A Course in Economic Growth
Lecture 1: Growth accounting in China

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Growth accounting in China

- In growth accounting, we may simplify a Cobb-Douglas production function by writing real GDP, Y, as

(1.1) $$Y = (BK)^{\alpha}(AL)^{1-\alpha}$$

where:

- B represents the index of effective capital or the productivity of capital,
- A an index of the productivity of labor of effective labor
- K the physical stock of capital
- L employment of labor

- α is the share of capital in income, or Real GDP, while the share of labor is 1- α. $0 < \alpha < 1$ to indicate diminishing marginal productivity of capital.
- For the United States, α is approximately equal to 1/3 while 1- α equals 2/3. This is consistent with constant returns to scale and product exhaustion.

Growth accounting in China

- Simplifying,

(1.2) $$Y = B^{\alpha} A^{1-\alpha} K^{\alpha} L^{1-\alpha}$$

or

(1.3) $$Y = A^{*} K^{\alpha} L^{1-\alpha}$$

Which yields the standard Cobb-Douglas production function

where $A^{*} = B^{\alpha} A^{1-\alpha}$, or total factor productivity.

Growth accounting in China

- In growth accounting, three factors explain growth in real GDP, Y: firstly, improvements in technology known as Total Factor Productivity (TFP) , A^*, secondly, increases in the physical capital stock, K, and thirdly increases in employment, L. As a production function, the Cobb-Douglas production function is written:

(1.4) $$Y = A^* K^{\alpha} L^{1-\alpha}$$

- Where $0 < \alpha < 1$ to indicate diminishing marginal productivity of capital. The share of capital in income, or Real GDP is α, while the share of labor is $1-\alpha$.

Growth accounting in China

- In terms of accounting for economic growth, (1.4) may be re-written:

(1.5) $$\frac{\dot{Y}}{Y} = \frac{\dot{A}^*}{A^*} + \alpha \frac{\dot{K}}{K} + (1-\alpha)\frac{\dot{L}}{L}$$

- Where $\dot{Y} \equiv \frac{dY}{dt}, \dot{K} \equiv \frac{dK}{dt}, \dot{L} \equiv \frac{dL}{dt}$
- Thus growth can be accounted for in three ways:
  - Growth in Total Factor Productivity (Technology) $\frac{\dot{A}^*}{A^*}$
  - The contribution of growth in capital $\alpha \frac{\dot{K}}{K}$
  - The contribution of growth in employment $(1-\alpha)\frac{\dot{L}}{L}$

Growth accounting in China

- A numerical example:

$$\frac{\dot{A}^*}{A^*} = .04 \qquad \alpha\frac{\dot{K}}{K} = .04$$

$$(1-\alpha)\frac{\dot{L}}{L} = .02$$

- Consequently,

$$\frac{\dot{Y}}{Y} = .04 + .04 + .02 = .10 = 10\%$$

Growth accounting in China

- In Robert Solow's model of growth accounting per worker, two factors explain growth in per worker output, *y*: firstly, improvements in technology known as Total Factor Productivity (TFP) , A^*, and secondly, increases in the capital stock per worker, *k*. As a production function, Solow's production function is written:

(1.6) $$y = A^* k^\alpha$$

- Where 0 < α <1 to indicate the diminishing marginal productivity of capital. In the IMF Article IV Consultation with China, the November 17, 2005 report sets α =0.36 to estimate the elasticity of output per worker with respect to an increase in the capital stock per worker.

Growth accounting in China

- The rate of growth in percentage terms is:

