THE 3-EQUATION MODEL

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THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

- Demand shocks, supply shocks
- Government intervention
  - stabilisation policy
- Inflation targeting - monetary policy regime
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Inflation in Industrialised Economies
1970-2015
The 3-Equation Model and Macroeconomic Policy

Figure 1.3 Volatility of real GDP growth in the United States: 1950 Q3–2009 Q1.


Note: Volatility has been calculated as the standard deviation of the GDP growth rate over a rolling 21-quarter period. Graph uses data from the series ‘Real GDP, chained dollars, billions of chained (2005) dollars’.
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Monetary Policy

• (1945 - 1971: Bretton Woods fixed exchange rate regime)

• 1970s - 1980s
From the Quantity Theory of Money: controlling the growth rate of the money supply allow policy makers to control the rate of inflation
- 1974 - monetary targeting in Germany and Switzerland

• For a monetary targeting to be successful:
(1) the CB met be able to control the chosen monetary aggregate,
(2) the relationship between inflation and the targeted monetary aggregate must be reliable
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Monetary Policy in the UK

- Goodhart’s law: When the CB chooses a monetary aggregate as a target, the financial system responds by switching to a close substitute outside the target and hence undermines it.

- Government targeted the growth of broad money.

- Early 1980s: substantial shifts in the money demand (alters the relationship between money supply and inflation).
  Monetary targeting could not control AD predictably.
  - Narrow money growth above target, yet disinflation cost higher than intended.

- Monetary targeting to anchor inflation was flawed.
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Monetary Policy in the UK

Figure 3.3 UK inflation and unemployment: 1971–2010.

Source: UK Office for National Statistics (data accessed February 2012).
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Monetary Policy

• Monetarist ideas did not pass all the tests
  US, UK Canada in 1980s discredited monetary targeting

• “The use of quantity of money as a target has not been a success. I’m not sure I would push it as hard as I once did.” Milton Friedman (Financial Times, 2003)

• Monetarism still has a strong influence
  - the constant inflation rate of unemployment is pinned down by the supply-side of the economy
  - monetary policy is the preferred policy instrument

• after 1985
  Abandonment of the monetary targeting for inflation targeting
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Modern Monetary Policy Framework

• Inflation targeting to anchor inflation
  real interest rate used to influence output gap

• CB is forward looking
  - CB forecasts inflation by analysing the state of the economy
  - lags matter

• How is monetary policy conducted?
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Modern Monetary Policy Framework

• How the CB responds to shocks to the economy?

• What is it the CB trying to achieve? (CB’s preferences)

• What prevents the CB to achieve its target? (CB’s constraints)

• How does the CB translate its objectives into monetary policy? (Monetary rule)
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The 3-Equations

- IS curve (equilibrium in the goods market)
- PC curve (unemployment-inflation relationship)
- MR curve (how the CB responds to shocks)
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The 3-Equations

• IS curve (equilibrium in the goods market)

• PC curve (unemployment-inflation relationship)

• MR curve (how the CB responds to shocks)

Boro - Tuesday!
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The three-equations: Monetary Rule

- Active rule-based MP: best response $r$ to achieve inflation target
- Deriving the Monetary Rule (MR):

1. Define the central bank’s preferences in terms of deviations from inflation target and equilibrium output.

2. Define the central bank’s constraints from the supply side, i.e., the Phillips Curve (PC).

3. Derive the best response monetary rule in the output-inflation space, which gives the MR curve.

4. Once the optimal output-inflation combination is determined using the MR, the central bank uses the IS curve to implement its choice (by setting the interest rate).
The three-equations: Monetary Rule

(1) Define the *central bank’s preferences* in terms of deviations from inflation target and equilibrium output.

The central bank’s preferences are given by a loss function:

\[ L = (y_t - y_e)^2 + \beta (\pi_t - \pi^T)^2 \]

The higher the loss \( L \), the worse off is the CB. The central bank is worse off the further inflation is away from its target level, and the further output is away from its equilibrium level; \( \beta \) reflects the relative degree of inflation aversion of the CB.
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The three-equations: Monetary Rule

Central Bank’s preferences

\[ L = (y_t - y_e)^2 + \beta (\pi_t - \pi^T)^2 \]

\[ \pi \]

\[ \pi^T \]

\[ y \]

\[ y_e \]

declining utility

Bliss point
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The three-equations: Monetary Rule

Central Bank’s preferences

\[ L = (y_t - y_e)^2 + \beta (\pi_t - \pi^T)^2 \]

\[ \beta = 1 \]

CB is equally concerned about inflation and output deviations from its targets.
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The three-equations: Monetary Rule

Central Bank’s preferences

\[ L = (y_t - y_e)^2 + \beta (\pi_t - \pi^T)^2 \]

\[ \beta > 1 \]

*Inflation averse CB*

CB places less weight on deviations from employment (output) from its target than on deviations on inflation.

