Economic growth: sources, potential GDP and growth accounting

Economics

1 A story: two runners

- Output per worker: what each worker produces
- Developing: little capital, so new capital pays well
- Developing: can copy technology, not invent it
- Developed: must innovate at the frontier

IN THE LESSON

- Picture two runners in a long race.
- One is far behind the pack, but she can follow the footsteps of those ahead.
- The other already leads, and must find new ground by herself.
- That is the difference between a developing and a developed economy.
- Level one gave you the idea of output per worker: how much each worker produces in a year.
- A developing economy starts with little capital per worker, few machines, little infrastructure.
- So the first machines it adds are very valuable.
- It can also copy technology that others took decades to invent.
- Both forces favour catching up.
- Priya calls the poorer, fast moving country Sunvale and the rich, mature one Norland.

2 What helps, what holds back

Two kinds of economy, read through the growth model

Economy	Effect on growth
Developing: helps	Catch-up
Developing: holds back	Weak foundations
Developed: helps	Strong institutions
Developed: holds back	Diminishing returns

IN THE LESSON

- Here is the contrast on one board.
- In a developing economy, two things help.
- Capital is scarce, so each new machine or road adds a lot.
- And the economy can copy technology that already exists.
- Together we call this catch up.
- But the foundations may be weak, and that holds growth back: low saving, so little to invest; weak property rights and rule of law, so owners fear their gains will be taken; political instability; poor schooling and health; shallow financial markets; and barriers to trade and foreign capital.
- A developed economy has strong institutions and deep markets, which help.
- But it already has a great deal of capital per worker, so extra capital adds little.
- Diminishing returns hold it back, and its growth must come from innovation.

3 Why capital pays more where it is scarce

Chart: Extra output from one more unit vs Capital per worker

- Sunvale
- Norland

IN THE LESSON

- Here is the catch up idea as a picture.
- Along the bottom is capital per worker, from small to large.
- Up the side is the extra output you get from one more unit of capital.
- Start with the falling curve.
- On the left, where capital is scarce, the curve is high: one more machine adds a lot.
- Moving right, it falls steadily, because each new machine finds less work still to do.
- That is diminishing marginal returns, which you met at level one.
- Now the two marks.
- Sunvale sits on the left, with ten units of capital per worker, high on the curve.
- Norland sits far to the right, with one hundred sixty units, low on the curve.
- The same new machine is worth far more in Sunvale.

4 Example 1: Sunvale against Norland

Output per worker y = A × k^0.4 (made-up numbers)

Extra output, Sunvale (k = 10)	0.4 × 10^−0.6	**0.100**
Extra output, Norland (k = 160)	0.4 × 160^−0.6	**0.019**
Ratio	0.100 ÷ 0.019	**5.3×**
Copy technology: A 0.7 to 1.0	1.0 ÷ 0.7 − 1	**+43%**

IN THE LESSON

- Let us put numbers on it.
- Suppose output per worker is a technology level, A, times capital per worker raised to the power zero point four.
- That power is capital's share of income, called alpha.
- The extra output from one more unit of capital is then alpha times capital per worker to the power minus zero point six.
- In Sunvale, with ten units, that is about zero point one zero.
- In Norland, with one hundred sixty units, it is about zero point zero one nine.
- The ratio is about five point three: a unit of capital is worth over five times more in Sunvale.
- Now the second force.
- If Sunvale copies better technology and lifts A from zero point seven to one point zero, with no extra capital at all, output per worker rises about forty three per cent.

5 Catch-up is not automatic

Strong foundations

Scarce capital → High return → Investment flows in → Catch-up

Weak foundations

Scarce capital → Same return on paper → Law and order fail → Falls behind

IN THE LESSON

- But catch up is not automatic.
- Follow the top row.
- With scarce capital, the return on new capital is high.
- If the foundations are strong, saving and foreign investment flow in, machines are bought, and the country catches up.
- Now the bottom row.
- The same scarce capital, and the same high return on paper.
- But if property rights are weak, the law cannot be trusted, or politics is unstable, owners expect to lose their gains.
- Capital stays away, and the country can fall further behind.
- That is the exam trap: assuming poor countries automatically grow faster.
- Scarce capital alone does not deliver rapid growth.
- So Priya checks the foundations before she believes any catch up story.
- And for Norland, growth rests on innovation at the frontier.

