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Bachelor of Commerce (B2001) | Level 1 • Part B Major | Monash University

Principles of macroeconomics

Course Code: ECC1100 • Module 1 Notes

Module 1: National Income Accounting, GDP, Inflation, Unemployment & Long-Run Growth

Chapter 1: Macroeconomic Perspectives, Circular Flow & National Income Accounting

1.1 Scope of Macroeconomics and Leading Schools of Thought

Macroeconomics analyses the aggregate performance, structure, and dynamics of an entire economy. Whereas microeconomics examines relative prices and resource allocation within individual markets, macroeconomics studies economy-wide aggregates: total production, the general price level, aggregate employment, national saving, interest rates, and long-run growth in living standards. In Australia, macroeconomic indicators compiled by the Australian Bureau of Statistics (ABS) and analysed by the Reserve Bank of Australia (RBA) and the Commonwealth Treasury guide decisions ranging from monetary policy settings to federal budget allocations.

Modern macroeconomic thought evolved through sustained debate across several major schools regarding market self-correction, price flexibility, and the role of government:

- **Classical and Neoclassical Economics:** Emphasises flexible wages and prices, rapid market clearing, and supply-side determinants of output. In the long run, real output is anchored by labour supply, capital accumulation, and technology, while changes in the money supply affect only nominal variables such as the price level (classical dichotomy).
- **Keynesian Economics:** Originating with John Maynard Keynes during the 1930s Great Depression, this tradition highlights nominal wage and price rigidities, coordination failures, and shifts in aggregate demand. When private investment or household confidence collapses, output can remain persistently below potential unless stabilised by fiscal or monetary policy.
- **Monetarism:** Led by Milton Friedman, monetarism stresses the destabilising effects of erratic monetary growth, long and variable policy lags, and the natural rate hypothesis—arguing that expansionary demand policies cannot permanently lower unemployment below its structural equilibrium rate.
- **New Keynesian and Modern Synthesis:** Integrates microeconomic foundations—optimising households and firms operating under monopolistic competition and nominal price stickiness—with dynamic general equilibrium modelling. Central banks such as the RBA rely heavily on this synthesis when setting inflation targets and interest rate rules.

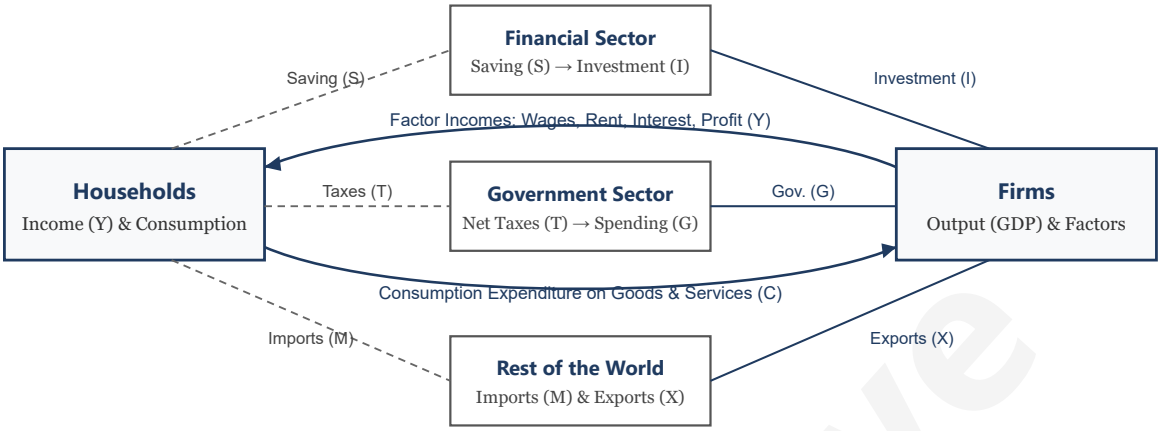
1.2 The Five-Sector Circular Flow of Income and Expenditure

National income accounting rests on a fundamental accounting identity: in any economy over a given period, total production equals total income generated and total expenditure on final goods and services. The five-sector circular flow model captures how income circulates among households, firms, the financial sector, the government sector, and the rest of the world.

