MACROECONOMICS FOR DEVELOPING ECONOMIES

The Residual: Growth and Development Accounting

Class 4 · Week 2

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Recap + Agenda

SO FAR

What are the trends in developing countries and developed countries?

- Class 1 – we can categorize the reasons for underdevelopment into four buckets: technology & human capital, trade, firms & coordination, institutions.
- Class 2 – big differences between developing and developed countries: 30-50× gaps in output per worker, longer life, higher standard of living, no unconditional convergence.
- Class 3, Data lab 1 – getting familiar with the data (the rest will be homework)

TODAY

How much of the gap is factors, and how much is "something else"?

Three questions:

(a) What is the "something else", and how do we measure it?

(b) Based on 60 years of research, what have we found – in East Asia, Latin America, Mexico?

(c) What do those numbers mean?

Main takeaway

Jones & Romer (2010), "The New Kaldor Facts", Fact #4

FACT 4 — LARGE INCOME AND TFP DIFFERENCES

"Differences in measured inputs explain less than half of the enormous cross-country differences in per capita GDP."

- **"Measured inputs"** = physical capital and human capital. Everything else is the residual — total factor productivity, TFP, or just ***A***.
- **"Less than half"** is derived from a decomposition. Today' agenda: details of that decomposition, assumptions, findings.

? **If inputs explain less than half, what is in the other half?**

PART 1

Using production functions to perform decompositions

What a production function is, and why competitive factor markets are important.

Two important questions

Acemoglu §3.1 and §3.5; Hsieh & Klenow (2010) eq. (1)

$$Y = A \cdot K^{a} (h\,L)^{1-a}$$

Y output · K physical capital · L workers (or hours) · h human capital per worker · A total factor productivity (“the residual”) · α the elasticity of output with respect to capital.

GROWTH ACCOUNTING

One country, over time

How much of the growth of Y/L between 1960 and 2019 is growth in K and h, and how much is growth in A?

Solow (1957); Young (1995); Kehoe & Ruhl (2010); Levy (2018).

DEVELOPMENT (LEVELS) ACCOUNTING

Many countries, one date

How much of the gap in Y/L between Mexico and the US in 2019 is a gap in K and h, and how much is a gap in A?

Klenow & Rodríguez-Clare (1997); Hall & Jones (1999); Caselli (2005).

Same identity in both cases: the second is the first with “country j vs. country j+1” in place of “year t vs. year t+1” (Acemoglu eq. 3.30).

Growth accounting: the identity

Solow (1957); Acemoglu §3.1, eqs. (3.4)–(3.5)

$$\hat{g}_A = g_Y - \alpha_K \cdot g_K - \alpha_L \cdot g_L$$

growth of the residual = growth of output − (capital share × growth of capital) − (labor share × growth of labor)

Where does it come from?

- Differentiate *Y = A·F(K, L)* with respect to time: the growth of Y is the growth of A plus the **output elasticities** times the growth of each input.
- With competitive factor markets each input is paid its marginal product, so the elasticity of output with respect to K equals the **capital share** of income, α_K = rK/Y — and α_L = wL/Y.
- Main requirements: elasticities are observable, growth rates of labor, capital and output are observable.

IN DISCRETE TIME (eq. 3.5)

$$\hat{x}_{t+1,t} = g_{t+1,t} - \bar{\alpha}_K g_K - \bar{\alpha}_L g_L$$

with ᾱ the average of the shares at t and t+1 (the "Törnqvist" form). A good approximation when the interval is short and K/L does not move much — remember this caveat for levels accounting, where the "interval" is Niger to the US.

? **Which assumption — an aggregate production function, constant returns, competitive factor markets, private returns = social returns — would you least want to defend for Mexico?**

Growth accounting: where the identity comes from

Five lines from the production function to the residual — and what each assumption buys

1 **Start from an aggregate production function**

F has constant returns to scale; A is Hicks-neutral technology.

$$Y = A \cdot F(K, L)$$

2 **Differentiate with respect to time**

The chain rule: output moves because A, K or L moves.

$$\dot{Y} = F \cdot \dot{A} + AF_K\dot{K} + AF_L\dot{L}$$

3 **Divide by Y; multiply and divide by A, K and L**

Growth rates appear, weighted by output elasticities ε.