6 A story: the dog on a lead

- Market value = economy × profit share × price per profit
- Short run: the dog runs ahead of the owner
- Long run: the market stays on the lead
- Only the economy can grow without limit

IN THE LESSON

- Picture a person walking a dog on a long, stretchy lead.
- The dog darts ahead, then dawdles behind, but over a long walk it ends up wherever the owner goes.
- The stock market is the dog, and the economy is the owner.
- Over a few years the market can run far ahead of the economy.
- Over decades it stays on the lead.
- Why?
- The value of a market is made of three things multiplied together: the size of the economy, the share of the economy that becomes company profit, and the price investors pay for each unit of profit.
- Two of those three cannot keep rising for ever.
- That is the key to this outcome.

7 Splitting the market into three

Market = GDP × (Earnings ÷ GDP) × (Price ÷ Earnings)
Market growth ≈ g(GDP) + g(profit share) + g(P/E)

GDP	Nominal: real growth + inflation
Profit share	Earnings ÷ GDP, has a ceiling
P/E multiple	Cannot expand for ever
Market value	Price appreciation

IN THE LESSON

- Here is the identity.
- Market value equals G D P, times earnings divided by G D P, times price divided by earnings.
- Check it: G D P cancels, earnings cancels, and market value is left.
- The middle piece is the profit share, how much of the economy's output ends up as company profit.
- The last piece is the price earnings ratio, or P E, what investors pay for each unit of profit.
- Because the three are multiplied, their growth rates add up, roughly.
- Market appreciation is about G D P growth, plus growth in the profit share, plus growth in the P E.
- We use price appreciation here, so dividends are left out.
- In the examples we compound the rates exactly, and show the quick sum beside it.

8 Example 2: a decade of gains, taken apart

Norland index, past decade (made-up numbers)

Nominal GDP growth	2.0% real + 2.5% inflation	**4.55%**
Profit share growth	earnings ÷ GDP rising	**+1.0%**
P/E growth	multiple expanding	**+1.5%**
Market appreciation	1.0455 × 1.01 × 1.015 − 1	**7.2%**

Simple addition gives about 7%, close enough

IN THE LESSON

- Example two.
- Priya looks at a past decade of the Norland equity index.
- Real G D P grew two per cent a year and inflation ran at two and a half, so nominal G D P grew four point five five per cent, because one point zero two times one point zero two five is one point zero four five five.
- During the decade the profit share crept up one per cent a year, and the price earnings multiple rose one and a half per cent a year.
- Compound the three: one point zero four five five times one point zero one times one point zero one five gives about seven point two per cent a year.
- Simple addition gives seven, close enough.
- But look at what is lasting.
- Only the four point five five from nominal G D P can go on for ever.

9 Which gains can last

Gain (% a year)

Real growth	**2.0%**
Inflation	**2.5%**
Profit share	**1.0%**
P/E multiple	**1.5%**

Green can last; gold and red cannot

IN THE LESSON

- Here are the sources as bars.
- Real G D P growth is two per cent a year.
- Inflation adds two and a half.
- Both are in green, because together they make nominal G D P growth, and an economy can go on growing in real terms and in prices for ever.
- Then the profit share, one per cent, in gold, and the price earnings multiple, one and a half per cent, in red.
- These two cannot go on.
- Profits cannot become more than the whole economy, and a multiple that keeps expanding would eventually imply an absurd price.
- So when Priya projects the future, she keeps the green bars and asks hard questions about the gold and the red.
- Over long horizons, equity appreciation converges to nominal potential G D P growth.