(1.7) $$\frac{\dot{y}}{y} = \frac{\dot{A}^*}{A^*} + \alpha \frac{\dot{k}}{k}$$

- Consequently growth in per worker income is the sum of the percentage growth in total factor productivity,

$$\frac{\dot{A}^*}{A^*}$$

and the percentage increase in per worker output attributable to growth in the capital stock per worker,

$$\alpha \frac{\dot{k}}{k}.$$

Growth accounting in China

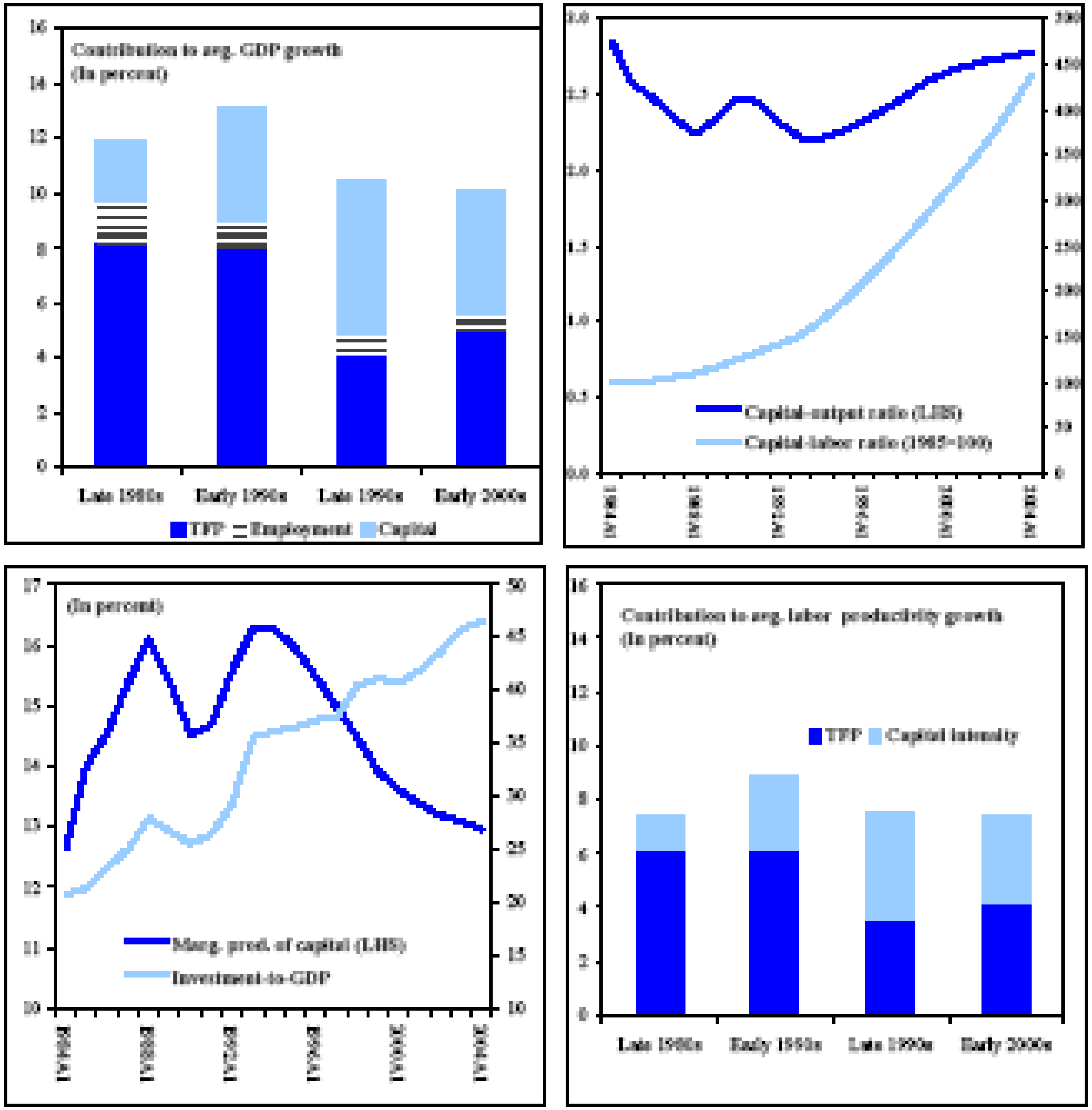
- In fact, growth in TFP is measured as a residual, known as the Solow residual, since we only can observe growth in income per worker and growth in the capital stock per worker. In other words:

(1.8) $$\frac{\dot{A}^*}{A^*} \equiv \frac{\dot{y}}{y} - \alpha \frac{\dot{k}}{k}$$

Growth accounting in China

- Since this is an identity, the framework is known as growth accounting. Unexplained growth is due to changes in total factor productivity, the residual. In the past ten years, growth in per worker income has averaged approximately 7.5% (IMF Article IV Consultation, Nov. 17, 2005, p. 12).
- Furthermore, growth in income due to increased capital per worker is approximately 3.5%. Consequently, growth in TFP has been a high 4% per year.