Households supply factor services—labour, physical capital, land, and entrepreneurship—to firms in exchange for factor incomes (wages, salaries, rent, interest, and profits). Households allocate disposable income to consumption (C), private saving (S), and net taxes (T, defined as gross taxes minus

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government transfers). Firms combine factor inputs to produce final goods and services, receiving consumption expenditure (C), investment expenditure (I) funded through financial intermediaries, government purchases (G), and export receipts (X) from overseas buyers, while households, firms, and governments also purchase imports (M).



Withdrawals from the domestic spending stream—saving (S), net taxes (T), and imports (M)—are termed **leakages**. Additions to domestic spending—investment (I), government purchases (G), and exports (X)—are termed **injections**. In macroeconomic equilibrium, total leakages must equal total injections:

$$S + T + M = I + G + X$$

Where:

- S denotes private household and corporate saving in dollars over the accounting period.
- T denotes net tax revenue (taxes collected less government transfer payments such as Age Pension or JobSeeker).
- M denotes total expenditure on imported goods and services from foreign producers.
- I denotes private gross fixed capital formation plus changes in business inventories.
- G denotes government final consumption and public capital expenditure (excluding transfer payments).
- X denotes foreign expenditure on domestically produced exports.

1.3 Measuring Gross Domestic Product (GDP): Three Equivalent Approaches

Gross Domestic Product (GDP) is defined as the market value of all final goods and services produced within a country's geographic borders during a specified period, typically a quarter or a year. The ABS compiles the *Australian System of National Accounts* (Catalogue 5204.0 and 5206.0) using three conceptually identical methods:

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1. **The Expenditure Approach:** Sums total spending on domestically produced final goods and services across four institutional categories:

$$Y = C + I + G + (X - M)$$

Where:

- Y represents nominal or real Gross Domestic Product depending on whether current or constant prices are used.
- C represents household final consumption expenditure (durable goods, non-durable goods, and services, including imputed rent on owner-occupied dwellings).
- I represents gross private domestic investment (business machinery, software, non-residential structures, new residential construction, and inventory changes—excluding purely financial asset purchases such as ASX shares).
- G represents federal, state, and local government expenditure on final goods and services (such as public hospitals, defence, and infrastructure, excluding transfer payments).
- $X - M$ represents net exports (NX), subtracting imported content already embedded within C, I, and G.

2. **The Income Approach:** Sums all factor incomes earned from domestic production plus taxes less subsidies on production and imports. In ABS national accounts, this equals Compensation of Employees (COE, wages, salaries, and employer superannuation contributions) plus Gross Operating Surplus (GOS, corporate profits and depreciation) plus Gross Mixed Income (GMI, income of unincorporated sole traders) plus Net Taxes on Production and Imports ($T_{prod} - Sub$):

$$GDP = COE + GOS + GMI + (T_{prod} - Sub)$$

Where:

- COE is total remuneration payable to employees for labour services, including compulsory Superannuation Guarantee contributions.
- GOS is corporate operating profits before interest, taxes, and depreciation (consumption of fixed capital).
- GMI is the combined return to labour and capital earned by unincorporated enterprises such as family farms and sole proprietors.
- $T_{prod} - Sub$ represents indirect taxes such as the Goods and Services Tax (GST) and customs duties, minus government production subsidies.

3. **The Production (Value-Added) Approach:** Sums the **value added** generated by every industry at each stage of production, where value added equals the market value of gross output minus the cost of intermediate inputs purchased from other firms. Counting only value added prevents double counting of raw materials and intermediate components.

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Worked Example 1.1: Reconciling the Three GDP Approaches in an Australian Supply Chain

Consider a simplified domestic supply chain in Victoria producing artisanal roasted coffee sold in Melbourne cafes during a quarter. Suppose an Australian dairy and agricultural cooperative supplies raw inputs worth $0 of intermediate purchases and sells green beans and dairy inputs to a Melbourne roaster for $420,000, paying $260,000 in wages and earning $160,000 in gross operating surplus. The roaster purchases those $420,000 inputs, processes and packages coffee beans, pays $310,000 in wages, retains $170,000 in operating surplus, and sells roasted beans to hospitality venues for $900,000. Finally, Melbourne cafes purchase the $900,000 roasted beans, pay $620,000 in barista wages, earn $230,000 in operating surplus, and sell final coffees to households for $1,750,000 (excluding GST for simplicity).