10 Example 3: forecasting the next decade

Norland forecast, next ten years (made-up numbers)

Nominal potential GDP growth	2.0% real + 2.5% inflation	**4.55%**
Profit share growth	margins squeezed	**−0.5%**
P/E growth	assumed flat	**0.0%**
Market appreciation	1.0455 × 0.995 − 1	**4.03%**
Real appreciation	1.0403 ÷ 1.025 − 1	**1.49%**

IN THE LESSON

- Example three is the forecast.
- Priya expects real potential growth of two per cent and inflation of two and a half for Norland, so nominal potential growth is four point five five.
- But profit margins are already high, so she expects the profit share to slip by half a per cent a year, and she holds the price earnings multiple flat.
- Market appreciation is one point zero four five five times zero point nine nine five, minus one: about four point zero three per cent a year.
- Now the exam detail.
- Compare real with real.
- Divide by one point zero two five to strip out inflation, and the real appreciation is about one point four nine per cent.
- That is below real growth of two, because the profit share is shrinking.

11 Example 4: when the multiple reverses

Norland index, P/E drifting back (made-up numbers)

P/E today, then in ten years	assumed	**18 to 15**
P/E growth a year	(15 ÷ 18)^(1/10) − 1	**−1.81%**
Market appreciation	1.0455 × 0.9819 − 1	**2.66%**
Cost of the reversal	4.55 − 2.66	**1.89 pts**

IN THE LESSON

- Example four shows the trap.
- Suppose a market has been re rated, and its price earnings ratio is eighteen.
- Priya thinks it will drift back to fifteen over ten years.
- The annual growth in the multiple is fifteen over eighteen, to the power one tenth, minus one: about minus one point eight one per cent a year.
- Combine it with nominal G D P growth of four point five five.
- One point zero four five five times zero point nine eight one nine is about one point zero two six six, so appreciation is only two point six six per cent a year.
- The reversal costs nearly two points a year.
- The trap is extrapolating a period when margins or multiples expanded.
- Those gains are temporary, and when they reverse they subtract from returns.

12 A story: the speed limit

- Potential GDP: output with resources fully employed
- Its growth rate is the economy's speed limit
- Output gap = (actual − potential) ÷ potential
- Positive gap: running hot. Negative gap: slack

IN THE LESSON

- Think of a motorway with a speed limit.
- Drive at the limit and you can go on all day.
- Drive faster and you may get away with it for a while, but something eventually gives.
- Potential G D P is the same kind of limit.
- It is the output an economy can produce with its labour and capital fully employed, at stable inflation.
- Its growth rate is the speed limit for sustainable expansion.
- Nobody can observe it directly, so economists estimate it.
- The gap between actual and potential output is called the output gap: actual minus potential, divided by potential.
- A positive gap means the economy is running hot.
- A negative gap means there is slack.
- Both equity and bond investors watch it, for different reasons.

13 Actual output around potential

Chart: Output vs Time

- Positive gap
- Negative gap
- Potential

IN THE LESSON

- Here is the picture.
- Time runs along the bottom, output up the side.
- Start with the grey line.
- That is potential output, rising steadily; its slope is the sustainable growth rate.
- Equity investors care most about that slope, because over the long run it sets the pace at which revenues, earnings and dividends can grow.
- Now the green line, actual output.
- It wobbles around potential.
- Near the peak, actual output sits above potential: a positive output gap.
- Labour is scarce, capacity is stretched, and wages and prices start to rise.
- Near the trough, actual output sits below potential: a negative gap, with slack and low inflation.
- Notice that the gap closes again.
- The slope of the grey line did not change.

14 Example 5: an output gap that widens

Norland, in billions (made-up numbers)

Output gap today	(1,030 − 1,000) ÷ 1,000	**+3.0%**
Potential next year	1,000 × 1.02	**1,020**
Actual next year	1,030 × 1.03	**1,060.9**
Output gap next year	(1,060.9 − 1,020) ÷ 1,020	**+4.0%**

Gap widening: inflation pressure builds

IN THE LESSON

- Example five.
- Norland's potential output is one thousand, in billions, and actual output is one thousand thirty.
- The output gap is thirty divided by one thousand: plus three per cent.
- Now suppose potential grows at two per cent, the speed limit, to one thousand twenty.
- Actual output grows at three per cent, to one thousand sixty point nine.
- The new gap is forty point nine divided by one thousand twenty, about four per cent.
- The gap has widened, so inflation pressure is building, and Priya expects the central bank to raise its policy rate.
- Bond yields tend to follow, and bond prices fall.
- A positive output gap is the bond investor's warning light.