Accounting for growth in China



Recent economic growth in labor productivity in China has been explained by mostly increasing capital intensity (3.5% per annum) and increasing total factor productivity (4% per annum).

Source: IMF Article IV Report on China, Nov. 2005.

This makes China an emerging world dragon

David Klein for the *WSJ*

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- China versus the United States: an arithmetic calculation
  - If income per capita in the US grows at the rate g_{us}

$$y^{us} = y_0^{us} e^{g_{us} t}$$

  - And income per capita in China grows at the rate g_c

$$y^{c} = y_0^{c} e^{g_c t}$$

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- China's income per capital overtakes that of the US when:

$$y_0^c e^{g_c t} = y_0^{us} e^{g_{us} t}$$

Or

$$\frac{y_0^{us}}{y_0^c} = e^{(g_c - g_{us})t}$$

That is:

$$\ln\left[\frac{y_0^{us}}{y_0^c}\right] = (g_c - g_{us})t$$

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- That is, China's income per capita overtakes that of the US when:

$$\hat{t} = \frac{\ln\left[\dfrac{y_0^{us}}{y_0^{c}}\right]}{\left(g_c - g_{us}\right)}$$

Or:

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- China's income per capita overtakes that of the US when:

$$\hat{t} = \frac{\ln\left[\frac{47,400}{7,400}\right]}{.07} = \frac{\ln[6.4]}{.07} = \frac{1.86}{.07} = 26.5$$

That is: in 26.5 years. In terms of absolute levels of income,

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- China's income absolute level of income overtakes that of the US when:

$$\hat{t} = \frac{\ln\left[\frac{14,720}{9,872}\right]}{.07} = \frac{\ln[1.491]}{.07} = \frac{0.3995}{.07} = 5.7$$

That is: in 5.7 years.

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- Economies of scale and growth accounting (1.9)

$$Y = A^* K^\alpha L^\beta$$

$\alpha + \beta > 1$ implies increasing returns to scale since:

$$A^* (\lambda K)^\alpha (\lambda L)^\beta = \lambda^{\alpha+\beta} A^* K^\alpha L^\beta = \lambda^{\alpha+\beta} Y$$

For example, if $\lambda = 2$, output more than doubles when inputs double since $\alpha + \beta > 1$

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- Economies of scale and growth accounting

$$Y = A^{*}K^{\alpha}L^{\beta}$$

- Divide by $L = L^{1-\alpha-\beta}L^{\beta}L^{\alpha}$ yielding

$$y = \frac{Y}{L} = \frac{A^{*}K^{\alpha}L^{\beta}}{L^{1-\alpha-\beta}L^{\alpha}L^{\beta}} = \frac{Ak^{\alpha}}{L^{1-\alpha-\beta}} = Ak^{\alpha}L^{\alpha+\beta-1}$$

- Consequently, growth in GDP per worker is increased by scale economies:
- (1.10) $\dfrac{\dot{y}}{y} = \dfrac{\dot{A}^{*}}{A^{*}} + \alpha\dfrac{\dot{k}}{k} + (\alpha+\beta-1)\dfrac{\dot{L}}{L}$

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	$\frac{\dot{Y}}{Y}$	$\alpha\frac{\dot{K}}{K}$	$(1-\alpha)\frac{\dot{L}}{L}$	$\frac{\dot{A}}{A}$
China 1985-2005	**11.35**	**3.85**	**1.2**	**6.3**
USA 1950-2005	**3.27**	**1.14**	**0.98**	**1.15**
% difference	**8.08**	**2.71**	**0.22**	**5.15**