Stage of Production	Sales Revenue ($)	Intermediate Inputs ($)	Value Added ($)	Wages Paid ($)	Operating Surplus ($)
Primary / Input Supplier	420,000	0	420,000	260,000	160,000
Melbourne Coffee Roaster	900,000	420,000	480,000	310,000	170,000
Hospitality Cafes (Final Retail)	1,750,000	900,000	850,000	620,000	230,000
Total Economy Aggregate	**3,070,000**	**1,320,000**	**1,750,000**	**1,190,000**	**560,000**

All three national accounting approaches yield the exact same GDP of $1,750,000:

- **Expenditure Approach:** Final sales to households equal $1,750,000 (intermediate sales of $420,000 and $900,000 are excluded).
- **Value-Added Approach:** Sum of value added across all three stages equals $420,000 + $480,000 + $850,000 = $1,750,000.
- **Income Approach:** Sum of wages ($1,190,000) plus operating surplus ($560,000) equals $1,750,000.

1.4 GDP Versus Gross National Income (GNI) and Limitations of GDP

While GDP measures production occurring *within* Australia's borders regardless of who owns the productive factors, **Gross National Income (GNI)** measures the income earned by Australian residents regardless of where the production takes place:

$$GNI = GDP + \text{Net Primary Income from Abroad}$$

Where:

- GNI is total income accruing to domestic residents and domestically owned corporations.

- Net Primary Income from Abroad equals wages, dividends, interest, and reinvested earnings received by Australians from overseas investments minus equivalent factor payments remitted to foreign investors who own equity or debt in Australian enterprises.

Because Australia has historically relied on net foreign capital inflows to finance mining, infrastructure, and banking investment, Australian Net Primary Income from Abroad is typically negative, meaning Australian GNI is slightly lower than Australian GDP.

Furthermore, GDP is a measure of market production rather than comprehensive societal well-being. It omits non-market household production (unpaid childcare, eldercare, and domestic maintenance), the informal or cash economy, leisure time, income distribution across quintiles, and environmental externalities such as carbon emissions or depletion of non-renewable mineral reserves. Consequently, economists supplement GDP per capita with broader measures such as real Net National Disposable Income (NNDI), the ABS *Measuring What Matters* framework, and inequality metrics like the Gini coefficient.

Chapter 2: Nominal vs Real GDP, Chain Volume Measures & Price Indices

2.1 Nominal GDP, Real GDP, and the GDP Deflator

Because GDP sums the dollar value of heterogeneous goods and services, an increase in nominal GDP over time may reflect either higher physical quantities produced or higher market prices. To isolate genuine changes in production volume, macroeconomists distinguish between nominal and real GDP:

- **Nominal GDP (GDP_{nom}):** Values current-period quantities at current-period market prices: $GDP_{nom,t} = \sum_i P_{i,t} Q_{i,t}$.
- **Real GDP (GDP_{real}):** Values current-period quantities using base-period (constant) prices: $GDP_{real,t} = \sum_i P_{i,0} Q_{i,t}$ in a fixed-base Laspeyres formulation, or using annually updated price weights in the ABS **chain volume measure**.

In fixed-base national accounts, choosing an outdated base year introduces substitution bias because goods whose relative prices fall sharply over time (such as semiconductors and computing equipment) receive excessively large weights from the distant base year. Since the late 1990s, the ABS has mitigated this bias by publishing **chain volume measures** of real GDP, which link consecutive annual price-weighted volume indices together using prior-year prices as rolling weights.

The implicit price index connecting nominal and real GDP is the **GDP Deflator**, which captures the average price level of all domestically produced final goods and services:

$$\text{GDP Deflator}_t = \left(\frac{\text{Nominal GDP}_t}{\text{Real GDP}_t}\right) \times 100$$

Where:

- GDP Deflator_t is the economy-wide production price index in period t (equal to 100 in the reference base period).
- Nominal GDP_t is total domestic output valued at period-t prices.
- Real GDP_t is total domestic output valued at base-period or chain-volume reference prices.

Worked Example 2.1: Computing Nominal GDP, Real GDP, and the GDP Deflator

Suppose a small Australian regional economy produces only two final goods: iron ore (measured in tonnes) and tertiary education services (measured in student-semesters). Base-year prices are set in Year 1.

