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Bachelor of Commerce (B2001) | Level 2 • Part B Major | Monash University

# Intermediate macroeconomics

Course Code: ECC2010 • Module 2 Notes

# Module 2: Short-Run Fluctuations: IS-LM, IS-MP-PC & Business Cycle Models

## Chapter 1: Business Cycle Stylised Facts & Short-Run Price Rigidity

### 1.1 Anatomy of Macroeconomic Fluctuations

Whereas Module 1 examined the supply-side determinants of long-run economic growth, short-run macroeconomics investigates why real GDP, employment, and inflation fluctuate around their long-run trends over horizons of one to five years. Business cycles are recurring—though non-periodic—expansions and contractions in aggregate economic activity. Since the early 1990s, Australia experienced nearly three decades of uninterrupted annual expansion before the 2020 COVID-19 contraction, followed by a rapid demand recovery and an inflation surge during 2022–2023.

Empirical analysis of ABS quarterly national accounts reveals several universal stylised facts regarding macroeconomic co-movement and relative volatility:

- **Procyclicality and Persistence:** Aggregate expenditure components—household consumption ($C$), private business and dwelling investment ($I$), imports ($M$), and hours worked—move positively with real GDP (*procyclical*) and exhibit strong serial correlation across quarters.
- **Relative Volatility:** Private fixed capital formation and durable goods consumption are roughly three to five times more volatile than real GDP, whereas non-durable consumption and services are substantially smoother than GDP, reflecting household consumption-smoothing behaviour.
- **Countercyclical Unemployment:** The unemployment rate rises sharply during recessions and falls gradually during expansions, often lagging turning points in real GDP because firms hoard labour initially and delay hiring until recovery is assured.
- **Procyclical Inflation and Policy Rates:** Inflation typically accelerates when demand persistently exceeds productive capacity and decelerates following contractions, while the Reserve Bank of Australia (RBA) adjusts the cash rate procyclically to lean against demand-driven overheating or recessions.

### 1.2 Potential Output, the Output Gap, and Okun's Law

Short-run stabilisation models centre on deviations of actual real GDP ($Y_t$) from **potential output** ($Y_n$), defined as the level of output an economy can sustain when labour and capital are utilised at their non-inflationary equilibrium rates (the NAIRU, $u_n$, and normal capacity utilisation). The percentage **output gap** ($\widetilde{y}_t$) measures cyclical slack or excess demand:

$$\widetilde{y}_t = \frac{Y_t - Y_n}{Y_n} \times 100$$

Where: $\widetilde{y}_t$ is the percentage output gap in period $t$; $Y_t$ is actual real GDP; and $Y_n$ is potential (natural) real GDP. A negative output gap ($\widetilde{y}_t < 0$) signals a recessionary or deflationary gap with spare capacity, whereas a positive output gap ($\widetilde{y}_t > 0$) signals an inflationary boom.

Because output fluctuations alter firms' demand for labour hours, Arthur Okun (1962) established an empirical regularity linking output growth and changes in the unemployment rate ($u_t$). In growth-rate form and gap form, **Okun's Law** is expressed as:

$$u_t - u_{t-1} = -\beta\left(g_{Y,t} - \bar{g}_Y\right), \qquad u_t - u_n = -\beta\widetilde{y}_t$$

Where: $u_t$ is the unemployment rate; $u_n$ is the natural rate of unemployment (NAIRU); $g_{Y,t}$ is actual real GDP growth; $\bar{g}_Y$ is the trend growth rate of potential output; $\widetilde{y}_t$ is the percentage output gap; and $\beta \in (0.3, 0.5)$ is the Okun coefficient. Notice that $\beta < 1$ because a $1\%$ decline in output reduces employment by less than $1\%$ due to labour hoarding, reduced average hours per worker, and discouraged-worker exits from the labour force.

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#### Worked Example 1: Estimating Output Gaps and Unemployment via Okun's Law

Suppose Australia's potential real GDP grows at $\bar{g}_Y = 2.75\%$ per year, the NAIRU is estimated at $u_n = 4.25\%$, and the Okun coefficient is $\beta = 0.40$. Initially, the economy is at potential output ($Y_0 = Y_{n,0}$, $u_0 = 4.25\%$). In Year 1, restrictive monetary policy and weaker global demand slow actual real GDP growth to $g_{Y,1} = 1.00\%$.

1. **Output gap at the end of Year 1:** Relative to potential output growing at $2.75\%$, actual output falls short by:

$$\widetilde{y}_1 \approx g_{Y,1} - \bar{g}_Y = 1.00\% - 2.75\% = -1.75\%$$

2. **Change in the unemployment rate:** Applying Okun's Law:

$$\Delta u_1 = -0.40 \times (1.00\% - 2.75\%) = -0.40 \times (-1.75\%) = +0.70 \text{ percentage points}$$

   Thus the unemployment rate rises from $4.25\%$ to $u_1 = 4.95\%$.

3. **Growth required in Year 2 to return to NAIRU:** To lower unemployment by $0.70$ percentage points back to $4.25\%$, the economy must grow above trend by $0.70/0.40 = 1.75\%$, requiring Year 2 GDP growth of $2.75\% + 1.75\% = 4.50\%$.

### 1.3 Nominal Rigidities: Why Aggregate Demand Matters in the Short Run

In a frictionless classical economy with instantaneously flexible prices and wages, changes in aggregate nominal spending affect only the price level while real output stays fixed at $Y_n$. In practice, short-run output responds strongly to demand shocks because of nominal rigidities:

- **Sticky Nominal Wages:** Multi-year enterprise bargaining agreements (EBAs), Fair Work Commission annual wage reviews, and implicit contracts prevent nominal wages from falling rapidly during downturns.
- **Menu Costs and Staggered Price Setting:** Firms face administrative, informational, and customer-relationship costs when changing posted prices (Calvo staggered pricing or Rotemberg quadratic adjustment costs). Consequently, when aggregate demand falls, firms initially hold prices relatively steady and cut production and hours instead.

