
Evolution of Per Capita Income, 1750-1990

Per Capita Income, 1985 US Dollars

- Africa
- US
- Mexico
- Japan
- China
- East Asia

Divergence ... Big Time!

Growth miracles

Source: Lucas (2002)
Typical estimate is $\beta \approx 0.02$, or 2% per year.

See Barro and Sala-i-Martin (1992) and the literature it spawned.

2% is consistent with $\alpha \approx 2/3$ ($\alpha = 1/3$ would imply around 10%).

But there are many challenges to estimating $\beta$ consistently:

- Where is the residual? If shocks, are they persistent?
- How does one adequately control for ss income differences?
- Hazardous to control for $l/Y$, $h$ or $A$ if transition dynamics.
Plethora of Cross-Country Growth Regressions (mostly in the 1990s).

A smaller literature regresses income levels on stuff.

**The list of plausible instruments is short:**

- Distance (instrument for trade? Frankel and Romer, 1999)
- Climate (for agriculture? Hall and Jones, 1999)
- Settler mortality (for institutions? AJR, 2002)
- Accidental leader deaths (for policy? Jones and Olken, 2005)
- Climate change (Dell, Jones and Olken, 2008)

**Some clever "interaction" instruments:**

- External financial dependence (Rajan and Zingales, 1998)
- Epidemiological transition (Acemoglu and Johnson, 2007)
- Declining cost of air travel (Feyrer, 2009)
Focus of Current Research

Quantitative Theory
- DGE growth/development model
- Key parameters calibrated to select micro, macro facts
- Positive analysis (how much does it explain?)
- Welfare analysis (what is the optimal policy?)

Disaggregate Data
- Regions, cities
- Industries
- Demographic groups
- Firms, plants, households, individuals
Sampling of Open Research Questions

Why is there an upward trend in $s_K$, $s_h$, $s_{R&D}$ in many countries?

Why have China and India taken off?

Why hasn’t Africa taken off yet? Or has it?

Measurement, modeling of technology transfer.

21st century Clark (x-country levels accounting within an industry).

Why did the world growth rate drop starting around 1975?