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \frac{AF_K K}{Y}\frac{\dot{K}}{K} + \frac{AF_L L}{Y}\frac{\dot{L}}{L}$$

4 **Competitive factor markets**

Profit-maximising, price-taking firms hire until A·F_K = r and A·F_L = w. Elasticities become income shares.

$$\frac{AF_K K}{Y} = \frac{rK}{Y} \equiv \alpha_K$$
$$\frac{AF_L L}{Y} = \frac{wL}{Y} \equiv \alpha_L$$

5 **Constant returns (Euler's theorem)**

Paying each factor its marginal product exactly exhausts output: no pure profits, and the two shares sum to one.

$$rK + wL = Y \quad \Rightarrow \quad \alpha_K + \alpha_L = 1$$

REARRANGE →

$$g_A = g_Y - \alpha_K g_K - \alpha_L g_L$$

Everything on the right is observable: output growth from the national accounts, K and L from statistical agencies, the shares from the income side of GDP. A is what is left.

ROLE OF EACH ASSUMPTION

- **An aggregate production function** exists and is stable over the period.
- **Constant returns to scale** → shares sum to one and there is no residual income to allocate. Without it, step 5 fails and α_K + α_L ≠ 1.
- **Competitive factor markets** → A·F_K = r, A·F_L = w, so the unobservable elasticities equal observable shares. Markups, monopsony or informality break this link (step 4).
- **No externalities** Firms equate private marginal products to prices; if the social product of K or h is higher, that excess is allocated to A.

Are factor shares stable? The Kaldor facts

Kaldor (1961); Jones & Romer (2010) §2

Growth accounting needs α_K to be a meaningful, stable number. Two of Kaldor's stylized facts of long-run growth say that it is.

Steady growth

Output per worker grows at a roughly constant rate over long periods.

Constant K/Y

The capital–output ratio is roughly constant.

Constant shares

The shares of capital and labor in income are roughly constant.

Different rates

Growth rates differ substantially across countries.

- **Constant shares** → a fixed α ≈ 1/3 is a defensible approximation, and Cobb–Douglas is the production function with that property.
- **Constant K/Y** → in the long run capital scales with output, not the other way round. This is the fact behind the "capital–output" decomposition two slides from now.

Jones & Romer (2010) list Kaldor's six facts on p. 225 and add six new ones; Fact 4 is where we started.

Development accounting: the Hall & Jones approach

Hall & Jones (1999) eqs. (2)–(3); Acemoglu §3.5.1

$$\frac{Y}{L} = \left(\frac{K}{Y}\right)^{\alpha/(1-\alpha)} \cdot h \cdot A$$

output per worker = capital-intensity term × human capital per worker × productivity (A in labor-augmenting units; every term expressed relative to the US)

1	**Output per worker**	Y/L from the Penn World Tables (PWT 5.6 in 1988 for H&J; PWT 11.0, 2019 for us).
2	**Physical capital**	Perpetual inventory: K_{t+1} = (1−δ)K_t + I_t, δ = 0.06, initial stock from pre-sample investment growth.
3	**Human capital**	h = exp[ψ(s)], Mincer returns by schooling band: 13.4% (years 1–4), 10.1% (5–8), 6.8% (9+).
4	**Capital share**	α = 1/3 for every country (Gollin 2002).
5	**Productivity**	A is whatever is left: the residual.

Returns to schooling from Psacharopoulos (1994): sub-Saharan Africa average for the first four years, world average for the next four, OECD average beyond. Verified: Hall & Jones (1999), p. 87.

Capital per worker, or capital per unit of output?

Hsieh & Klenow (2010) eqs. (2) and (3); Hall & Jones (1999) p. 85

DECOMPOSITION A — CAPITAL PER WORKER

$$Y/L = A \cdot (K/L)^{\alpha} \cdot h^{1-\alpha}$$

Thought experiment: raise A holding K/L fixed. Used by Mankiw, Romer & Weil (1992) and Acemoglu §3.5.

But if A rises, investment brings forth more capital: some of what is "fundamentally due to productivity" gets booked as capital accumulation.