## Chapter 2: Goods Market Equilibrium & the IS Curve

### 2.1 Planned Aggregate Expenditure and the Keynesian Cross

The goods market equilibrium condition requires that real output ($Y$) equals planned aggregate expenditure ($E$):

$$Y = E = C + I + G + NX$$

Where: $Y$ is real output (income); $C$ is household consumption; $I$ is planned private investment; $G$ is government purchases of goods and services; and $NX = X - M$ is net exports (exports minus imports). Behavioural equations specify each component linearly around equilibrium:

$$C = c_0 + c_1(Y - T), \qquad T = t_0 + tY$$

$$I = \bar{I} - br, \qquad G = \bar{G}, \qquad NX = \overline{NX} - mY$$

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Where: $c_0 > 0$ is autonomous consumption; $c_1 \in (0,1)$ is the marginal propensity to consume (MPC) out of disposable income $Y_d = Y - T$; $t_0$ is lump-sum net taxes and $t \in [0,1)$ is the proportional income tax rate; $\bar{I}$ is autonomous investment; $b > 0$ is the interest sensitivity of investment; $r$ is the real interest rate; $\bar{G}$ is exogenous government purchases; $\overline{NX}$ is autonomous net exports; and $m \in (0,1)$ is the marginal propensity to import.

Grouping all terms independent of $Y$ and $r$ into autonomous expenditure $\bar{A} = c_0 - c_1 t_0 + \bar{I} + \bar{G} + \overline{NX}$, planned expenditure becomes $E = \bar{A} - br + [c_1(1-t) - m]Y$. Equating $Y = E$ solves for the **IS (Investment-Saving) curve**:

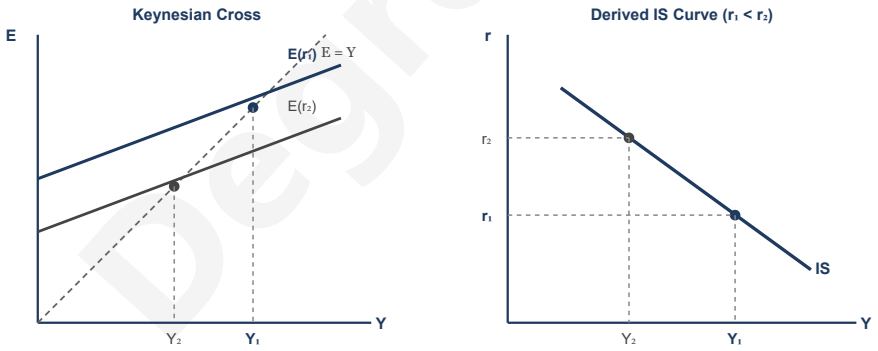
$$Y = \frac{1}{1 - c_1(1-t) + m}(\bar{A} - br)$$

Where: $\mu = \frac{1}{1-c_1(1-t)+m}$ is the open-economy Keynesian spending multiplier; $\bar{A}$ is total autonomous spending; $b$ is the interest-rate responsiveness of aggregate demand (investment plus interest-sensitive durable consumption); and $r$ is the real interest rate. Because $b > 0$, a higher real interest rate reduces planned investment and durable spending, lowering equilibrium output via the multiplier—producing a downward-sloping IS curve in $(Y, r)$ space.

## 2.2 Fiscal Multipliers, Automatic Stabilisers, and IS Slope

Differentiating the IS equation with respect to government purchases, lump-sum taxes, and the real interest rate yields three core comparative-static results:

- **Government Purchases Multiplier ($\Delta Y / \Delta \bar{G}$):** Equal to $\mu = \frac{1}{1-c_1(1-t)+m}$. Note that proportional income taxes ($t > 0$) and import leakages ($m > 0$) both reduce the multiplier by acting as **automatic stabilisers**, dampening output swings from private demand shocks.
- **Tax Multiplier ($\Delta Y / \Delta t_0$):** Equal to $-c_1\mu = \frac{-c_1}{1-c_1(1-t)+m}$. In absolute value, a lump-sum tax cut has a smaller initial impact than an equal-sized increase in $G$ because households save a fraction $(1 - c_1)$ of the tax rebate in the first round.
- **Slope of the IS Curve:** Expressing the IS curve with $r$ on the vertical axis gives $r = \frac{\bar{A}}{b} - \frac{1}{\mu b}Y$. The IS curve is flatter when investment is highly sensitive to the real interest rate ($b$ is large) or when the spending multiplier $\mu$ is large.




### Worked Example 2: Open-Economy Multiplier and IS Schedule

Suppose a small open economy has parameters $c_0 = 120$, $c_1 = 0.75$, lump-sum tax $t_0 = 40$, marginal tax rate $t = 0.20$, planned investment $I = 350 - 15r$ (where $r$ is measured in percentage points, e.g., $r = 4$ for 4%), government purchases $\bar{G} = 400$, and net exports $NX = 100 - 0.10Y$ (all currency figures in billion AUD).

1. **Autonomous spending ($\bar{A}$) and multiplier ($\mu$):**

$$\bar{A} = c_0 - c_1 t_0 + \bar{I} + \bar{G} + \overline{NX} = 120 - (0.75 \times 40) + 350 + 400 + 100 = 940$$

$$\mu = \frac{1}{1 - c_1(1-t) + m} = \frac{1}{1 - 0.75(1-0.20) + 0.10} = \frac{1}{1 - 0.60 + 0.10} = \frac{1}{0.50} = 2.00$$

2. **IS equation and equilibrium at $r = 4\%$:**

$$Y = 2.00(940 - 15r) = 1{,}880 - 30r$$

At $r = 4$, equilibrium GDP is $Y = 1{,}880 - 30(4) = 1{,}760$ billion AUD.

3. **Fiscal expansion holding $r$ constant:** If the Commonwealth Government raises infrastructure spending $\bar{G}$ by $50$ billion AUD to $450$, $\bar{A}$ rises to $990$ and the IS curve shifts horizontally rightward by $\Delta Y = \mu \Delta \bar{G} = 2.00 \times 50 = 100$ billion AUD (to $Y = 1{,}860$ billion AUD at $r = 4\%$).

