Development Accounting

David N. Weil

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- We see these huge income differences among countries
- We see a good degree of historical persistence
- We have all sorts of theories
- Maybe we can learn more by looking directly at income differences
- Key tool will be “Development Accounting” (cross-sectional analogue of Solow-style growth accounting)
Productivity and Factor Accumulation

(a) Differences in output due to factor accumulation

Output per worker

Country 2  Country 1
Factors of production per worker

Production function in both countries

y1

y2

(b) Differences in output due to productivity

Output per worker

Country 2  Country 1
Factors of production per worker

Production function in Country 1

Both countries

Production function in Country 2

(c) Differences in output due to both productivity and factor accumulation

Output per worker

Country 2  Country 1
Factors of production per worker

Production function in Country 1

Production function in Country 2
Implementing Development Accounting

We need

- a production function (functional form and parameters)
- measurements of the relevant factors of production (physical and human capital)
Measuring Physical Capital

Perpetual Inventory Method

\[ K_{i,t+1} = (1 - \delta)K_{i,t} + I_{i,t} \]

\( K_{i,1970} \) will be some sort of informed guess, like \( 2 \times Y_{i,1970} \)

\( \delta \) most frequently taken to be 6%

potential problems:

- mis-measurement of investment (see below)
- cross-country differences in depreciation rates (i.e. old cars in developing countries)
Measuring Human Capital

- Data on educational attainment of working age population widely available (Barro and Lee, 2013)
- Mincerian approach allows for conversion into years of schooling
The Mincerian Approach

Aggregate Production: \( Y_i = A_i K_i^\alpha H_i^{1-\alpha} \)

Human Capital Aggregate: \( H_i = \sum_{j=1}^{L} h_{ij} \)

where \( i \) indexes countries and \( j \) indexes individuals

Return to one unit of human capital: \( w_i = \frac{dY_i}{dH_i} = (1 - \alpha) A_i \left( \frac{K_i}{H_i} \right)^\alpha \)

Wages for individual: \( \ln(w_{i,j}) = \ln(w_i) + \ln(h_{i,j}) + \eta_{i,j} \)

Human capital and schooling: \( \ln(h_{i,j}) = \phi(s_{i,j}) = \beta s_{i,j} \)

- We can recover \( \beta \) by regressing individual log wages on years of schooling (\( s_i \)) within a country
- Once we know \( \beta \), we can construct \( H_i \) based on aggregate data on schooling
## Two Approaches to Human Capital in the Production Function

<table>
<thead>
<tr>
<th>Approach</th>
<th>Mincer</th>
<th>Mankiw, Romer, Weil (1992)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production function in general form</strong></td>
<td>$Y = F(K, hL)$</td>
<td>$Y = F(K, H, L)$</td>
</tr>
<tr>
<td><strong>Production function in CD, CRS form</strong></td>
<td>$Y = AK^\alpha (hL)^{1-\alpha}$</td>
<td>$Y = AK^\alpha H^\beta L^{1-\alpha-\beta}$</td>
</tr>
<tr>
<td><strong>Salient Characteristic</strong></td>
<td>human capital and raw labor are really the same thing</td>
<td>human capital and raw labor are different things</td>
</tr>
<tr>
<td><strong>return to human capital</strong></td>
<td>return to human capital is invariant to quantity</td>
<td>As $H$ increases, return to human capital declines</td>
</tr>
<tr>
<td><strong>big advantage</strong></td>
<td>can learn mapping from education to $h$ from micro data</td>
<td>dynamics are much easier to analyze if we treat $H$ like $K$</td>
</tr>
<tr>
<td><strong>nagging worry</strong></td>
<td>try to move a piano with one Ph.D. vs four uneducated guys</td>
<td>Hard to believe that raw labor's share of income is constant</td>
</tr>
</tbody>
</table>
Well known property of Cobb-Douglas production function that if factors are paid their marginal products, the capital share of national income is invariant to the $K/L$ ratio.

Holds for US time series.


We take this as "permission" to use Cobb-Douglas.
Capital's share of national income

GDP per capita in 2000

- Ecuador
- Botswana
- South Korea
- Greece
- Spain
- Canada
- United States

Average = 0.35
## Development Accounting Results

<table>
<thead>
<tr>
<th>Country</th>
<th>Output per Worker, $y$</th>
<th>Physical Capital per Worker, $k$</th>
<th>Human Capital per Worker, $h$</th>
<th>Factors of Production, $Y^{1/3}H^{2/3}$</th>
<th>Productivity, $A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Norway</td>
<td>1.12</td>
<td>1.32</td>
<td>0.98</td>
<td>1.08</td>
<td>1.04</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.82</td>
<td>0.68</td>
<td>0.87</td>
<td>0.80</td>
<td>1.03</td>
</tr>
<tr>
<td>Canada</td>
<td>0.80</td>
<td>0.81</td>
<td>0.96</td>
<td>0.91</td>
<td>0.88</td>
</tr>
<tr>
<td>Japan</td>
<td>0.73</td>
<td>1.16</td>
<td>0.98</td>
<td>1.04</td>
<td>0.70</td>
</tr>
<tr>
<td>South Korea</td>
<td>0.62</td>
<td>0.92</td>
<td>0.98</td>
<td>0.96</td>
<td>0.64</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.37</td>
<td>0.28</td>
<td>0.78</td>
<td>0.55</td>
<td>0.68</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.35</td>
<td>0.33</td>
<td>0.84</td>
<td>0.61</td>
<td>0.56</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.20</td>
<td>0.19</td>
<td>0.78</td>
<td>0.48</td>
<td>0.42</td>
</tr>
<tr>
<td>India</td>
<td>0.10</td>
<td>0.089</td>
<td>0.66</td>
<td>0.34</td>
<td>0.31</td>
</tr>
<tr>
<td>Kenya</td>
<td>0.032</td>
<td>0.022</td>
<td>0.73</td>
<td>0.23</td>
<td>0.14</td>
</tr>
<tr>
<td>Malawi</td>
<td>0.018</td>
<td>0.029</td>
<td>0.57</td>
<td>0.21</td>
<td>0.087</td>
</tr>
</tbody>
</table>