DECOMPOSITION B — CAPITAL–OUTPUT RATIO

$$Y/L = A^{1/(1-\alpha)} \cdot (K/Y)^{\alpha/(1-\alpha)} \cdot h$$

Thought experiment: raise A holding K/Y fixed — capital per worker is allowed to respond. Used by Klenow & Rodríguez-Clare, Hall & Jones, Caselli, Kehoe & Prescott.

A's exponent becomes 1/(1−α) = 1.5: its direct effect plus the capital it attracts.

- **Same data, same α, different answer.** B gives A a larger role — and it is the form used in almost all of the literature we look at today.
- **The justification for B is a growth model:** "along a balanced growth path the capital–output ratio is proportional to the investment rate" (Hall & Jones). That is next week's Solow model. Today, take it as a choice and watch what it does.

What the residual is: “the measure of our ignorance”

Abramovitz (1956); Acemoglu §3.1, p. 79

> **“Moses Abramovitz famously dubbed the [residual] term ‘the measure of our ignorance’ — after all, it was the residual we could not explain and decided to call ‘technology’.”**
>
> — Acemoglu (2009), p. 79

Everything not captured in the production function is considered “A”:

Technology

better blueprints, better organisation, better machines of the same measured price

Allocation

the same inputs used by the wrong firms, the wrong sectors, the wrong places

Institutions & policy

what Hall & Jones call “social infrastructure”: what determines whether inputs are used productively

Measurement error

capital quality, utilisation, hours, schooling quality, informal output — anything mis-measured in K, h or Y

Acemoglu’s counter-argument: in its extreme form the criticism is unfair — by the identity, A is technology. But if K and L are under-measured, A is inflated.

PART 2

Growth accounting: what the estimates say

The United States in 1957, the East Asian tigers in 1995, Latin America and Mexico since.

The founding number: Solow (1957)

"Technical Change and the Aggregate Production Function", Review of Economics and Statistics

× 2

output per man-hour roughly doubled over the forty years

≈ 1/8

of the doubling of US output per man-hour, 1909–1949, traceable to more capital per worker

≈ 7/8

traceable to "technical change" — the residual

- **"A large part of the growth was due to technological progress"** (Acemoglu, p. 79). Important landmark in Economics: technology, rather than savings, became the centre of growth economics.
- **Origin of growth accounting + results + criticisms:** The results were very influential, but the paper also introduced the concept of growth accounting, and also asked the same questions we ask today: what if inputs are mismeasured?
- Jorgenson and co-authors, adjusting for the quality of labor and capital, later shrank the US residual "perhaps almost to zero" (Acemoglu, p. 80). **The number depends on how carefully inputs are measured.**

East Asia I: “The Tyranny of Numbers”

Young (1995), QJE — growth accounting for the four tigers

	Period	GDP per capita growth, % / yr	TFP growth, % / yr
Hong Kong	1966–91	5.7	**2.3**
Singapore	1966–90	6.8	**0.2**
South Korea	1966–90	6.8	**1.7**
Taiwan	1966–90	6.7	**2.1**

- Per-capita growth of 6–7% a year, but TFP growth of 0.2–2.3% — *“not exceptional by the standards of the OECD or several large developing countries”* (A&H, p. 111).
- **The rest is inputs:** participation rates rising, hours rising, schooling rising, and investment rates that pushed K/Y up 2.8% a year in Singapore and 3.4% in Korea (Hsieh 2002, p. 502).
- **Young’s interpretation:** East Asia is transition dynamics in a neoclassical model — accumulation, not miracle.

? **If this is right, what does it predict for Singapore's growth once participation, hours and schooling stop rising?**

East Asia II: the same countries, from the factor markets

Hsieh (2002), AER — the “dual” approach

If TFP were flat while K/Y rose 2.8% a year, diminishing returns say the return to capital should have fallen dramatically.

≈ 0

change in Singapore's return to capital, early 1960s – 1990, from observed asset returns

0.2 → 2.2

Singapore's TFP growth, % / yr: primal (quantities) vs dual (prices)

+1 pt

Taiwan's dual estimate exceeds the primal; Korea and Hong Kong are about the same either way

- **The dual identity:** if there is no TFP growth, the wage and the rental rate cannot both rise. Weight the growth of factor prices by the shares and you get TFP growth without ever measuring K.
- **The two methods agree if the data are consistent.** For Singapore they do not — Hsieh's diagnosis: the national accounts overstate capital accumulation, and the gap survives controls for financial repression, taxes and risk premia.
- **Lesson for us:** the residual is only as good as the capital series that produced it.