## Chapter 3: Money Market Equilibrium, the LM Curve & Policy Mix

### 3.1 Liquidity Preference and the LM Schedule

In the traditional Hicks-Hansen IS-LM model, the central bank controls the nominal money supply ($M$). Households and firms allocate wealth between non-interest-bearing money and interest-bearing bonds. Real money demand ($M^d/P$) increases with real income ($Y$, reflecting transaction needs) and decreases with the nominal interest rate ($i = r + \pi^e$, the opportunity cost of holding cash rather than bonds). Equating real money supply ($M/P$) to linear real money demand yields the **LM (Liquidity-Money) curve**:

$$\frac{M}{P} = L(Y, i) = kY - h(r + \pi^e)$$

Where: $M$ is the nominal money stock; $P$ is the price level (fixed in the short run at $\bar{P}$); $k > 0$ is the income sensitivity of money demand; $h > 0$ is the interest sensitivity of money demand; $r$ is the real interest rate; and $\pi^e$ is expected inflation (taken as fixed in the short-run IS-LM baseline, often normalised to zero so $i = r$).

Solving for $r$ as a function of $Y$ gives the upward-sloping LM schedule:

$$r = -\frac{1}{h}\left(\frac{M}{P}\right) + \frac{k}{h}Y - \pi^e$$

Where: the slope $k/h > 0$ reflects how much the real interest rate must rise to keep the money market in equilibrium when higher income boosts transaction demand for money. When $h \to \infty$ (the Keynesian **liquidity trap** at the effective lower bound where $i \approx 0$), money and short-term Treasury bills become near-perfect substitutes, flattening the LM curve horizontally. Conversely, if $h \to 0$ (classical quantity theory), LM becomes vertical.

### 3.2 IS-LM Equilibrium, Crowding Out, and Fiscal-Monetary Policy Mix

Short-run general equilibrium $(Y^*, r^*)$ occurs at the intersection of IS and LM. Analysing policy shocks illustrates why interest-rate feedback alters simple Keynesian multiplier predictions:

- **Expansionary Fiscal Policy ($\Delta G > 0$ or $\Delta T < 0$):** Shifts IS rightward. Higher output increases transaction money demand; with fixed $M/P$, the real interest rate $r$ rises to clear the money market. Higher $r$ partially **crowds out** interest-sensitive private investment ($I$) and durable consumption, making the full IS-LM fiscal multiplier smaller than the pure Keynesian cross multiplier $\mu$. Crowding out is zero in a liquidity trap (flat LM) and $100\%$ when LM is vertical ($h = 0$).
- **Expansionary Monetary Policy ($\Delta M > 0$):** Shifts LM downward/rightward. Excess liquidity lowers the real interest rate $r$, stimulating private investment and raising output $Y$. In a liquidity trap, expanding base money simply adds to idle

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reserves without lowering $r$ further unless paired with forward guidance or quantitative easing targeting longer-term bond yields.

- **Policy Mix:** Combining expansionary fiscal policy with monetary accommodation (holding $r$ constant) expands $Y$ without crowding out private investment, whereas fiscal consolidation paired with monetary easing reduces budget deficits while keeping output near potential and raising the investment share of GDP.

#### Worked Example 3: Simultaneous IS-LM Equilibrium and Investment Crowding Out

Continue with the IS curve from Worked Example 2: $Y = 1{,}880 - 30r$ (where $I = 350 - 15r$ and $\mu = 2.00$). Suppose expected inflation is $\pi^e = 0$ (so $i = r$), real money supply is $M/P = 400$ billion AUD, and real money demand is $L(Y, r) = 0.25Y - 10r$.

1. **Derive the LM equation:** Setting $400 = 0.25Y - 10r$ gives $10r = 0.25Y - 400$, or:

$$r = 0.025Y - 40 \quad \Leftrightarrow \quad Y = 1{,}600 + 40r$$

2. **Solve initial IS-LM equilibrium $(Y_0^*, r_0^*)$:** Substitute $r = 0.025Y - 40$ into IS:

$$Y = 1{,}880 - 30(0.025Y - 40) = 1{,}880 - 0.75Y + 1{,}200 = 3{,}080 - 0.75Y$$

$\$1.75Y_0^* = 3{,}080 \implies Y_0^* = 1{,}760$ billion AUD$

$$r_0^* = 0.025(1{,}760) - 40 = 44 - 40 = 4.00\%$$

Initial investment is $I_0 = 350 - 15(4.00) = 290$ billion AUD.

3. **Fiscal expansion ($\Delta G = +50$ billion AUD, shifting IS to $Y = 1{,}980 - 30r$):** Re-solving with unchanged LM ($r = 0.025Y - 40$):

$$Y = 1{,}980 - 30(0.025Y - 40) = 3{,}180 - 0.75Y \implies 1.75Y_1^* = 3{,}180 \implies Y_1^* = 1{,}817.14 \text{ billion AUD}$$

$$r_1^* = 0.025(1{,}817.14) - 40 = 45.43 - 40 = 5.43\%$$

4. **Quantifying crowding out:** Without interest-rate feedback, output would have risen by $\mu\Delta G = 100$ billion AUD (to $1{,}860$). Actual output rises by only $1{,}817.14 - 1{,}760 = 57.14$ billion AUD (an effective IS-LM fiscal multiplier of $57.14/50 = 1.14$). Higher interest rates ($\Delta r = +1.43$ percentage points) reduce investment from $290$ to $I_1 = 350 - 15(5.43) = 268.57$ billion AUD—a direct investment drop of $21.43$ billion AUD, which through the multiplier $\mu = 2.00$ crowds out $2.00 \times 21.43 = 42.86$ billion AUD of GDP ($100 - 42.86 = 57.14$).