Period	Iron Ore Price ($/tonne)	Iron Ore Qty (tonnes)	Education Price ($/unit)	Education Qty (units)
Year 1 (Base)	120	1,000	5,000	40
Year 2	150	1,100	5,400	45

Step 1 — Nominal GDP:

In Year 1: $(120 \times 1,000) + (5,000 \times 40) = 120,000 + 200,000 = \$320{,}000$.

In Year 2: $(150 \times 1,100) + (5,400 \times 45) = 165,000 + 243,000 = \$408{,}000$. Nominal GDP grew by $\frac{408,000 - 320,000}{320,000} = 27.50\%$.

Step 2 — Real GDP (at Year 1 constant prices):

In Year 1: \$320,000 (equal to Nominal GDP in the base year).

In Year 2: $(120 \times 1,100) + (5,000 \times 45) = 132,000 + 225,000 = \$357{,}000$. Real GDP grew by $\frac{357,000 - 320,000}{320,000} = 11.56\%$.

Step 3 — GDP Deflator and Deflator Inflation:

In Year 1: $\frac{320,000}{320,000} \times 100 = 100.00$.

In Year 2: $\frac{408,000}{357,000} \times 100 = 114.29$. Thus, the GDP deflator inflation rate between Year 1 and Year 2 is 14.29%.

2.2 The Consumer Price Index (CPI) and Inflation Measurement

While the GDP deflator tracks the prices of all domestically produced goods and services (including capital goods and exports, while excluding imports), the **Consumer Price Index (CPI)** measures the change in the cost of a fixed representative basket of goods and services purchased by metropolitan households across Australia's eight capital cities (Sydney, Melbourne, Brisbane, Adelaide, Perth, Hobart, Darwin, and Canberra). In Australia, the ABS updates CPI expenditure weights annually using household expenditure and national accounts data to reduce substitution bias.

Mathematically, a fixed-basket CPI compares the cost of the reference basket in period t to its cost in the base period 0:

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$$CPI_t = \left(\frac{\sum_{i=1}^{n} P_{i,t} Q_{i,0}}{\sum_{i=1}^{n} P_{i,0} Q_{i,0}}\right) \times 100$$

Where:

- CPI_t is the Consumer Price Index in period t (referenced to 100 in the base period).
- $P_{i,t}$ and $P_{i,0}$ denote the retail price of item i in period t and base period 0, respectively.
- $Q_{i,0}$ denotes the fixed quantity weight of item i in the representative household basket.

The annual percentage rate of **headline inflation** (π_t) between period $t-1$ and period t is calculated as:

$$\pi_t = \left(\frac{CPI_t - CPI_{t-1}}{CPI_{t-1}}\right) \times 100$$

Where:

- π_t is the percentage inflation rate over the period from $t-1$ to t.
- CPI_t and CPI_{t-1} are the index values at the end and start of the measurement period.

Because headline CPI can be distorted by temporary supply shocks to volatile items such as fresh fruit and vegetables or automotive fuel, the RBA closely monitors measures of **underlying (core) inflation**—specifically the **trimmed mean CPI** (which excludes the largest 15 per cent price rises and largest 15 per cent price falls by weight each quarter) and the **weighted median CPI**. Notice also the structural difference between the CPI and the GDP deflator: a surge in the price of imported European automobiles raises the Australian CPI immediately because households buy imported cars, whereas it does not directly enter the Australian GDP deflator because those vehicles are not produced domestically. Conversely, a surge in Australian iron ore export prices raises the GDP deflator but leaves the domestic household CPI largely unaffected.

2.3 Measurement Biases, Real Values, and the Fisher Equation

Even with annual re-weighting, fixed-basket price indices tend to overstate true changes in the cost of living by roughly 0.5 to 1.0 percentage points annually due to four well-documented biases:

- **Substitution Bias:** Consumers substitute away from goods whose relative prices rise sharply toward relatively cheaper alternatives, whereas a fixed-weight basket assumes rigid proportions.
- **Outlet Substitution Bias:** Households shift purchases toward discount retailers and online platforms that price-collectors may under-sample.
- **Quality Change Bias:** Price increases that reflect genuine improvements in product durability, safety, or computing performance should not be counted as pure inflation.
- **New Goods Bias:** Newly introduced goods and digital services gain substantial consumer surplus before entering the official CPI basket.