Latin America: 100 years of 30%

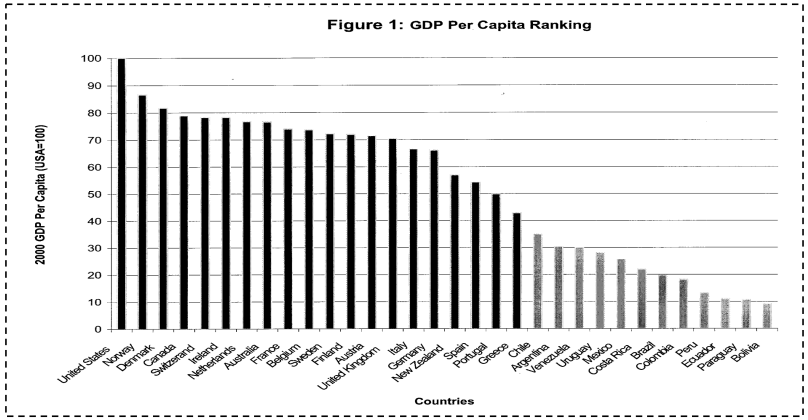
Cole, Ohanian, Riascos & Schmitz (2005), Journal of Monetary Economics

28% → 22%
Latin American income per capita relative to the US, 1950 → 2000

40% → 67%
Western Europe over the same fifty years

16% → 57%
East Asia over the same fifty years

≈ 29%
Latin America relative to the US across the whole of 1900–2001



- **The accounting:** Latin American TFP is about half the US level; the TFP gap accounts for roughly two-thirds of the labor-productivity gap, the capital–labor ratio for about one-third.
- **Not human capital:** it has been rising steadily while relative income has not.
- **Their suspects:** barriers to competition — tariffs of 68–172% vs ~10% in Europe, entry costs of ~80% of GDP per capita vs 1.7% in the US, state ownership, dismissal costs.

Mexico I: reforms, openness, but no growth

Kehoe & Ruhl (2010), Journal of Economic Literature

+510%

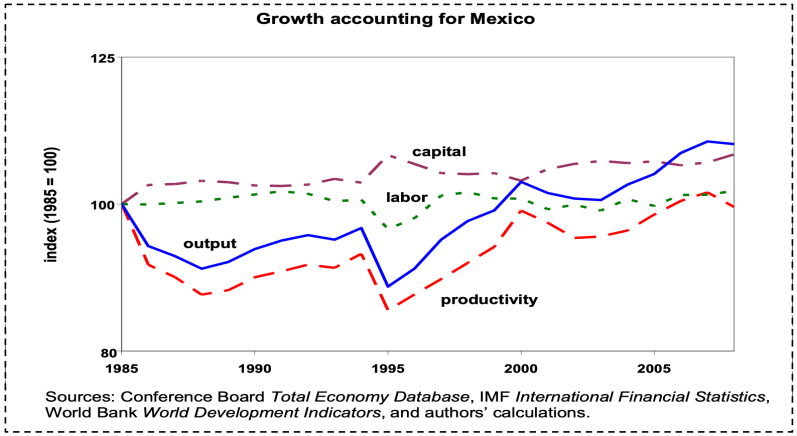
China: real GDP per working-age person, 1985–2008 (8.2% / yr)

+10%

Mexico over the same 23 years (0.4% / yr) — after NAFTA, privatisation, fiscal reform

3.8 / −1.7 / 1.7

Mexico's growth, % / yr: 1953–81 · 1981–95 "great depression" · 1995–2008



Sources: Conference Board *Total Economy Database*, IMF *International Financial Statistics*, World Bank *World Development Indicators*, and authors' calculations.

- **"The poor performance in terms of real GDP growth is driven by an even worse performance in terms of TFP growth."** Post-1995 growth, such as it is, is TFP-driven.
- **Method note:** Kehoe–Prescott accounting uses the capital–output form (Decomposition B). With K/L instead, Mexican capital would look far more important.
- **Their hypotheses:** inefficient financial system, weak rule of law, labor-market rigidity, no competition in petroleum, electricity, telecoms, transport.