15 What the gap and the speed limit do to bonds

The gap, near term

Growth above potential → Inflation pressure → Policy rate rises → Bond prices fall

The speed limit, long term

Faster potential growth → Higher real rate → Stronger revenues → Safer sovereign debt

IN THE LESSON

- Now the bond investor's chains, drawn as two rows.
- The top row is about the gap.
- Growth above potential opens a positive output gap.
- That brings inflation pressure, as wages and prices rise.
- The central bank raises its policy rate to cool things down.
- Yields rise, and bond prices fall.
- The bottom row is about the speed limit itself.
- Faster potential growth tends to raise the equilibrium real interest rate, because there are more profitable uses for money.
- It also lifts tax revenues, which helps a government carry its debt, so sovereign credit quality improves.
- So the gap matters for the near term, and the speed limit matters for the long term.
- Different horizons, different levers.

16 Example 6: growth and the debt ratio

Debt held at 600 for ten years (illustration)

Debt to GDP today	600 ÷ 1,000	**60%**
Slower: nominal growth 3.5%	GDP 1,000 × 1.035^10	**42.5%**
Faster: nominal growth 5.0%	GDP 1,000 × 1.05^10	**36.8%**
Gap after ten years	42.5 − 36.8	**5.7 pts**

IN THE LESSON

- Example six is about debt.
- Norland's government owes six hundred, and national output is one thousand, so debt is sixty per cent of G D P.
- To keep the arithmetic clean, suppose the debt stays at six hundred for ten years; this is only an illustration.
- If nominal G D P grows at three and a half per cent, it reaches about one thousand four hundred eleven, and the debt ratio falls to forty two point five per cent.
- If nominal G D P grows at five per cent, it reaches about one thousand six hundred twenty nine, and the ratio falls to thirty six point eight.
- The faster economy has a debt ratio almost six points lower, which makes it easier to service its debt.
- That is why sovereign bond investors care about potential growth.

17 Mistakes to avoid so far

- Poor countries do not grow faster automatically
- Margin or multiple gains are temporary, not trend
- Compare real with real, nominal with nominal
- A boom above potential is not higher potential

IN THE LESSON

- Before we go on, here are the mistakes this part of the exam likes.
- First, assuming that poor countries automatically grow faster.
- Without sound institutions, scarce capital alone does not deliver rapid growth, and some countries fall further behind.
- Second, projecting a decade in which profit margins or price earnings multiples expanded.
- Those gains are temporary and can reverse.
- Third, comparing nominal and real figures.
- Compare real returns with real growth, and nominal with nominal.
- Fourth, treating a burst of growth above potential as a permanent rise in capacity.
- Growth above potential opens a positive output gap, and that means inflation pressure and higher policy rates, not a higher speed limit.
- Keep these four in mind and you will avoid most of the traps.

18 A story: more ovens or a better recipe

- Capital deepening: more capital for each worker
- Technology (TFP): a better way to use what you have
- Deepening moves along the curve; technology shifts it up
- Both raise labour productivity, output per worker

IN THE LESSON

- A baker wants to bake more bread per baker.
- She has two options.
- She can buy more ovens, so each baker works with more equipment.
- Or she can find a better recipe, so the same ovens and the same bakers make more loaves.
- The first is capital deepening, more capital for each worker.
- The second is technological progress, which economists measure as total factor productivity, said T F P, the output growth that more inputs cannot explain.
- Both raise labour productivity, output per worker or per hour.
- But the third oven helps less than the first, because there is only so much baking to do.
- A better recipe does not run out in that way.
- That difference is the heart of this outcome.