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Comparing dollar magnitudes across time requires converting nominal figures into constant-purchasing-power real values, and distinguishing nominal from real interest rates via the **Fisher equation**:

$$r \approx i - \pi^e \quad \text{and exactly} \quad 1 + r = \frac{1 + i}{1 + \pi^e}$$

Where:

- r is the ex-ante real interest rate (purchasing-power return per annum).
- i is the nominal interest rate quoted on a loan, deposit, or government bond.
- π^e is the expected annual inflation rate over the life of the financial contract.

Worked Example 2.2: CPI Inflation, Real Wage Growth, and the Exact Fisher Relation

Suppose the Australian CPI rises from 130.0 in June 2025 to 135.2 in June 2026, while a graduate analyst in Melbourne receives a nominal salary increase from $72,000 to $74,160 and earns a nominal term-deposit rate of $i = 4.80\%$ with expected inflation $\pi^e = 4.00\%$.

1. **Headline Inflation Rate:** $\pi = \frac{135.2 - 130.0}{130.0} \times 100 = 4.00\%$.
2. **Nominal vs Real Wage Change:** Nominal wage growth is $\frac{74{,}160 - 72{,}000}{72{,}000} \times 100 = 3.00\%$. Converting the 2026 wage into June 2025 dollars gives $\frac{74{,}160}{135.2/130.0} = \frac{74{,}160}{1.04} = \$71{,}307.69$. Because nominal wage growth (3.00%) fell short of CPI inflation (4.00%), real purchasing power declined by $\frac{71{,}307.69 - 72{,}000}{72{,}000} = -0.96\%$.
3. **Real Interest Rate:** Using the approximation, $r \approx 4.80\% - 4.00\% = 0.80\%$. Using the exact Fisher formula, $r = \frac{1.048}{1.040} - 1 = 0.007692 = 0.77\%$ per annum.

2.4 Economic Costs of Anticipated and Unanticipated Inflation

Even perfectly anticipated inflation imposes real resource costs: **shoe-leather costs** (time and effort spent economising on non-interest-bearing cash balances), **menu costs** (expenses of updating price lists, software, and contracts), **relative-price distortions** when firms adjust prices asynchronously, and **bracket creep / tax distortions** when progressive income tax thresholds or nominal capital gains are not automatically indexed to CPI. Unanticipated inflation imposes sharper redistributive and efficiency costs: it arbitrarily transfers wealth from creditors to debtors (when actual π exceeds π^e, lowering the ex-post real interest rate), erodes fixed nominal pensions, and heightens price uncertainty, discouraging long-term capital investment. Conversely, **deflation** (persistent negative inflation) raises the real burden of nominal debt (debt-deflation spiral) and induces households to defer consumption while pushing nominal interest rates toward the zero lower bound.

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Chapter 3: Labour Market Indicators, Participation & Unemployment Typologies

3.1 ABS Labour Force Framework and Core Ratios

In Australia, the ABS Monthly Labour Force Survey classifies the civilian population aged 15 years and over into three mutually exclusive categories based on activity during the survey reference week:

- **Employed (E):** Persons aged 15+ who worked for at least one hour for pay, profit, commission, or payment in kind, or who worked without pay in a family business, or who had a job from which they were temporarily absent on leave.
- **Unemployed (U):** Persons aged 15+ who were not employed during the reference week, had actively looked for full-time or part-time work at any time in the prior four weeks, and were available to start work in the reference week.
- **Not in the Labour Force ($NILF$):** Persons aged 15+ who were neither employed nor actively seeking and available for work—such as full-time university students not working or job-seeking, retirees, and full-time carers.

The sum of employed and unemployed persons forms the **Labour Force ($LF = E + U$)**, and the total working-age civilian population is $WAP = LF + NILF$. Three core labour market indicators are derived from these counts:

$$\text{Unemployment Rate } (u) = \left(\frac{U}{LF}\right) \times 100$$

$$\text{Labour Force Participation Rate } (LFPR) = \left(\frac{LF}{WAP}\right) \times 100$$

$$\text{Employment-to-Population Ratio} = \left(\frac{E}{WAP}\right) \times 100$$

Where:

- U is the total number of unemployed individuals actively seeking and available for work.
- E is the total number of employed individuals (full-time plus part-time).
- $LF = E + U$ is the active civilian labour force.
- WAP is the civilian working-age population aged 15 years and older.

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Worked Example 3.1: Computing ABS Labour Market Aggregates

Suppose a representative snapshot of the Australian labour market records 14,250,000 employed persons, 600,000 unemployed persons, and 7,650,000 persons aged 15+ not in the labour force.