Mexico II: two decades of effort

Levy (2018), Under-Rewarded Efforts: The Elusive Quest for Prosperity in Mexico, IDB

+0.14% / yr

Mexican TFP growth, 1996–2015, without adjusting labor for quality

−0.53% / yr

the same, once labor is adjusted for rising schooling — TFP fell

K + L only

"Mexico's GDP growth has resulted only from the accumulation of physical capital and growth of the labor force."

> **"This book argues that persistent misallocation of resources is the main reason why productivity growth in Mexico has stagnated and, in turn, why growth has been disappointingly low."**
>
> — Levy (2018), ch. 1, p. 6

- Investment rose, schooling rose, the economy opened – the inputs improved. **The residual did not increase.** Same verdict as Kehoe-Ruhl, but from firm-level census data instead of aggregates.
- "Misallocation" is one of our 4 "buckets": the same K and L in the wrong firms.

Discussion: reconcile three Mexican facts

1

Since 1985 Mexico opened to trade and FDI, privatised, and signed NAFTA (Kehoe & Ruhl).

2

Investment rates and schooling rose steadily through 1996–2015 (Levy).

3

Measured TFP was flat or falling for thirty years (both).

? **What would you have to believe about the Mexican economy for all three to be true at once? Which of the four buckets — technology, allocation, institutions, measurement — do you think is the main reason for this?**

PART 3

Development accounting: the estimates

Hall & Jones (1999), Klenow & Rodríguez-Clare (1997), Caselli (2005), Hsieh & Klenow (2010) — and the three ingredients they all depend on.

Hall & Jones (1999): the headline

127 countries, 1988; five richest vs. five poorest in output per worker

$$31.7 = 1.8 \times 2.2 \times 8.3$$

31.7×	1.8×	2.2×	8.3×
output per worker, richest five over poorest five (geometric averages)	from the capital–output term $(K/Y)^{\alpha/(1-\alpha)}$	from human capital per worker h	from productivity A — the residual

- **"With no differences in productivity, output per worker in the five richest countries would have been only about four times larger than in the five poorest."** Inputs have a factor of 4; the residual has the other factor of 8.
- Paper uses the example of US–Niger gap which is 35×: "in just over ten days the average worker in the United States produced as much as an average worker in Niger produced in an entire year."

Hall & Jones, Table I: the decomposition by country

Ratios to US values, 1988. Column 1 is the product of columns 2–4.

Country	Y/L	(K/Y)^{α/(1−α)}	H/L	A
United States	1.000	1.000	1.000	1.000
Canada	0.941	1.002	0.908	1.034
Italy	0.834	1.063	0.650	1.207
Hong Kong	0.608	0.741	0.735	1.115
Singapore	0.606	1.031	0.545	1.078
Japan	0.587	1.119	0.797	0.658
Mexico	**0.433**	**0.868**	**0.538**	**0.926**
Argentina	0.418	0.953	0.676	0.648
India	0.086	0.709	0.454	0.267
China	0.060	0.891	0.632	0.106
Kenya	0.056	0.747	0.457	0.165
Zaire	0.033	0.499	0.408	0.160

HOW TO READ IT

- **Canada:** same K/Y, 91% of US human capital → A ≈ US.
- **China:** 6% of US output with 89% of its capital intensity and 63% of its human capital — A is 11% of the US.
- **Hong Kong & Singapore:** A above the US in levels, even as Young finds little TFP growth. Levels and growth are different questions.
- **Mexico:** 43% of US output per worker — and almost none of it is productivity. K/Y and h are the main gaps.

Averages over 127 countries: Y/L 0.296, capital term 0.853, H/L 0.565, A 0.516. Correlation of log A with log Y/L: 0.89. Verified: Hall & Jones (1999), Table I, p. 91.

The Mexican puzzle: 1988 levels vs. thirty years of growth

Hall & Jones (1999) Table I; Kehoe & Ruhl (2010); Levy (2018); PWT 11.0

1988 — LEVELS

$A \approx 0.93$

Mexican productivity was almost at the US level in Hall & Jones's accounting. The 43% output gap was a gap in capital intensity (0.87) and above all in human capital (0.54).