## Chapter 4: The Modern IS-MP-PC Framework & Taylor Rule

### 4.1 From Money Targeting (LM) to Interest-Rate Rules (MP)

While the IS-LM model remains indispensable for understanding liquidity preference and fiscal-monetary interaction, modern central banks—including the Reserve Bank of Australia, the US Federal Reserve, and the Bank of England—do not target the monetary aggregate $M$. Unstable money velocity in deregulated financial systems led central banks in the 1990s to adopt **short-term policy interest rate targeting** (in Australia, the overnight cash rate target) within an inflation-targeting framework.

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Replacing the LM curve with an explicit **Monetary Policy (MP) curve** grounded in John Taylor's (1993) policy rule produces the modern three-equation New Keynesian / Intermediate Macro framework: **IS-MP-PC**. Let the IS curve be written in output-gap form around potential output $Y_n$ and the neutral real interest rate $r_n$ (the Wicksellian natural rate at which $Y = Y_n$ when demand shocks are zero):

$$Y_t - Y_n = -\alpha_{IS}(r_t - r_n) + \epsilon_{d,t}$$

Where: $Y_t - Y_n$ is the output gap (or $\tilde{y_t} = (Y_t - Y_n)/Y_n$ in percentage terms); $\alpha_{IS} > 0$ combines the interest sensitivity of spending and the multiplier ($\mu b$); $r_t$ is the actual real policy interest rate; $r_n$ is the neutral real interest rate; and $\epsilon_{d,t}$ represents exogenous aggregate demand shocks (fiscal stimulus, business confidence, or foreign demand shifts).

### 4.2 The Taylor Rule and the Taylor Principle

An inflation-targeting central bank sets the nominal policy rate ($i_t$) systematically in response to deviations of inflation ($\pi_t$) from its target ($\pi^*$, such as the midpoint $2.5\%$ of the RBA's $2\%$–$3\%$ target band) and the output gap ($\tilde{y_t}$):

$$i_t = r_n + \pi_t + \phi_\pi(\pi_t - \pi^*) + \phi_y \tilde{y_t}$$

Where: $i_t$ is the nominal cash rate target; $r_n$ is the neutral real rate; $\pi_t$ is current (or expected) inflation; $\pi^*$ is the central bank's inflation target; $\tilde{y_t} = 100(Y_t - Y_n)/Y_n$ is the percentage output gap; and $\phi_\pi > 0, \phi_y \geq 0$ are policy weights (in Taylor's original calibration, $\phi_\pi = 0.5$ and $\phi_y = 0.5$). Using the Fisher relation $r_t = i_t - \pi_t$ (or $i_t - \pi^e_{t+1}$), subtracting $\pi_t$ from both sides yields the **MP curve** in real interest rate space:

$$r_t = r_n + \phi_\pi(\pi_t - \pi^*) + \phi_y \tilde{y_t}$$

Where: $r_t$ is the real policy interest rate; $\phi_\pi > 0$ guarantees the **Taylor Principle**—when inflation rises by $1$ percentage point above target, the central bank raises the nominal cash rate by $1 + \phi_\pi > 1$ percentage points so that the *real* interest rate $r_t$ actually rises! If instead $\phi_\pi < 0$ (passive monetary policy raising $i_t$ less than one-for-one with inflation), higher inflation would *lower* the real interest rate, fuelling further spending and creating an unstable inflationary spiral.

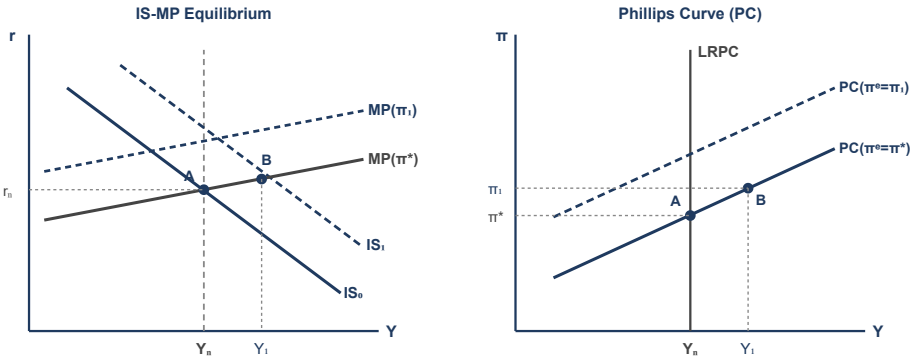
### 4.3 Deriving the Aggregate Demand (AD) Curve from IS-MP

Substituting the MP rule $r_t = r_n + \phi_\pi(\pi_t - \pi^*) + \phi_y \tilde{y_t}$ into the IS curve $\tilde{y_t} = -\alpha_{IS}(r_t - r_n) + \epsilon_{d,t}$ eliminates $r_t$ and yields the **Dynamic Aggregate Demand (AD)** relationship linking output negatively to inflation:

$$\tilde{y_t} = -\frac{\alpha_{IS}\phi_\pi}{1 + \alpha_{IS}\phi_y}(\pi_t - \pi^*) + \frac{1}{1 + \alpha_{IS}\phi_y}\epsilon_{d,t}$$

Where: $\tilde{y_t}$ is the percentage output gap; $\pi_t - \pi^*$ is the inflation gap; and $\epsilon_{d,t}$ is a demand shock. Unlike the classical AD curve (which slopes down solely via real-money-balance effects on $M/P$), the modern IS-MP Aggregate Demand curve slopes downward because *central bank policy responds to rising inflation by raising the real interest rate*, thereby cooling interest-sensitive investment, housing construction, and household cash flows.