\( \pi^T = 3\% \)
\( \pi^T = 2\% \)

output gap >1%
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The three-equations: Monetary Rule

Central Bank’s preferences

\[ L = (y_t - y_e)^2 + \beta(\pi_t - \pi^T)^2 \]

\[ \beta < 1 \]

*unemployment averse CB*

CB places less weight on deviations from inflation from its target than on deviations on output.
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

The 3-Equations

- Active rule-based MP: best response $r$ to achieve inflation target
- Deriving the Monetary Rule (MR):
  1. Define the central bank’s preferences in terms of deviations from inflation target and equilibrium output.
  2. Define the central bank’s constraints from the supply side, ie the Phillips Curve (PC)
  3. Derive the best response monetary rule in the output-inflation space, which gives the MR curve.
  4. Once the optimal output-inflation combination is determined using the MR, the central bank uses the IS curve to implement its choice (by setting the interest rate).
Define the central bank’s constraints from the supply side, i.e., the Phillips Curve (PC)

- The PC is a constraint for the CB because it shows all the output and inflation combinations from which the CB can choose for a given level of expected inflation.

- In any period, the CB can only choose to locate the economy at a point on the PC it faces!
The three-equations: Phillips Curve

\[ L = (y_1 - y_e)^2 + \beta (\pi_1 - \pi_1^e)^2 \]

\[ \pi_t = \pi_{t-1} + \alpha (y - y_e) \]

Loss Function

Phillips Curve
The three-equations: Phillips Curve

\[ L = (y_1 - y_e)^2 + \beta(\pi_1 - \pi^T)^2 \]

\[ \pi_t = \pi_{t-1} + \alpha(y - y_e) \]

Loss Function

Phillips Curve

shock to inflation
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

The three-equations: Phillips Curve

\[ L = (y_1 - y_e)^2 + \beta(\pi_1 - \pi^T)^2 \]

\[ \pi_t = \pi_{t-1} + \alpha(y - y_e) \]

Loss Function

Phillips Curve

shock to inflation
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The three-equations: Monetary Rule

\[ L = (y_1 - y_e)^2 + \beta (\pi_1 - \pi^T)^2 \]

\[ \pi_t = \pi_{t-1} + \alpha (y - y_e) \]

Loss Function

Phillips Curve

\[ PC(\pi^E = 4) \]
\[ PC(\pi^E = 3) \]
\[ PC(\pi^E = 2) \]
The three-equations: Phillips Curve

\[ \min L = (y_1 - y_e)^2 + \beta (\pi_1 - \pi^T)^2 \quad \text{s.t.} \quad \pi_1 = \pi_0 + \alpha (y_1 - y_e) \]
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The three-equations: Phillips Curve

\[ \min \quad L = (y_1 - y_e)^2 + \beta(\pi_1 - \pi^T)^2 \quad \text{s.t.} \quad \pi_1 = \pi_0 + \alpha(y_1 - y_e) \]

Substitute the constraint into the loss function:

\[ L = (y_1 - y_e)^2 + \beta((\pi_0 + \alpha(y_1 - y_e)) - \pi^T)^2 \]
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The three-equations: Phillips Curve

\[
\min \quad L = (y_1 - y_e)^2 + \beta(\pi_1 - \pi^T)^2 \quad \text{s.t.} \quad \pi_1 = \pi_0 + \alpha(y_1 - y_e)
\]

substitute the constraint into the loss function:

\[
L = (y_1 - y_e)^2 + \beta((\pi_0 + \alpha(y_1 - y_e)) - \pi^T)^2
\]

differentiate with respect to \(y_1\) and equal it to zero:

\[
\frac{\partial L}{\partial y_1} = (y_1 - y_e) + \alpha\beta(\pi_0 + \alpha(y_1 - y_e) - \pi^T) = 0
\]
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The three-equations: Phillips Curve

\[ \begin{align*}
\min \quad & L = (y_1 - ye)^2 + \beta(\pi_1 - \pi^T)^2 \\
\text{s.t.} \quad & \pi_1 = \pi_0 + \alpha(y_1 - ye)
\end{align*} \]

substitute the constraint into the loss function:

\[ L = (y_1 - ye)^2 + \beta((\pi_0 + \alpha(y_1 - ye)) - \pi^T)^2 \]

differentiate with respect to \( y_1 \) and equal it to zero:

\[ \frac{\partial L}{\partial y_1} = (y_1 - ye) + \alpha \beta(\pi_0 + \alpha(y_1 - ye) - \pi^T) = 0 \]

we finally find:

\[ (y_1 - ye) = -\alpha \beta(\pi_1 - \pi^T) \quad \text{Monetary Rule} \]
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The three-equations: Phillips Curve

\[(y_1 - y_e) = -\alpha \beta (\pi_1 - \pi^T)\]