- **Labour Force (LF):** $LF = 14,250,000 + 600,000 = 14,850,000$ persons.
- **Working-Age Population (WAP):** $WAP = 14,850,000 + 7,650,000 = 22,500,000$ persons.
- **Unemployment Rate (u):** $\frac{600,000}{14,850,000} \times 100 = 4.04\%$.
- **Participation Rate ($LFPR$):** $\frac{14,850,000}{22,500,000} \times 100 = 66.00\%$.
- **Employment-to-Population Ratio:** $\frac{14,250,000}{22,500,000} \times 100 = 63.33\%$.

Notice a critical nuance: if 150,000 unemployed job-seekers become discouraged and stop searching for work, they move from U to $NILF$. Both U and LF fall by 150,000, causing the measured unemployment rate to drop artificially to $\frac{450,000}{14,700,000} \times 100 = 3.06\%$ even though zero jobs were created. For this reason, the ABS also publishes the **underemployment rate** (employed part-time workers willing and available to work more hours) and the **underutilisation rate** (sum of unemployment and underemployment as a share of the labour force), alongside **hours worked**.

3.2 Typologies of Unemployment, Wage Rigidity, and the NAIRU

Economists decompose aggregate unemployment into distinct functional categories because each carries different welfare implications and requires distinct policy remedies:

Unemployment Type	Underlying Mechanism	Primary Policy Remedy
Frictional	Time required for job search and matching between heterogeneous workers and vacancies (e.g., graduates entering the market).	Job-matching platforms, transparent credential recognition, mobility support.
Structural	Persistent mismatch between worker skills or locations and employer demand due to technological change, offshoring, or institutional wage floors.	TAFE/university retraining, vocational education, regional infrastructure, labour market deregulation.
Cyclical	Insufficient aggregate demand during economic downturns or recessions when sticky wages prevent rapid labour market clearing.	Expansionary monetary policy (RBA cash rate cuts) and countercyclical fiscal stimulus.
Seasonal	Predictable calendar fluctuations in sectors such as tourism, hospitality, construction, and agricultural harvesting.	Seasonal adjustment in ABS reporting; flexible work arrangements.

Even when an economy operates at potential output with zero cyclical unemployment, frictional and structural unemployment remain positive. This baseline equilibrium rate is termed the **natural rate of unemployment** or, in inflation-targeting frameworks, the **Non-Accelerating Inflation Rate of Unemployment (NAIRU)**, denoted u^*. The RBA estimates Australia's NAIRU to lie broadly in the 4.0% to 4.5% range, though it shifts slowly over time with labour market efficiency and demographics.

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Structural unemployment can also arise when real wages are held persistently above the market-clearing equilibrium wage (W^*) due to three institutional or behavioural mechanisms: (1) **Minimum wages and industrial awards** set by the Fair Work Commission, which protect low-paid workers but can reduce hiring of lower-productivity entrants if set too high relative to marginal product; (2) **Collective bargaining and union power**, creating insider-outsider wage rigidity; and (3) **Efficiency wages**, whereby firms voluntarily pay above-clearing wages to raise worker morale, reduce costly turnover, attract higher-quality applicants, and deter shirking.

Finally, prolonged recessions can generate **hysteresis**: long-term unemployed workers experience skill atrophy, weaker professional networks, and employer stigma, causing temporary cyclical unemployment to harden into permanent structural unemployment and raising the NAIRU over time.

Chapter 4: Long-Run Economic Growth, Productivity & Capital Accumulation

4.1 Compounding, Real GDP Per Capita, and the Rule of 70

Short-run business cycles cause real GDP to fluctuate around trend, but long-run living standards are governed almost entirely by sustained growth in **real GDP per capita** and **labour productivity** (output per hour worked). Over multi-decade horizons, small differences in annual compound growth rates generate dramatic divergence in material prosperity.

If real GDP per capita starts at y_0 and grows at constant annual rate g, its level after t years is $y_t = y_0(1+g)^t$. A convenient benchmark for compounding speed is the **Rule of 70**, which approximates the number of years required for a variable growing at $g\%$ per year to double:

$$\text{Doubling Time (years)} \approx \frac{70}{g_{\%}}$$

Where:

- $g_{\%}$ is the annual compound percentage growth rate (for example, $g_{\%} = 2.0$ for 2% annual growth).