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## Chapter 5: The Expectations-Augmented Phillips Curve & Supply Shocks

### 5.1 Expectations Formation, NAIRU, and Vertical Long-Run Phillips Curve

Completing the IS-MP-PC system requires a supply-side equation describing price setting and wage inflation. Building on Friedman (1968) and Phelps (1967), the **expectations-augmented Phillips Curve** relates actual inflation ($\pi_t$) to expected inflation ($\pi_t^e$), the output gap ($\widetilde{y}_t$) or unemployment gap ($u_t - u_n$), and cost-push supply shocks ($v_t$):

$$\pi_t = \pi_t^e + \kappa \widetilde{y}_t + v_t \qquad \text{or equivalently} \qquad \pi_t = \pi_t^e - \gamma(u_t - u_n) + v_t$$

Where: $\pi_t$ is actual inflation; $\pi_t^e$ is expected inflation formed by wage and price setters; $\widetilde{y}_t$ is the percentage output gap; $\kappa > 0$ is the slope of the Phillips curve (capturing price-stickiness sensitivity); $u_t - u_n$ is the cyclical unemployment gap; $\gamma = \kappa/\beta > 0$ via Okun's Law; and $v_t$ is a supply (cost-push) shock such as an oil price spike, shipping disruption, or GST rate change.

Two expectations regimes lead to starkly different disinflation dynamics:

- **Adaptive (Backward-Looking) Expectations ($\pi_t^e = \pi_{t-1}$):** Wage and price setters forecast next period's inflation as equal to last period's inflation. Substituting $\pi_t^e = \pi_{t-1}$ produces the *accelerationist Phillips curve* $\Delta\pi_t = \kappa\widetilde{y}_t + v_t$. Maintaining output above potential ($\widetilde{y}_t > 0$) does not merely produce high inflation—it produces *ever-accelerating* inflation. Conversely, lowering entrenched inflation requires a protracted recession ($\widetilde{y}_t < 0$), with cumulative lost output measured by the **sacrifice ratio** (the percentage-point years of lost GDP per $1$-percentage-point permanent reduction in inflation, equal to $1/\kappa$ under pure adaptive expectations).
- **Credibly Anchored Expectations ($\pi_t^e = \pi^*$):** When a central bank enjoys high credibility around its $2.5\%$ target, temporary deviations of inflation do not unanchor wage-setting norms. Consequently, returning inflation to target requires a smaller cumulative output loss, and demand shocks do not spiral into persistent inflation regimes.

In the long run, once expectations fully adjust ($\pi_t = \pi_t^e$) and supply shocks dissipate ($v_t = 0$), the output gap must be zero ($\widetilde{y}_t = 0$) and unemployment equals the NAIRU ($u_t = u_n$), regardless of the inflation rate. Hence, the **Long-Run Phillips Curve (LRPC)** is vertical at $Y = Y_n$ (or $u = u_n$): monetary policy cannot buy permanently lower unemployment at the cost of permanently higher inflation.

### 5.2 Demand-Pull vs. Cost-Push Shocks: The Policy Trade-Off

The IS-MP-PC framework clarifies why central bankers welcome demand shocks relative to supply shocks:

- **Positive Demand Shock ($\epsilon_d > 0$):** Shifts IS rightward, pushing $Y > Y_n$ and $\pi > \pi^*$. Raising the real interest rate along the MP rule simultaneously pulls output back toward $Y_n$ and pulls inflation back toward $\pi^*$. There is *no conflict* between output stabilisation and price stability ("divine coincidence").
- **Adverse Supply Shock ($v_t > 0$, e.g., global energy or supply-chain shock):** Shifts the short-run Phillips curve upward, generating *stagflation*—rising inflation ($\pi > \pi^*$) alongside falling output ($Y < Y_n$) if the central bank tightens to restrain inflation. Monetary policy faces an acute short-run trade-off: tightening aggressively (large $\phi_\pi$) contains inflation

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quickly at the cost of a deeper recession, whereas accommodating the shock ($\phi_\pi$ small) cushions output but risks unanchoring inflation expectations.

**Worked Example 4: Dynamic IS-MP-PC Adjustment to an Adverse Supply Shock**

Consider an economy calibrated to an inflation target $\pi^* = 2.5\%$, neutral real rate $r_n = 1.5\%$, IS curve $\tilde{y}_t = -1.0(r_t - r_n)$, Taylor rule $r_t = r_n + 0.5(\pi_t - \pi^*)$ (with $\phi_y = 0$), and adaptive Phillips curve $\pi_t = \pi_{t-1} + 0.5\tilde{y}_t + v_t$. Initially at $t = 0$, $\pi_0 = 2.5\%$, $\tilde{y}_0 = 0\%$, and $r_0 = 1.5\%$. In Period 1, a temporary energy supply shock of $v_1 = +2.0\%$ hits ($v_2 = v_3 = 0$ thereafter).

1. **Derive the reduced-form AD equation:** Substituting $r_t - r_n = 0.5(\pi_t - 2.5)$ into IS gives $\tilde{y}_t = -0.5(\pi_t - 2.5)$.
2. **Period 1 equilibrium (shock hits):** Substituting $\tilde{y}_1 = -0.5(\pi_1 - 2.5)$ into the Phillips curve with $\pi_0 = 2.5$ and $v_1 = 2.0$:

$$\pi_1 = 2.5 + 0.5\,[-0.5(\pi_1 - 2.5)] + 2.0 = 2.5 - 0.25(\pi_1 - 2.5) + 2.0$$

$$1.25(\pi_1 - 2.5) = 2.0 \implies \pi_1 - 2.5 = 1.60 \implies \pi_1 = 4.10\%$$ Then $\tilde{y}_1 = -0.5(1.60) = -0.80\%$, $r_1 = 1.5 + 0.5(1.60) = 2.30\%$, and the nominal cash rate is $i_1 = r_1 + \pi_1 = 2.30\% + 4.10\% = 6.40\%$.