19 Productivity growth, two sources

Y = A × K^α × L^(1−α)
Productivity growth = TFP growth + α × growth in capital per worker

TFP growth	Shifts the curve up
Capital's share	Capital's share of income
Capital per worker	Deepening: move along the curve
Output per worker	Output per worker

IN THE LESSON

- Here are the formulas.
- With a Cobb Douglas production function, output equals the technology level, A, times capital to the power alpha, times labour to the power one minus alpha.
- Alpha is capital's share of income.
- Divide by labour and you get output per worker, the technology level times capital per worker to the power alpha.
- Take growth rates and you get the key result.
- Labour productivity growth equals T F P growth, plus alpha times the growth in capital per worker.
- The first term is the shift of the curve, technology.
- The second is the movement along the curve, capital deepening, scaled down by alpha, because capital's share is less than one.
- Remember which is which, because the exam tests it.

20 Moving along, or shifting up

Chart: Output per worker vs Capital per worker

- A
- B: more capital
- C: more TFP

IN THE LESSON

- Here is the production function per worker.
- Capital per worker runs along the bottom, output per worker up the side.
- Follow the lower curve first.
- It rises steeply on the left and flattens to the right.
- That bend is diminishing returns.
- Point A is where Sunvale starts.
- Now add capital: move right to point B.
- Output per worker is higher, but the climb is gentler than it was at the start.
- Piling on capital keeps lifting the level, by less each time.
- Now the dashed curve.
- It is the same economy with higher T F P.
- Every amount of capital produces more, so point C sits directly above A with no extra capital at all.
- Technology shifts the curve.
- Capital moves you along it.

21 Example 7: deepening cannot go on for ever

Sunvale, no TFP growth, α = 0.4 (made-up numbers)

Capital per worker growth	each year	**10%**
Productivity growth	0.4 × 10%	**≈ 4%**
Capital per worker, ten years	1.10^10	**× 2.59**
Output per worker, ten years	1.10^4	**× 1.46**

IN THE LESSON

- Example seven.
- Sunvale has no technology growth.
- Suppose its capital per worker grows ten per cent a year, and alpha is zero point four.
- Productivity growth is about alpha times ten, four per cent a year.
- To be exact it is one point one to the power zero point four, minus one, about three point nine.
- Four per cent sounds good.
- But look at the cost.
- After ten years, capital per worker has been multiplied by one point one to the power ten, about two point five nine.
- That is more than two and a half times as many machines for every worker.
- Output per worker has risen by one point one to the power four, only about one point four six times.
- Sustaining even this takes ever more saving.
- Deepening lifts the level, but it cannot keep growth up.

22 Example 8: splitting productivity growth

Sunvale: productivity 2.0%, TFP 1.0%, α = 0.4

Labour productivity growth	observed	**2.0%**
Less TFP growth	technology	**1.0%**
Capital deepening contribution	2.0 − 1.0	**1.0%**
Capital per worker growth	1.0 ÷ 0.4	**2.5%**
Long-run productivity growth	TFP ÷ (1 − α) = 1.0 ÷ 0.6	**1.67%**

IN THE LESSON

- Example eight.
- A statistician tells Priya that Sunvale's labour productivity grows two per cent a year, and that T F P grows one per cent.
- The rest must come from capital deepening: two minus one, one point zero.
- That one point zero is alpha times the growth in capital per worker.
- With alpha at zero point four, capital per worker must be growing at one divided by zero point four, which is two point five per cent a year.
- Now the long run.
- In the neoclassical model, capital per worker settles to grow at the same rate as output per worker.
- Then productivity growth equals T F P growth divided by one minus alpha: one over zero point six, one point six seven per cent.
- Deepening only keeps pace with technology.
- You will meet this result again.

23 Only technology sustains growth

Productivity growth (% a year)

Steady state	**1.67%**
Investment boom	**3.00%**
Boom over	**1.67%**
TFP up to 2%	**3.33%**

The boom lifts growth only while it lasts

IN THE LESSON

- Here is the whole story in four bars, all for Sunvale.
- The first bar is the long run steady state with T F P growth of one per cent: productivity grows one point six seven per cent a year.
- Now an investment boom.
- Capital per worker grows five per cent a year.
- Productivity growth is one plus zero point four times five: three per cent.
- The second bar.
- But diminishing returns bite, the boom fades, and growth drops back to one point six seven in the third bar.
- Now compare the fourth bar.
- If T F P growth rises to two per cent, the long run rate becomes two divided by zero point six, three point three three, and it stays there.
- The trap is expecting more investment to raise the long run growth rate.
- Only technology does.