1985–2015 — GROWTH

$\Delta A \approx 0$

Kehoe & Ruhl: TFP growth worse than GDP growth. Levy: −0.5% a year 1996–2015 with quality-adjusted labor. Meanwhile US TFP kept growing.

2019 — LEVELS (PWT 11.0)

$y \approx 0.34 \cdot h \approx 0.74$

Output per worker (cgdpo/emp) and PWT's human-capital index, Mexico relative to the US. If K/Y were equal, A^{1.5} = 0.34/0.74 ≈ 0.46, so A ≈ 0.6.

? **Are these three consistent? A country whose A was 93% of the US in 1988 and then stopped growing while the US did not would be at roughly 55–65% today. The two kinds of accounting are telling one story.**

The debate

Klenow & Rodríguez-Clare (1997), NBER Macroeconomics Annual — vs. Mankiw, Romer & Weil (1992)

MANKIW, ROMER & WEIL (1992) — "FACTORS EXPLAIN IT"

78% / 22%

share of cross-country variation in output per worker (levels, 1985) attributed to inputs / to productivity.

How: secondary-school enrolment as the human-capital investment rate, and a human-capital elasticity of about 1/3 — from a regression.

KLENOW & RODRÍGUEZ-CLARE (1997) — "NO, PRODUCTIVITY DOES"

34% / 66%

inputs / productivity, same question, 1985 levels. For growth rates 1960–85: 9% / 91%.

How: years of attainment (primary + secondary + tertiary, Barro–Lee) with a Mincer return of 9.5% — from micro data, not a regression. The human-capital elasticity falls, and the residual grows.

- **The entire disagreement is about how to measure h.** MRW's implied return to a year of schooling is far above anything in the labor literature (Acemoglu §3.4.3: 12 more years should make a country 2–3× richer, not 11×).

Caselli (2005): one number for “how well do inputs do?”

“Accounting for Cross-Country Income Differences”, Handbook of Economic Growth

SUCCESS OF THE FACTOR-ONLY MODEL

$$success_1 = Var[logy_{KH}]/Var[logy]$$

y_KH = k^α h^{1−α}: what output per worker would be if only inputs differed. Baseline: success₁ = 0.39; the 90/10 percentile version success₂ = 0.34.

Table 1
Baseline success of the factor-only model

var[log(y)]	1.297	y^{90}/y^{10}	21
var[log(y_{KH})]	0.500	y_{KH}^{90}/y_{KH}^{10}	7
$success_1$	0.39	$success_2$	0.34

What the number does and does not move with

Variation	Success of factors alone	Reading
Baseline (PWT 6.1, 1996, α = 1/3, Mincer returns)	0.39	Inputs explain ≈ 40% of the log-variance; A the rest
Alternative measures of physical capital	as low as 0.22	Initial-stock and depreciation guesses bite hardest for poor countries
Restricting to the Americas	≈ 0.50	Inputs do better within our region
Restricting to Europe	≈ 1.00	Among similar countries, A barely varies
Stretching human capital (quality, health, experience…)	up to 0.80 in principle	Requires elasticities “much larger than the limited micro evidence” supports

Summary of main findings

How much of the cross-country income gap is inputs, how much is A? The answer depends on the assumptions in the last column.

Study	Data	Inputs	Residual A	The assumption that drives the answer
Mankiw, Romer & Weil (1992)	98 countries, 1985	≈ 78%	≈ 22%	Human-capital elasticity ≈ 1/3 from a regression; enrolment as investment
Klenow & Rodríguez-Clare (1997)	1985 levels; 1960–85 growth	34% · 9%	66% · 91%	Mincer return 9.5% on attainment; K/Y form
Hall & Jones (1999)	127 countries, 1988	factor 4 (1.8 × 2.2)	factor 8.3	Piecewise Mincer returns 13.4 / 10.1 / 6.8%; α = 1/3; K/Y form
Caselli (2005)	94 countries, 1996	≈ 39%	≈ 61%	Variance decomposition; every ingredient varied one at a time
Hsieh & Klenow (2010)	survey	K ≈ 20% · h 10–30%	50–70%	Range across human-capital measures; K/Y form
Hendricks & Schoellman (2018)	immigrant wage gains	h ≈ 60%	"country" ≈ 40%	Measures h from what workers earn after moving, not from years of schooling

- **Consensus, 1997–2010:** inputs explain something like a third to a half; the residual the rest. Jones & Romer's "less than half" is this row of the table.
- **The role of human-capital quality**: Measured by migrants' wage gains rather than years of schooling, h roughly doubles its share. The residual shrinks — but does not vanish.