3. **Period 2 equilibrium ($v_2 = 0, \pi_2^e = \pi_1 = 4.10\%$):**

$$\pi_2 = 4.10 - 0.25(\pi_2 - 2.5) \implies \pi_2 - 2.5 = \frac{1.60}{1.25} = 1.28 \implies \pi_2 = 3.78\%$$

$$\tilde{y}_2 = -0.5(1.28) = -0.64\%, \qquad r_2 = 1.5 + 0.5(1.28) = 2.14\%, \qquad i_2 = 5.92\%$$

4. **Period 3 equilibrium ($v_3 = 0, \pi_3^e = \pi_2 = 3.78\%$):**

$$\pi_3 - 2.5 = \frac{1.28}{1.25} = 1.024 \implies \pi_3 = 3.524\%, \qquad \tilde{y}_3 = -0.512\%, \qquad r_3 = 2.012\%$$

Notice how inflation and the negative output gap decay geometrically by a factor of $1/1.25 = 0.80$ each period, gradually converging back to $(\pi^*, \tilde{y}, r_n) = (2.5\%, 0\%, 1.5\%)$.

## Chapter 6: RBA Monetary Policy Operations & Australian Cycles

### 6.1 Implementation of the Cash Rate and the Corridor System

The Reserve Bank of Australia operates under the *Reserve Bank Act 1959 (Cth)* and the Statement on the Conduct of Monetary Policy agreed with the Commonwealth Treasurer, targeting consumer price inflation of 2%–3% on average over time alongside full employment. Operational implementation centres on the overnight market for **Exchange Settlement (ES) balances** held by commercial banks at the RBA:

- **Interest-Rate Corridor:** Commercial banks needing overnight liquidity can borrow from the RBA standing repo facility at a ceiling of $+0.25$ percentage points above the cash rate target (historically; adjusted to $+0.10$ pp when the floor narrowed during 2020–2021), while surplus ES balances earn the deposit floor rate below target. Because no bank will lend in the interbank market below the deposit floor or borrow above the lending ceiling, the overnight cash rate trades tightly within the corridor.
- **Surplus Liquidity Regime:** Following large-scale asset purchases during 2020–2021, ES balances expanded dramatically above minimum clearing needs, anchoring the actual cash rate close to the ES remuneration floor rather than requiring daily open-market fine-tuning around scarce reserves.

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### 6.2 Transmission Channels in the Australian Economy

Changes in the RBA cash rate transmit to aggregate demand and inflation through five channels:

1. **Intertemporal Substitution (Saving & Investment):** Higher real interest rates increase the return to saving and raise the user cost of capital, curbing business investment and residential construction.
2. **Cash-Flow Channel:** Particularly potent in Australia because a high share of household mortgages are variable-rate (or short-term fixed-rate) contracts. Rate hikes directly reduce borrowers' disposable cash flow more rapidly than in fixed-rate mortgage systems such as the United States.
3. **Asset Price and Wealth Channel:** Higher discount rates reduce equity and dwelling valuations, dampening household net wealth and consumption as well as relaxing collateral values for SME borrowing.
4. **Exchange Rate Channel:** Higher domestic interest rates relative to foreign rates attract capital inflows and appreciate the Australian dollar (Module 4), lowering import prices and reducing export competitiveness.
5. **Expectations Channel:** Credible RBA communication anchors medium-term inflation expectations in wage bargaining and price setting.

### 6.3 Unconventional Monetary Policy and the 2020–2024 Australian Cycle

When the COVID-19 pandemic struck in March 2020, the RBA lowered the cash rate target to the effective lower bound of $0.10\%$ and deployed a suite of unconventional policies to flatten the yield curve and sustain credit supply: a **3-year Australian Government Securities (AGS) yield target** at $0.10\%$, the **Term Funding Facility (TFF)** providing low-cost three-year funding to authorised deposit-taking institutions (ADIs) linked to SME lending, forward guidance tied to actual inflation outcomes, and a **Bond Purchase Program (QE)** purchasing longer-dated Commonwealth and state government bonds. As supply bottlenecks, fiscal stimulus, and global energy shocks drove Australian CPI inflation to $7.8\%$ in late 2022, the RBA executed its fastest tightening cycle since 1994—lifting the cash rate by $425$ basis points from $0.10\%$ to $4.35\%$ between May 2022 and November 2023—demonstrating the Taylor Principle in action.

| Analytical Dimension | Traditional IS-LM Model | Modern IS-MP-PC Framework |
|---|---|---|
| Monetary instrument | Exogenous money supply $M$ | Policy interest rate rule $i_t$ (Taylor Rule) |
| Price level & inflation | Fixed price level $\bar{P}$ | Endogenous inflation $\pi_t$ via Phillips Curve |
| Crowding out of fiscal policy | Automatic via fixed $M$ raising $r$ | Occurs if central bank hikes $r$ to offset inflation |
| Effective lower bound (ELB) | Horizontal LM liquidity trap ($h \to \infty$) | MP floored at $r = -\pi^e$ (requires QE / fiscal support) |
| Long-run anchor | Requires adding AS-AD price adjustment | Built-in convergence to $Y_n$ and $\pi^*$ via Taylor Principle |

## Chapter 7: Real Business Cycles, New Keynesian Synthesis & the Effective Lower Bound

### 7.1 Real Business Cycle (RBC) Theory vs. New Keynesian Fluctuations

While the IS-MP-PC framework emphasises aggregate demand shocks and nominal price stickiness, **Real Business Cycle (RBC)** theory—pioneered by Kydland and Prescott (1982)—demonstrates that fluctuations can also arise in frictionless, perfectly competitive economies driven by persistent real total factor productivity (TFP) shocks ($A_t$). In an RBC model, a temporary positive productivity shock ($\Delta A_t > 0$) raises both the marginal product of capital ($MPK$) and the marginal product of labour ($MPL$), elevating the real wage ($w_t$) and the real interest rate ($r_t$).

Because higher $w_t$ and higher $r_t$ make working today unusually rewarding relative to working in the future, optimising households increase current labour supply via **intertemporal substitution of labour**. Firms simultaneously expand investment to take advantage of higher $MPK$. Consequently, an RBC model reproduces key empirical co-movements—procyclical output, consumption, investment, hours worked, real wages, and labour productivity—without any price stickiness or monetary non-neutrality. However, pure RBC models struggle to explain involuntary unemployment, the strong real effects of monetary policy tightenings, and why recessions occur without measurable technological regress.

