Productivity: Introduction

References: Weil, Chapter 7

Taking account for all factors of endowment

- physical capital
- labor
  - health
  - human capital
- ...

not all income/growth differences between countries are explained.

What is left?

- The Residual (Solow)
- Productivity $\rightarrow$ “New” Growth Theory

[Production functions: 3 ways to explain income differences]

Problem: we don't see the production function in real data.

3 Possibilities:

- 2 easy special cases
- The normal, complicated case: is productivity
  - higher
  - lower

  in country 2 ?

[Inferring the production function from output data]

$\rightarrow$ we need more information about the shape of the production function.

Assume the production function is Cobb-Douglas:

$$Y = AK^{\alpha}(hL)^{1-\alpha}$$

- factors of production: K, L, h
- productivity: A

Dividing through by L and indexing with 1 and 2:

$$y_1 = A_1 k_1^{\alpha} h_1^{1-\alpha}$$
$$y_2 = A_2 k_2^{\alpha} h_2^{1-\alpha}$$

for 2 countries 1 and 2.

And in relation:

$$\frac{y_1}{y_2} = \left(\frac{A_1}{A_2}\right)\left(\frac{k_1^{\alpha} h_1^{1-\alpha}}{k_2^{\alpha} h_2^{1-\alpha}}\right) \tag{1}$$

$\rightarrow$ infer the unmeasurable from the measurable:

$$\frac{A_1}{A_2} = \frac{\frac{y_1}{y_2}}{\left(\frac{k_1^{\alpha} h_1^{1-\alpha}}{k_2^{\alpha} h_2^{1-\alpha}}\right)} \tag{2}$$

Example:

- Country 1: $y = 24,\ k = 27,\ h = 8$
- Country 2: $y = 1,\ k = 1,\ h = 1$

Using our standard value of $\alpha = 1/3$

$$\frac{A_1}{A_2} = \frac{\left(\frac{24}{1}\right)}{\left(\frac{27^{1/3} \cdot 8^{2/3}}{1^{1/3} \cdot 1^{2/3}}\right)} = \frac{24}{\frac{3 \cdot 4}{1}} = 2$$

Now, with real data (U.S. normalized to 1):

Table 7.2

Output, Factor Accumulation, and Productivity Relative to the United States, 1998

Country	Output per Worker, y	Physical Capital per Worker, k	Human Capital per Worker, h	Factors of Production, $k^{1/3}h^{2/3}$	Productivity, A
United States	1.00	1.00	1.00	1.00	1.00
Canada	0.76	1.02	0.98	0.99	0.77
Japan	0.74	1.37	0.87	1.00	0.73
Finland	0.71	1.14	0.89	0.96	0.74
United Kingdom	0.70	0.80	0.82	0.81	0.87
South Korea	0.44	0.75	0.92	0.86	0.51
Mexico	0.32	0.36	0.74	0.58	0.55
Peru	0.20	0.24	0.77	0.52	0.39
India	0.086	0.047	0.55	0.24	0.35
Kenya	0.041	0.021	0.53	0.18	0.23
Tanzania	0.015	0.019	0.45	0.16	0.094

Sources: Output per worker: Heston, Summers, and Aten (2002); physical capital: Bernanke and Gürkaynak (2001); education: Barro and Lee (2000). The data set used here and in Section 7.3 is composed of 71 countries for which consistent data are available for 1960 and 1998.

Observe

- huge productivity differentials
  - with equal factor endowment India would produce 35% of U.S. income per capita
  - and Tanzania 9%.
- countries' relative strength and weaknesses $\rightarrow$ where do they come from?
- (i) Measurement problems
  - quality of schooling (h)
  - price of (public) investment goods ($\rightarrow$ corruption)
- (ii) "real" differentials in technology
- (iii) something else

In our 2–country example the 24 fold output differential was explained by

- 12 fold differential of factor endowment
- 2 fold productivity differential

and in the real world?

Divide the countries of the world in 5 income groups.

Differential Relative to U.S. in Percent

Group	Factors	Productivity
richest	95	86
2nd richest	70	70
middle	44	52
2nd poorest	32	37
poorest	16	24

implying, for example, that the countries in the poorest group have $0.16 \cdot 0.24 = 3.8\%$ of U.S. income.

Observe:

- Productivity differential more important for rich countries
- Factor endowment more important for poor countries
- Both decline with decreasing income at roughly same rate

→ Stylized fact: both are equally important.
[About 57 % of the cross-country variance of income is explained by factor accumulation and 43 % by productivity differentials].

That were levels, now look at growth rates. $\rightarrow$ Growth Accounting

How much of the cross-country differential of growth rates is explained by

- speed of factor accumulation
- productivity growth

Take the Cobb-Douglas production function:

$$y = Ak^{\alpha}h^{1-\alpha}$$

Differentiate logarithmically w.r.t. time

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + \alpha\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{h}}{h}$$

Or with a $\hat{}$ on top of a variable indicating a growth rate

$$\hat{A} = \hat{y} - \alpha\hat{k} - (1-\alpha)\hat{h}.$$

Example.

DATA: INCOME AND FACTOR ENDOWMENT

year	output y	capital k	human capital h
1965	1	20	5
2000	4	40	10

Obtain growth rates:

$$y_{2000} = y_{1965} \cdot (1 + \hat{y})^{35} \quad \Rightarrow \quad \hat{y} = \left(\frac{y_{2000}}{y_{1965}}\right)^{1/35} - 1$$

Thus $\hat{y} = 4^{1/35} - 1 = 0.04 = 4\%$ and likewise

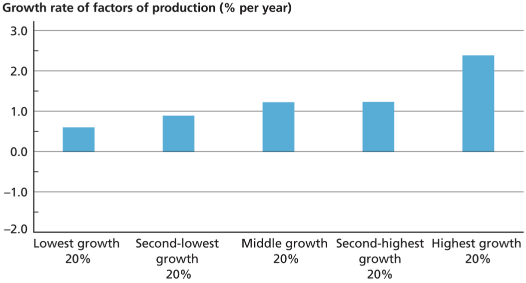
- $\hat{k} = 2\%$
- $\hat{h} = 2\%$

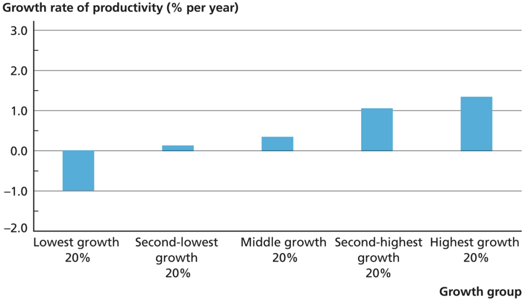
Providing

$$\hat{A} = 0.04 - \frac{1}{3} \cdot 0.02 - \frac{2}{3} \cdot 0.02 = 0.02 = 2\%$$

Conclusion: half of income growth is "explained" by productivity growth.

Turning to the real world. Subdivide the countries into 5 groups according to their speed of growth.





Observe

- the faster a country grows the faster the speed of factor accumulation and the higher productivity growth.
- huge speed of factor accumulation for the fastest growing group
  - this result fits best with our standard (neoclassical) growth theory
  - these countries are catching up
- productivity growth for the lowest growth group is negative !

Stylized fact: about half of the income growth differential between countries is explained by factor accumulation.

[58 % of variation of income growth rates due to productivity, 42 % due to accumulation].