Ingredient 1: physical capital

Perpetual inventory — Hall & Jones p. 86; Acemoglu §3.5.1; A&H §5.3.1

$$K_{t+1} = (1-\delta)K_t + I_t, K_0 = I_0/(g+\delta)$$

capital is cumulated investment net of depreciation; the initial stock is guessed from the pre-sample growth of investment g (Hall & Jones: δ = 0.06, 1960s onward)

Depreciation δ

One number for structures and machines; 6% is a convention. Poor countries' stocks are more sensitive because investment is a larger share of their K.

The initial stock

A guess from pre-sample investment growth. Caselli: alternative capital measures cut the success of inputs from 0.39 to 0.22.

Relative prices

Equipment is far dearer relative to consumption goods in poor countries — PPP for investment is not PPP for GDP (Hsieh & Klenow 2007).

Quantities vs. prices

Singapore's return to capital did not fall while measured K/Y rose 2.8%/yr. When quantities and prices disagree, doubt the quantities (Hsieh 2002).

PWT 11.0: cn (capital stock at current PPPs, built by PIM with asset-specific depreciation) and rnna. For PSET 1 you take cn as given — but know what is inside it.

Ingredient 2: human capital

Hall & Jones p. 87; Klenow & Rodríguez-Clare; Hsieh & Klenow (2010) §B

$$h = B \cdot \exp[\varphi(s) \cdot s] \quad \text{— the macro-Mincer assumption}$$

human capital per worker rises log-linearly in years of schooling s at the private return ϕ;
B contains quality, experience, early-life and on-the-job human capital

WHAT GOES IN

- **Years of schooling** of the workforce (Barro & Lee), not enrolment of the young.
- **A return per year** from micro wage regressions: 9.5% flat (KRC) or 13.4 / 10.1 / 6.8% by band (H&J) — diminishing in s, so a year of primary school counts more.
- **No externalities:** the social return equals the private return. Acemoglu §3.5.2 lists this as the calibration's key assumption.

WHAT DOES NOT

- **Quality.** A year of school in Chiapas and in CDMX count the same. KRC: allowing quality to vary moves h's share between 10% and 30%.
- **Skill types.** If skilled and unskilled labor are imperfect substitutes, h differences can look far larger (Jones 2014) — or not (Caselli & Ciccone 2019).
- **Migrants.** Workers who move gain only ~40% of the income gap → h ≈ 60% (Hendricks & Schoellman 2018).

PWT 11.0: hc is exactly this object — Barro–Lee attainment with Psacharopoulos returns. Compare your own exp[ψ(s)] to it in PSET 1.

Ingredient 3: the capital share α

Gollin (2002); Acemoglu §3.5.2; PWT labsh

WHY EVERYONE USES 1/3

- **Raw national accounts** show labor shares from 0.05 to 0.80 — because in poor countries most income is self-employed and gets booked as “operating surplus”.
- **Gollin (2002):** allocate self-employment income between labor and capital and the labor share settles in the 0.65–0.80 range everywhere — rich and poor alike.
- **So a common α ≈ 1/3 is defensible,** and Acemoglu (§3.5.2) notes that almost all levels accounting uses it because country-specific shares are unavailable or unreliable.

WHY IT STILL MATTERS

- **The exponent on A is 1/(1−α).** With α = 1/3 it is 1.5; with α = 1/2 it is 2. A higher α makes the same output gap require a smaller A gap.
- **Natural resources.** Land and minerals are a bigger share of “capital” income in poor countries; strip them out and the marginal product of capital is not higher there (Caselli & Feyrer 2007).
- **PWT gives you both.** labsh is country- and year-specific; PWT's ctfp uses it. Your PSET A with α = 1/3 will not match ctfp — the difference is this slide.

? **Mexico's labsh in PWT is well below 2/3. Does using it raise or lower Mexico's measured A relative to the US?**

PART 4

What the residual cannot explain

Three limitations: the decomposition is not unique; accounting is not causation; A is not “technology”.