Modern central bank forecasting models (such as the RBA's MARTIN model and New Keynesian DSGE frameworks) combine both paradigms: RBC-style supply shocks alter potential output $Y_n$ and the neutral real rate $r_n$, while nominal rigidities and forward-looking Taylor rules govern short-run output gaps ($\widetilde{y}_t$) and inflation ($\pi_t$).

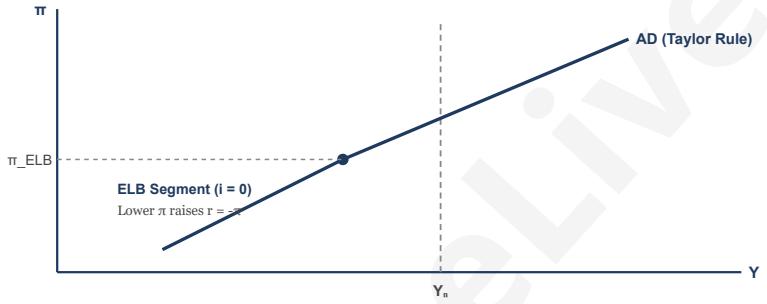
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### 7.2 Fiscal Multipliers at the Effective Lower Bound (ELB)

A critical insight of the New Keynesian IS-MP-PC model is that the size of the fiscal multiplier depends sharply on the monetary policy regime. During normal economic conditions, an expansionary fiscal shock ($\Delta G > 0$) raises $\widetilde{y}_t$ and $\pi_t$; following the Taylor rule, the central bank raises $r_t$ to restrain inflation, partially crowding out private demand and yielding a fiscal multiplier below $1.0$.

By contrast, when a severe recession pushes the nominal cash rate down to its **effective lower bound (ELB)** ($i_t = i_{\min} \approx 0$), the central bank cannot lower $i_t$ further, and the real interest rate is pinned by expected inflation ($r_t = i_{\min} - \pi^e_{t+1}$). Under a binding ELB:

- **Perverse Deflationary Spiral Risk:** Falling inflation or deflation ($\pi^e_{t+1} < 0$) raises the real interest rate $r_t = -\pi^e_{t+1}$, depressing aggregate demand further and creating an upward-sloping AD segment at low inflation.
- **Fiscal Crowding-In ($\Delta Y / \Delta G > 1$):** Because the central bank holds $i_t$ pinned at $i_{\min}$ rather than hiking rates against mild fiscal stimulus, higher government spending raises inflation expectations ($\pi^e_{t+1} \uparrow$), which *lowers* the real interest rate $r_t = i_{\min} - \pi^e_{t+1}$! Lower $r_t$ stimulates private investment and consumption, generating fiscal multipliers exceeding $1.5$—explaining why coordinated Australian fiscal support (such as JobKeeper in 2020) proved highly potent when the RBA cash rate stood at $0.10\%$.




#### Worked Example 5: Normal-Times vs. Effective Lower Bound Fiscal Multiplier

Suppose the short-run IS curve is $\widetilde{y}_t = -1.2(r_t - r_n) + g_t$, where $g_t$ is a fiscal impulse measured in percentage points of potential GDP and $r_n = 1.5\%$, and the Phillips curve is $\pi_t = \pi^e_t + 0.5\widetilde{y}_t$ with current expected inflation anchored at $\pi^e_t = 2.0\%$ during normal times, or $\pi^e_t = 0.0\%$ during a deflationary slump.

1. **Normal times (active Taylor rule $r_t = r_n + 0.5(\pi_t - \pi^*) + 0.5\widetilde{y}_t$ with $\pi^* = 2.0\%$):** Substituting $\pi_t - \pi^* = 0.5\widetilde{y}_t$ into the Taylor rule gives $r_t - r_n = 0.5(0.5\widetilde{y}_t) + 0.5\widetilde{y}_t = 0.75\widetilde{y}_t$. Substituting into IS gives:

$$\widetilde{y}_t = -1.2(0.75\widetilde{y}_t) + g_t = -0.90\widetilde{y}_t + g_t \implies 1.90\widetilde{y}_t = g_t \implies \frac{\Delta\widetilde{y}_t}{\Delta g_t} = \frac{1}{1.90} = 0.53$$

   Because the central bank raises real rates by $0.75$ percentage points per percentage point of output expansion, nearly half of the fiscal stimulus is crowded out.

2. **Binding ELB ($i_t = 0$ fixed, and fiscal stimulus lifts $\pi^e_{t+1}$ proportionally to current inflation $\Delta\pi^e_{t+1} = 0.5\Delta\pi_t = 0.25\Delta\widetilde{y}_t$):** With $i_t = 0$, $\Delta r_t = -\Delta\pi^e_{t+1} = -0.25\Delta\widetilde{y}_t$. Substituting into IS yields:

$$\Delta\widetilde{y}_t = -1.2(-0.25\Delta\widetilde{y}_t) + \Delta g_t = +0.30\Delta\widetilde{y}_t + \Delta g_t \implies 0.70\Delta\widetilde{y}_t = \Delta g_t \implies \frac{\Delta\widetilde{y}_t}{\Delta g_t} = \frac{1}{0.70} = 1.43$$

   At the ELB, a fiscal expansion of $2.0\%$ of GDP raises real output by $2.86\%$ rather than $1.06\%$, because higher inflation expectations reduce real borrowing costs and crowd in private expenditure.

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# Chapter 4: The 3-Equation New Keynesian Macroeconomic Framework

## 4.1 The Canonical Three Equations: IS Curve, Phillips Curve & Monetary Policy Rule

Modern central bank policy analysis synthesises short-run fluctuations into the canonical three-equation New Keynesian macroeconomic model. Unlike static IS-LM representations, the three-equation framework explicitly embeds forward-looking household optimisation, staggered nominal price setting by monopolistically competitive firms, and an active interest-rate reaction function calibrated by monetary authorities:

1. **The Dynamic IS Equation:** Derived from the Euler equation for intertemporal consumption choice:

$$\tilde{y}_t = E_t[\tilde{y}_{t+1}] - \sigma^{-1}(i_t - E_t[\pi_{t+1}] - r^*) + g_t$$

   Where $\tilde{y}_t$ is the output gap, $E_t[\tilde{y}_{t+1}]$ is expected future output, $\sigma > 0$ is the household coefficient of relative risk aversion, $i_t$ is the nominal policy interest rate, $E_t[\pi_{t+1}]$ is expected future inflation, $r^*$ is the natural (neutral) real interest rate, and $g_t$ captures exogenous demand disturbances (such as fiscal spending or terms-of-trade shifts).

