Growth Accounting

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A. Basic Organizing Tool – Neoclassical Production Theory:

- **Consider a neoclassical production function in constant-returns-to-scale Cobb-Douglas form with Harrod-neutral technical progress:**
  $$Y = F(K,L) = K^{\alpha} (AL)^{1-\alpha}$$
- **It can be rewritten in per worker form as:**
  $$y = Y/L = B\, k^{\alpha}$$
  where *total factor productivity* (TFP) $B = A^{1-\alpha}$ and $k = K/L$
- **By log differentiation, the economic growth rate can be expressed as:**
  $$\theta = \frac{\dot{y}}{y} = \frac{\dot{B}}{B} + \alpha \frac{\dot{k}}{k}$$

B. Growth Accounting

- **Thus, economic growth is decomposed into capital deepening (measured by growth in capital per worker) and TFP growth**
- **Denison, Jorgenson and Solow estimate TFP as Solow residual – the residual of output per worker not be explained by capital deepening: Solow residual = $\ln(y) - \hat{\alpha} \ln(k)$, with $\hat{\alpha}$ = 1/3 (capital income share)**

- **Growth accounting estimates in OECD countries**

% of Growth Driven by TFP Growth	Countries
50-59	Iceland, Italy, Spain, US
60-69	Austria, Belgium, Canada, France, Germany, Portugal, UK
70-79	Australia, Denmark, Finland, Ireland, Netherlands, New Zealand, Norway, Sweden, Switzerland
80-90	Greece, Japan

Thus, TFP growth accounted for at least half of the economic growth of OECD countries, from 55% (Spain) to 86% (Greece), averaging about 68% (which is 1.61% of the average growth rate of 2.41%)

- **Some earlier work uses raw labor, but the later ones include human capital as part of the capital deepening component**

- **Using data from East Asian Tigers, Young (1995) shows very different TFP growth estimates from the above figures:**

Country	Economic Growth (%)	TFP Growth (%)	% of Growth Driven by TFP Growth
Hong Kong	5.7	2.3	40
Korea	6.8	1.7	25
Singapore	6.8	0.2	3
Taiwan	6.7	2.1	31

- **Using data from Taiwan, Tallman and Wang (1994) develops a framework to identify the contribution by human capital separately from physical capital.**
  - **generalized production function with both disembodied technology and human capital:**

    $$Y = F(K,L) = AK^{\alpha} (HL)^{1-\alpha}$$

  - **output per worker,**

    $$y = Y/N = A\, k^{\alpha} H^{1-\alpha}$$

    where k = K/L

- **conventional studies use crude measures of human capital, such as:**
  - **literacy rate**
  - **primary (P)/secondary (S)/higher (H) education enrollment**
  - **P/S/H education attainment**
  - **years of schooling**
- **it is more appropriate to use refined measures:**
  - **Bils and Klenow (2000) use weighted enrollment rate: $E=6\times P+6\times S+5H$**
  - **Tallman and Wang (1994) use weighted attainment rates: $E=1\times P+1.4\times S+2\times H$, or, $1\times P+2\times S+4\times H$**
- **setting $H = E^{\nu}$ and log-differentiating,**

$$\frac{\dot{y}}{y}=\frac{\dot{A}}{A}+\alpha\left(\frac{\dot{K}}{K}-n\right)+(1-\alpha)\nu\frac{\dot{E}}{E}$$

- **estimation shows that human capital accounted for 45% of output growth in Taiwan**
- **using similar approach, Lee, Liu and Wang (1994) and Thanapura and Wang (2002) find the comparable figures in Korean and Thailand are 20% and 28%, respectively**

C. Problems with Growth Accounting

- **Difficult to separate productivity growth from capital deepening:**
  - **technology is likely embodied in new capital goods:**
    - **Gordon (1990) and Cummins and Violante (2002) find the relative price of capital goods falling dramatically over several decades**
    - **this cannot be explained without technological improvements**
  - **inventive knowledge or new productive idea is likely embodied in human capital**
    - **the real cost of education has risen sharply, but people over-educate to gain wage premium**
    - **such a wage premium is paid only because human capital generates productive returns**
- **National accounts systematically overestimate the accumulation of capital:**
  - **government corruption (Prichett 2000)**
  - **firm misallocation due to capital and institutional barriers (Hsieh and Klenow 2007)**

- **Estimation of TFP based on the production function is biased:**
  - **should Young (1995) be right, Singapore must have fallen rate of returns to capital: Hsieh (2002) finds a roughly constant rate of return – so it must be productivity growth to prevent capital from facing diminishing marginal products**
  - **Hsieh (2002) thus proposes to use the *dual* method by estimating TFP based on the unit cost function that should be equal to the unit price p:**

$$\text{unit cost} = \frac{1}{B}\left(\frac{r}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha} = p$$

since factor prices (r, w) and goods price (p) are observable, TFP (B) can be estimated, which turns out to be 2.2% for the case of Singapore (2 percentage points higher than Young's estimate)

D. Could Theory Help?

The answer is definitely yes. For illustrative purposes, let us focus on:

- **the interactions between technical progress and capital depending**
- **the interactions between technical progress and skill improvements**

As a country develops,

- **production sophistication increases (Romer 1990), which requires not only more capital and skilled labor, but better organizational capital that is not accounted for under the above growth accounting exercise**
- **service complexity rises (also an application of Romer 1990), which requires special and professional skills that cannot be measured by years of schooling**
- **knowledge and human capital spillovers (Romer 1986 and Lucas 1988) become stronger and more valuable for production, but these are not accounted**