24 A story: the recipe for forecasting

- Growth accounting: split growth into its sources
- Weights are income shares: capital α, labour 1 − α
- Two methods, one identity
- Forecast: project each piece, hold TFP near trend

IN THE LESSON

- A forecast of potential G D P is a bit like a recipe: you add up the ingredients, each in its proper amount.
- Growth accounting splits output growth into its sources.
- There are two standard routes.
- The first uses the Cobb Douglas weights: potential growth is T F P growth, plus capital's share times capital growth, plus labour's share times labour growth.
- The second is the labour productivity approach: potential growth is growth in labour input, such as total hours, plus growth in labour productivity.
- They are the same identity cut at different points.
- Priya will use both on Norland and check they agree.
- The forecast then means projecting each ingredient, usually holding T F P near its trend, and adding.

25 Growth accounting with Cobb-Douglas

g = TFP growth + α × g(K) + (1 − α) × g(L)

TFP growth	Taken whole
Capital's share	Weight on capital growth
Capital growth	Growth in capital stock
Labour growth	Growth in labour input
Potential growth	Potential GDP growth

IN THE LESSON

- Here is the first formula.
- Potential G D P growth equals T F P growth, plus alpha times capital growth, plus one minus alpha times labour growth.
- Read it as a weighted sum.
- T F P goes in whole, because it is the growth that no input explains.
- Capital's growth is weighted by capital's share of income, alpha.
- Labour's growth is weighted by the remaining share, one minus alpha.
- Two points are worth remembering.
- The weights add to one, and labour usually has the bigger one.
- And a faster growing input matters more only if it also has weight: capital can grow quickly and still add little if its share is small.
- Keep the weights straight and the arithmetic is easy.

26 Example 9: potential growth, bar by bar

Norland: α = 0.35, TFP 0.8%, capital 3.0%, hours 0.6%

TFP growth	taken whole	**0.80%**
Capital: 0.35 × 3.0%	capital's share × growth	**1.05%**
Labour: 0.65 × 0.6%	labour's share × growth	**0.39%**
Potential GDP growth	0.80 + 1.05 + 0.39	**2.24%**

IN THE LESSON

- Example nine.
- Norland's capital share of income is zero point three five.
- T F P is growing at zero point eight per cent a year, the capital stock at three per cent, and labour input, total hours, at zero point six.
- T F P goes in whole: zero point eight.
- Capital contributes zero point three five times three, which is one point zero five.
- Labour contributes zero point six five times zero point six, which is zero point three nine.
- Add them up and potential G D P grows at two point two four per cent a year.
- Notice that labour has the bigger weight, but capital is growing five times as fast here, so it contributes more.
- To forecast, Priya projects each input and fills them in.

27 The labour productivity approach

g = growth in labour input + growth in labour productivity
Labour input = labour force growth + growth in hours per worker

Labour input	Total hours worked
Labour productivity	Output per hour; includes TFP
Potential growth	Potential GDP growth

IN THE LESSON

- Here is the second route, which is simpler.
- Potential G D P growth equals growth in labour input plus growth in labour productivity.
- Labour input is total hours worked.
- It combines two things: the labour force, and average hours per worker.
- So hours grow at about the labour force growth rate plus the growth in hours per worker.
- Falling hours per worker offset some labour force growth; think of a country with shorter working weeks.
- Labour productivity is output per hour.
- Remember from the last outcome that it already contains T F P growth and the effect of capital deepening.
- So the forecast is two pieces, not three: how many hours, and how much each hour produces.
- That is why this route is often preferred.