*Sources*: Output per worker: Heston, Summers, and Aten (2011); physical capital: author’s calculations; human capital: Barro and Lee (2010). The data set used here and in Section 7.3 is composed of data for 90 countries for which consistent data are available for 1975 and 2009.

Productivity differences are really large!
I will follow Caselli (2005). Other related treatments are Klenow and Rodriguez-Clare (1997) and Hall and Jones (1999).

production function in per-worker terms:

\[ y = Ak^\alpha h^{1-\alpha} \]

define

\[ y_{KH} = k^\alpha h^{1-\alpha} \]

This is the part of output due to factor accumulation. So....

\[ y = A \times y_{KH} \]
Measures of Success of the Factor-Only Model

Variance decomposition:

\[
\text{var}(ln(y)) = \text{var}(ln(A)) + \text{var}(ln(y_{KH})) + 2\text{cov}(ln(A), ln(y_{KH}))
\]

\[
\text{Success}_1 = \frac{\text{var}(ln(y_{KH}))}{\text{var}(ln(y))}
\]

\[
\text{Success}_2 = \frac{\frac{y_{KH}^{90}}{y_{KH}^{10}}}{\frac{y^{90}}{y^{10}}}
\]

<table>
<thead>
<tr>
<th>\text{var}(ln(y))</th>
<th>1.297</th>
<th>\frac{y_{KH}^{90}}{y_{KH}^{10}}</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{var}(ln(y_{KH}))</td>
<td>0.500</td>
<td>\frac{y_{KH}^{90}}{y_{KH}^{10}}</td>
<td>7</td>
</tr>
<tr>
<td>success_1</td>
<td>0.39</td>
<td>success_2</td>
<td>0.34</td>
</tr>
</tbody>
</table>
Aside: Other Stuff in the Caselli Paper
Caselli says that all the covariance terms are not part of success, because he is trying to assess the factor-only model. But no one believes the factor only model.

- we are more interested in what fraction of variation is due to factors and what fraction to productivity
- so maybe we should split the covariance term

\[
\text{var}(\ln(y)) = \text{var}(\ln(A)) + \text{var}(\ln(y_{KH})) + 2\text{cov}(\ln(A), \ln(y_{KH}))
\]

\[
\text{Success}_1 = \frac{\text{var}(\ln(y_{KH}))}{\text{var}(\ln(y))}
\]

\[
\text{AlternativeSuccess}_1 = \frac{\text{var}(\ln(y_{KH})) + \text{cov}(\ln(A), \ln(y_{KH}))}{\text{var}(\ln(y))}
\]

This would be bigger (it is the measure used by Klenow and Rodriguez-Clare)
to some extent Caselli’s approach *overstates* the role of factor accumulation because of “induced factor accumulation”

to see this: imagine that all countries had the same saving rate
Issue goes back all the way to Solow-style growth accounting

\[ Y = AK^\alpha L^{1-\alpha} \]

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

share of growth due to technology = \( \hat{A}/\hat{Y} \)

Now consider the steady state of a Solow model with exogenous technological progress and \( \hat{L} = 0 \)

rewrite production as \( Y = K^\alpha (eL)^{1-\alpha} \) where \( e = A^{1/(1-\alpha)} \)

steady state: \( \hat{Y} = \hat{K} = \hat{e} = (1/(1 - \alpha)) \hat{A} \)

share of growth due to technology: \( \frac{\hat{A}}{\hat{Y}} = \frac{\hat{A}}{(1/(1-\alpha)) \hat{A}} = (1 - \alpha) \)

But really, all growth is due to technology!
To Fix Induced Capital Accumulation

\[ Y = AK^\alpha H^{1-\alpha} \]

divide by \( Y^\alpha \)

\[ Y^{1-\alpha} = A \left( \frac{K}{Y} \right)^\alpha H^{1-\alpha} \]

\[ Y = A^{1/(1-\alpha)} \left( \frac{K}{Y} \right) H \]

- Key Point: the \( A \) derived this way will be the same, but now we give it more weight in affecting output!
- This would reduce the importance assigned to factors relative to productivity
- Objection: why stop here? What about technology induced by human capital? etc.
Other Biases in These Calculations

- Pritchett “CUDIE is not Capital” (2000)
  - Investment overstated in poor countries; gaps in physical capital are thus larger than indicated in the data.

- Education quality (Hanushek)
  - Rich countries have higher test scores; gaps in human capital are thus larger than indicated in the data.

- In both cases, productivity gaps are over-stated.

- Neither of these will overturn the basic conclusion of development accounting that productivity differences are very important