At 3.5% annual per-capita growth, living standards double roughly every $\frac{70}{3.5} = 20$ years; at 1.0% annual growth, doubling requires 70 years. Historically, Australia achieved rapid post-war and 1990s productivity growth (averaging over 2% annual multifactor and labour productivity gains during the microeconomic reform era), whereas slower productivity growth in the 2010s and early 2020s has become a central policy focus of the Productivity Commission.

4.2 The Aggregate Production Function and Per-Worker Output

To analyse the proximate sources of growth, economists specify an aggregate production function exhibiting **constant returns to scale (CRS)** and diminishing marginal returns to individual inputs. In standard Cobb-Douglas form:

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$$Y = AK^{\alpha}L^{1-\alpha}, \qquad 0 < \alpha < 1$$

Where:

- Y is total real output (real GDP).
- A denotes **Total Factor Productivity (TFP)**, capturing technological know-how, management quality, institutional efficiency, and intangible capital.
- K is the aggregate physical capital stock (machinery, buildings, infrastructure, equipment).
- L is aggregate labour input (total hours worked or workers).
- α is the output elasticity of capital (typically around 0.30 to 0.35 in industrialised economies, matching capital's share of national income under competitive markets).

Dividing both sides by L transforms the production function into intensive (per-worker) form, writing $y = Y/L$ for output per worker and $k = K/L$ for the capital-labour ratio (capital deepening):

$$y = Ak^{\alpha}$$

Where:

- $y = Y/L$ is labour productivity (output per worker).
- $k = K/L$ is physical capital per worker.
- A is Total Factor Productivity.

Because $\alpha \in (0, 1)$, the derivative $\frac{dy}{dk} = \alpha A k^{\alpha-1} > 0$ is positive, while the second derivative $\frac{d^2y}{dk^2} < 0$ is negative. Adding more machines per worker raises labour productivity, but each additional unit of capital yields smaller and smaller increments to output when technology A and labour L are held fixed.

4.3 The Solow-Swan Capital Accumulation Model and Steady State

Robert Solow (1956) and Australian economist Trevor Swan (1956, at the Australian National University) independently formalised how saving, depreciation, population growth, and technological progress determine long-run output per worker. Assume a closed economy with no government where a constant fraction $s \in (0, 1)$ of output is saved and invested ($i = sy$), physical capital depreciates at constant rate δ, and the labour force grows at rate n.

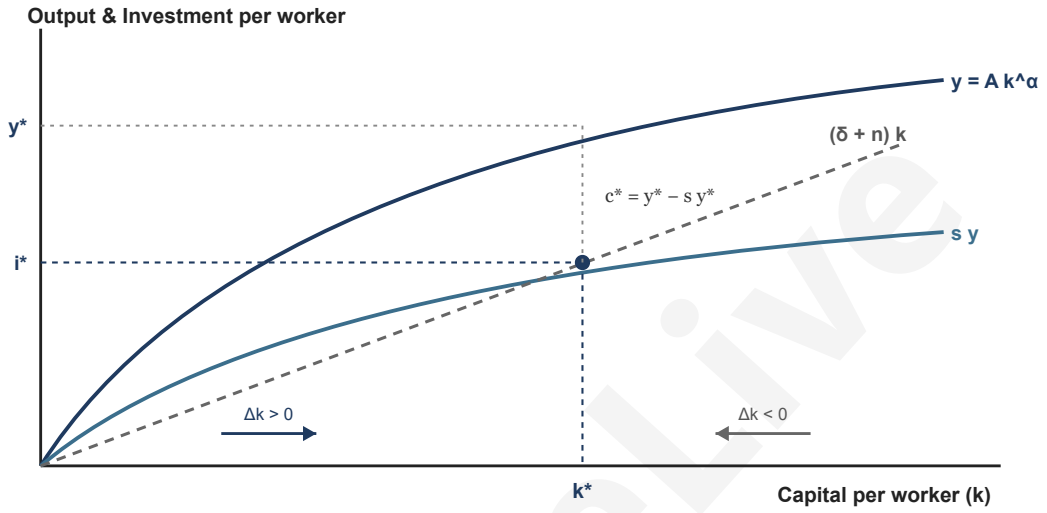
In per-worker terms, investment per worker adds to the capital-labour ratio (sy), while depreciation and spreading existing capital across new workers dilute the capital-labour ratio by $(\delta + n)k$. Thus, the fundamental Solow-Swan equation of motion is:

$$\Delta k = sy - (\delta + n)k = sAk^{\alpha} - (\delta + n)k$$

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Where:

- Δk is the annual change in capital per worker ($k_{t+1} - k_t$).
- s is the aggregate saving (and investment) rate as a share of GDP.
- δ is the annual rate of physical capital depreciation.
- n is the annual growth rate of the labour force.
- $(\delta + n)k$ is **break-even investment** required to hold capital per worker constant.