28 Example 10: the same answer by the second route

Norland: labour force +0.9%, hours per worker −0.3%, capital +3.0%

Labour input, total hours	0.9% − 0.3%	**0.6%**
Capital per hour	3.0% − 0.6%	**2.4%**
Labour productivity	0.8% + 0.35 × 2.4%	**1.64%**
Potential GDP growth	0.6% + 1.64%	**2.24%**

IN THE LESSON

- Example ten.
- Same Norland.
- The labour force is growing at zero point nine per cent a year, and hours per worker are falling at zero point three, so labour input grows at zero point six.
- Capital grows at three per cent, so capital per hour grows at three minus zero point six, two point four.
- Labour productivity growth is T F P, zero point eight, plus alpha times two point four: zero point eight plus zero point three five times two point four, which is one point six four.
- Potential G D P growth is zero point six plus one point six four: two point two four per cent, exactly what growth accounting gave.
- Both routes agree because they are one identity, cut at different points.
- If your two answers disagree, check the weights.

29 Example 11: the two classic slips

Norland again; the right answer is 2.24%

Swapped weights	0.8 + 0.65 × 3.0 + 0.35 × 0.6	**2.96%**
TFP counted twice	0.6 + 1.64 + 0.8	**3.04%**
Error in growth	3.04 − 2.24	**0.80 pts**
Economy overstated, ten years	(1.0304 ÷ 1.0224)^10 − 1	**8.1%**

IN THE LESSON

- Example eleven shows the two slips that cost marks.
- The first is swapping the weights.
- Putting zero point six five on capital and zero point three five on labour gives zero point eight, plus zero point six five times three, plus zero point three five times zero point six: two point nine six per cent.
- The second is the double count.
- Labour productivity growth already contains T F P and capital deepening.
- So adding T F P on top of it, zero point six plus one point six four plus zero point eight, gives three point zero four per cent.
- The correct answer is two point two four.
- Over ten years, the double count overstates the size of the economy by about eight per cent.
- That is a big error from one careless addition.

30 Recap: the formulas to remember

Market ≈ g(GDP) + g(share) + g(P/E)
Productivity = TFP + α × g(K per worker)
Potential = TFP + α g(K) + (1 − α) g(L) = hours + productivity

Market value	Lasting: nominal GDP
Output gap	(Actual − potential) ÷ potential
TFP growth	Shifts the curve up
Capital's share	Weight on capital, not labour
Potential growth	Same answer by both routes

IN THE LESSON

- Let us pull the lesson together.
- Poor countries can catch up through scarce capital and copied technology, but only with sound institutions.
- Over the long run, market appreciation converges to nominal potential G D P growth, and gains from margins or multiples do not last.
- Potential G D P is the speed limit: a positive output gap means inflation pressure and higher yields, and faster potential growth helps both earnings and sovereign credit.
- Capital deepening moves you along the curve with diminishing returns, while technology shifts the curve and is the only source of permanent growth per worker.
- Growth accounting adds T F P, capital growth weighted by alpha, and labour growth weighted by one minus alpha.
- The two routes give the same answer.

31 Try three quick questions

1. Real 2%, inflation 3%, profit share +0.5%, P/E −0.5%. Appreciation?
   Answer: 2 + 3 + 0.5 − 0.5 = 5% (5.06% exact).
2. TFP 1%, α 0.4, capital per worker +2.5%. Productivity growth?
   Answer: 1 + 0.4 × 2.5 = 2.0%.
3. α 0.3, TFP 0.5%, capital +4%, labour +1%. Potential growth?
   Answer: 0.5 + 1.2 + 0.7 = 2.4%.

IN THE LESSON

- Now try three quick questions yourself.
- Pause after each one.
- Question one.
- Real potential growth is two per cent and inflation is three.
- Profit share is expected to grow half a per cent a year and the price earnings multiple to fall half a per cent a year.
- What is expected market appreciation?
- Two plus three plus a half minus a half is five per cent a year, about five point zero six exactly.
- Question two.
- T F P grows one per cent, alpha is zero point four and capital per worker grows two and a half per cent.
- What is labour productivity growth?
- One plus zero point four times two point five is two per cent.
- Question three.
- Alpha is zero point three, T F P is a half, capital grows four per cent and labour one per cent.
- What is potential growth?
- A half, plus one point two, plus zero point seven, is two point four per cent.