Limit 1: the decomposition is not unique

Acemoglu §3.5.2; Hsieh & Klenow (2010) §I

Same countries, same year, same output gap — four reasonable choices, four different sizes for A.

Choice	Option 1	Option 2	What it does to the residual
Capital form	K/L (Decomposition 1)	K/Y (Decomposition 2)	1 raises A's exponent to 1/(1−α); more of the gap is attributed to A
Capital share α	1/3 everywhere	country-specific labor-share	Changes both exponents; sign depends on K/Y relative to the US
Human capital	years × flat return	quality-adjusted / migrant-based	Moves h's share from ~10% to ~60%; A absorbs the difference
Functional form	Cobb–Douglas	general F with average shares (eq. 3.30)	Large factor-proportion gaps make the Törnqvist approximation biased (Acemoglu Ex. 3.1)

- **None of this makes accounting useless.** It makes "A explains 60%" a statement with hidden assumptions, and a well-done paper (Caselli) reports how the number moves when each one changes.
- **But the choice of K/L or K/Y has a more definitive answer.** Next week.

Limit 2: accounting is not causation

Aghion & Howitt §5.3.2; Hsieh & Klenow (2010) p. 208; Klenow & Rodríguez-Clare (1997)

> **“Even though capital deepening might account for as much as 70 percent of the observed growth of output per worker in some OECD countries, it might still be that all of the growth is caused by technological progress.”**
>
> — Aghion & Howitt (2009), §5.3.2

THE MECHANISM

Take $Y = A^{1-\alpha}K^{\alpha}L^{1-\alpha}$ with a constant saving rate. A rise in `A` raises the return to capital; investment responds; K/L rises until K/Y is back where it was. Growth accounting on K/L then allocates the growth to capital — capital that would not exist without the rise in A.

THE SAME POINT FOR h

If schooling is chosen in response to its return, and the return depends on A, then part of the human-capital term is also caused by A. Decomposition B fixes this for K but not for h — Hsieh & Klenow call this its “asymmetry”. A factor-based accounting is a lower bound on A's causal role.

This is exactly why Hall & Jones and Klenow & Rodríguez-Clare write the decomposition in K/Y — and why justifying that choice needs the Solow model.

Limit 3: A is not “technology”, it is a “bucket”

What the elements of the residual are, and where in this course each topic is covered

Misallocation	The same K and h in the wrong firms. Hsieh & Klenow (2009): reallocating to US efficiency would raise manufacturing TFP 30–50% in China and 40–60% in India. Levy's Mexico.	**Week 13**
Sectoral composition	Output per worker in agriculture is a fraction of non-agriculture in poor countries, even after adjusting hours and human capital (Gollin, Lagakos & Waugh 2014).	**Week 13**
Institutions	Hall & Jones's own explanation: “social infrastructure” — the rules that determine whether inputs are used productively, invented, or diverted.	**Week 14**
Technology proper	Blueprints, adoption lags, distance to the frontier — the part of A that really is technology.	**Weeks 5–7**
Measurement	Capacity utilisation, hours, capital quality, natural resources in the capital share (Caselli & Feyrer 2007), schooling quality (Hendricks & Schoellman 2018), informal output.	**Today**

Accounting sizes the bin. It cannot say what is inside — and every candidate is a claim about the economy, not about arithmetic.

Readings for this week

REQUIRED

- Acemoglu, Ch. 3, §3.1 and §3.5 (§3.6 optional; §3.2–3.4 next week).
- Aghion & Howitt, Ch. 5, especially §5.3.
- Hall & Jones (1999), QJE, §I–III (the accounting; §IV–VI on social infrastructure returns in Week 14).
- Hsieh & Klenow (2010), "Development Accounting", AEJ: Macro — 17 pages, the best summary.

RECOMMENDED

- Caselli (2005), Handbook of Economic Growth — the reference for every ingredient.
- Klenow & Rodríguez-Clare (1997), NBER Macro Annual.
- Young (1995), QJE; Hsieh (2002), AER — the East Asian debate.
- Kehoe & Ruhl (2010), JEL; Levy (2018), IDB, Ch. 1 — Mexico.
- Cole, Ohanian, Riascos & Schmitz (2005), JME — Latin America.
- Hendricks & Schoellman (2018), QJE — the human-capital challenge.