2. **The New Keynesian Phillips Curve (NKPC):** Derived from Calvo staggered price-setting:

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa \tilde{y}_t + u_t$$

   Where $\pi_t$ is current inflation, $\beta \in (0, 1)$ is the subjective discount factor, $\kappa > 0$ governs the slope of the Phillips curve (reflecting both the frequency of price adjustments and the sensitivity of marginal cost to economic activity), and $u_t$ represents cost-push supply shocks (such as global energy price spikes).

3. **The Monetary Policy Reaction Function (Taylor-Type Rule):** Setting the policy rate relative to neutral:

$$i_t = r^* + \pi^* + \phi_\pi(\pi_t - \pi^*) + \phi_y \tilde{y}_t$$

   Where $\pi^*$ is the target inflation rate (the midpoint of the RBA's $2\%$ to $3\%$ target band), $\phi_\pi > 1$ satisfies the Taylor principle, and $\phi_y \geq 0$ captures the central bank's concern for output stabilisation.

## 4.2 The Taylor Principle and Macroeconomic Stability

The Taylor principle dictates that the coefficient on inflation in the monetary policy rule must strictly exceed unity ($\phi_\pi > 1$). When inflation rises by one percentage point, the central bank must raise the nominal policy rate by more than one percentage point. This ensures that the real policy interest rate increases:

$$\Delta r_t = \Delta i_t - \Delta \pi_t = (\phi_\pi - 1)\Delta \pi_t > 0 \quad \text{when } \phi_\pi > 1$$

Higher real interest rates increase borrowing costs, dampen consumer spending on durables, curb business capital expenditures, and appreciate the floating Australian dollar. The resulting contraction in aggregate demand opens a negative output gap ($\tilde{y}_t < 0$), relieving pressure on domestic productive capacity and anchoring inflation expectations back to the central target.

Conversely, if a central bank implements a passive policy rule with $\phi_\pi < 1$, an increase in inflation triggers an insufficient nominal rate response, causing the real interest rate to fall. Lower real borrowing costs stimulate further demand, driving inflation higher in an unstable self-fulfilling inflationary spiral. Australian macroeconomic stability under the Reserve Bank of Australia's post-1993 flexible inflation targeting framework fundamentally depends upon adherence to this Taylor principle.

## 4.3 Worked Numerical Example: New Keynesian Policy Adjustment to a Cost-Push Supply Shock

Consider an open economy calibrated to Australian macroeconomic parameters:

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- Target inflation: $\pi^* = 2.50\%$ per annum.
- Neutral real interest rate: $r^* = 1.50\%$ per annum.
- Dynamic IS slope parameter: $\sigma^{-1} = 0.80$.
- Phillips curve parameters: $\beta = 0.99$, $\kappa = 0.40$.
- Monetary policy rule weights: $\phi_\pi = 1.50$, $\phi_y = 0.50$.

Suppose the economy initially rests at long-run equilibrium ($\widetilde{y} = 0, \pi = 2.50\%, i = 4.00\%$). A global geopolitical disruption generates a sudden cost-push supply shock of $u_t = +1.60\%$ to domestic headline inflation. Assuming static expectations for a one-period impact analysis ($E_t[\pi_{t+1}] = 2.50\%, E_t[\widetilde{y}_{t+1}] = 0$):

1. The NKPC becomes:

$$\pi_t = 0.99(2.50\%) + 0.40\widetilde{y}_t + 1.60\% = 2.475\% + 1.60\% + 0.40\widetilde{y}_t = 4.075\% + 0.40\widetilde{y}_t$$

2. The central bank's policy rate response is:

$$i_t = 1.50\% + 2.50\% + 1.50(\pi_t - 2.50\%) + 0.50\widetilde{y}_t = 4.00\% + 1.50(\pi_t - 2.50\%) + 0.50\widetilde{y}_t$$

3. Substituting the NKPC expression into the policy rule:

$$i_t = 4.00\% + 1.50(1.575\% + 0.40\widetilde{y}_t) + 0.50\widetilde{y}_t = 4.00\% + 2.3625\% + 0.60\widetilde{y}_t + 0.50\widetilde{y}_t = 6.3625\% + 1.10\widetilde{y}_t$$

4. The real interest rate deviation from neutral is:

$$r_t - r^* = (i_t - 2.50\%) - 1.50\% = i_t - 4.00\% = 2.3625\% + 1.10\widetilde{y}_t$$

5. Substituting into the IS curve:

$$\widetilde{y}_t = 0 - 0.80(2.3625\% + 1.10\widetilde{y}_t) = -1.89\% - 0.88\widetilde{y}_t \implies 1.88\widetilde{y}_t = -1.89\% \implies \widetilde{y}_t \approx -1.005\%$$

6. Evaluating realized inflation and policy rate:

$$\pi_t = 4.075\% + 0.40(-1.005\%) = 4.075\% - 0.402\% = 3.673\% \approx 3.67\%$$

$$i_t = 6.3625\% + 1.10(-1.005\%) = 6.3625\% - 1.1055\% = 5.257\% \approx 5.26\%$$

Conclusion: To prevent the temporary supply shock from unanchoring inflation expectations, the central bank raises the nominal cash rate from $4.00\%$ to $5.26\%$. The resulting real rate tightening creates a negative output gap of $-1.01\%$, successfully containing inflation at $3.67\%$ before returning it to the $2.50\%$ target.

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