Because sAk^{α} is concave while $(\delta + n)k$ is linear, the two curves intersect at a unique positive **steady-state capital-labour ratio (k^*)** where $\Delta k = 0$. Setting $sA(k^*)^{\alpha} = (\delta + n)k^*$ yields the closed-form steady state:

$$k^* = \left(\frac{sA}{\delta + n}\right)^{\frac{1}{1-\alpha}} \quad \text{and} \quad y^* = A^{\frac{1}{1-\alpha}} \left(\frac{s}{\delta + n}\right)^{\frac{\alpha}{1-\alpha}}$$

Where:

- k^* is the long-run steady-state capital stock per worker where investment per worker exactly offsets depreciation and labour dilution.
- y^* is the steady-state level of output per worker (labour productivity).

Worked Example 4.1: Calculating Steady-State Capital and Output in the Solow-Swan Model

Suppose an economy has an aggregate production function $y = Ak^{0.5}$ (so $\alpha = 0.5$), Total Factor Productivity $A = 2.0$, a saving rate $s = 0.25$ (25% of GDP), a depreciation rate $\delta = 0.08$ (8% per year), and labour force growth $n = 0.02$ (2% per year).

1. **Break-even requirement rate:** $\delta + n = 0.08 + 0.02 = 0.10$.
2. **Steady-state capital per worker (k^*):**

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$$k^* = \left(\frac{0.25 \times 2.0}{0.10}\right)^{\frac{1}{1-0.5}} = (5.0)^2 = 25.0 \text{ units per worker}$$

3. **Steady-state output per worker (y^*):**

$$y^* = 2.0 \times (25.0)^{0.5} = 2.0 \times 5.0 = 10.0 \text{ units per worker}$$

4. **Steady-state consumption per worker (c^*):**

$$c^* = (1 - s)y^* = (1 - 0.25) \times 10.0 = 7.5 \text{ units per worker}$$

5. **Effect of raising the saving rate to $s = 0.30$:** The new steady state becomes $k^{**} = \left(\frac{0.30 \times 2.0}{0.10}\right)^2 = 36.0$ and $y^{**} = 2.0 \times 6.0 = 12.0$. Notice that raising s temporarily increases growth during the transition from $k^* = 25$ to $k^{**} = 36$, permanently raising the *level* of y^*, yet once the new steady state is reached, per-worker output stops growing unless TFP (A) expands continuously.

4.4 Productivity, Convergence, and Australian Long-Run Growth Policy

The fundamental insight of the Solow-Swan model is that capital accumulation alone faces diminishing returns and cannot sustain perpetual growth in per-capita income. Sustained long-run growth in living standards requires ongoing technological innovation and human capital deepening—increases in A driven by research and development (R&D), university education, digital infrastructure, competition policy, and institutional quality (secure property rights, contract enforcement, and low corruption).

The model also predicts **conditional convergence**: economies that share identical saving rates, population growth rates, and technologies (s, n, δ, A) will converge toward the same steady-state income per worker regardless of their initial capital stock, because capital-scarce economies enjoy a higher marginal product of capital ($\alpha A k^{\alpha-1}$) and grow faster during transition. Empirical evidence confirms strong convergence among OECD economies and East Asian industrialisers, whereas countries trapped by weak institutions, low education, or macroeconomic instability converge to lower steady states.

In Australia, long-run macroeconomic policy focuses heavily on lifting multifactor productivity alongside skilled migration and superannuation-supported national saving. Compulsory Superannuation Guarantee contributions (rising to 12% of ordinary time earnings) bolster the domestic pool of long-term capital available for infrastructure and corporate investment, while microeconomic reforms overseen by bodies such as the ACCC and Productivity Commission aim to raise A through competition, renewable energy grid integration, and human capital investment.

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