- Shows the CB’s best response to a shock
- Relationship between the inflation rate chosen indirectly and the level of output chosen directly by the CB to maximise its utility given its preferences and the constraints it faces
- It shows an inverse relationship between output and inflation
- Larger is \(\alpha\) or larger \(\beta\) the flatter will be the slope of the MR
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The three-equations: Phillips Curve

\[(y_1 - y_e) = -\alpha\beta(\pi_1 - \pi^T)\]

\[\alpha = 1 \quad \beta = 1\]

\[\alpha = 1 \quad \beta > 1\]
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The three-equations: Phillips Curve

\[(y_1 - y_e) = -\alpha\beta(\pi_1 - \pi^T)\]

\[\alpha = 1 \quad \beta = 1\]

\[\alpha > 1 \quad \beta = 1\]
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The three-equations: Phillips Curve

\[(y_1 - y_e) = -\alpha \beta (\pi_1 - \pi^T)\]

two economies

\[\alpha = 1 \quad \beta = 1\]

\[\alpha = 1 \quad \beta > 1\]

economies with inflation averse CB will experience a higher cut in AD following an inflation shock
The three-equations: Phillips Curve

\[(y_1 - y_e) = -\alpha\beta(\pi_1 - \pi^T)\]

two economies

\[\alpha = 1 \quad \beta = 1\]

\[\alpha > 1 \quad \beta = 1\]

smaller rise in unemployment is required in order to achieve desired inflation target
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

The 3-Equations

• Active rule-based MP: best response r to achieve inflation target

• Deriving the Monetary Rule (MR):

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The 3 Equations

- **IS curve** (equilibrium in the goods market)
- **PC curve** (unemployment-inflation relationship)
- **MR curve** (how the CB responds to shocks)
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THE IS CURVE

• The CB must choose a real interest rate to secure the appropriate level of AD (and output)

• The Demand side captures the spending decisions of:
  - Households: Domestic & Foreign (Open Economy)
  - Firms
  - The Government

\[ y^D = C + I + G + (X - M) \]

• Why study this?
  Fluctuations in AD affect unemployment and inflation
  Relevance to monetary and fiscal policy makers
  Understand the transmission mechanism of monetary and fiscal policy
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THE IS CURVE

• How do we model the demand side: The IS Curve

Features:
- Downward Sloping
  (high int rate → lower AD)
- Affected by expectations of the future
  (pessimistic expectations → lower AD at every int rate)

![Diagram of the IS Curve](image)
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THE IS CURVE

• The IS Curve shows combinations of the real interest rate \( r \) and output \( y \) under goods market equilibrium.

• Goods Market Equilibrium: \( y^D = y \)
Aggregate Demand = Output / Income
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THE IS CURVE

\[ y^D = y = C + I + G \]
\[(closed\ economy)\]

- \[ C = c_0 + c_1(1 - t)y \] - Keynesian consumption function
- \[ I = a_0 - a_1r \] - Investment function

\[ y = \frac{1}{1 - c_1(1 - t)} \left[ c_0 + (a_0 - a_1r) + G \right] \]

\[ y = k \left[ c_0 + (a_0 - a_1r) + G \right] \]

\[ y = k(c_0 + a_0 + G) - ka_1r \]
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THE IS CURVE

\[ y^D = y = C + I + G \]

\( (closed \ economy) \)

- \( C = c_0 + c_1(1 - t) \, y \) - Keynesian consumption function
- \( I = a_0 - a_1r \) - Investment function

\[ y = k(c_0 + a_0 + G) - ka_1r \]

- The larger the multiplier \( (k) \), or the larger the interest-sensitivity of investment \( (a_1) \), the larger the effect of \( r \) on \( y \).
  (IS curve is flatter)

\[ y = A - ar \]

IS Curve
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THE IS CURVE

**IS Curve Properties:**

- Downward sloping
  Low $r$ - ↑ Investment - ↑ Output

- IS curve slope
  Changes with multiplier, $k$ and hence $c_i$ and $t$.
  Changes with $a_i$.

- Shifts in the IS Curve:
  When autonomous consumption $c_o$, autonomous investment $a_o$, or government spending $G$ change.
  When the multiplier changes.
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Forward-Looking Behaviour:

- Spending decisions today are influenced by expectations of the future:
  - Households adjust current spending based on expected future income; Consumption Smoothing
  - Firms make investment decisions based on expected future profits.

- People desire to smooth consumption
  - Diminishing marginal utility of consumption
  - Requires taking into account the future, and the ability to save and borrow.
    - PHI, LCH

- Investment are also forward looking
Other factors shifting the IS:

- Consumption
  PHI predicts that changes in expected lifetime wealth shifts the IS

- Role of Uncertainty: ↑ unemployment - ↑ precautionary savings - IS shifts leftwards

- Housing Price Boom:
  If home equity loans obtainable - ↓ credit constraints - IS shifts rightwards
  If home equity loans unobtainable - ↑ down-payments for mortgages - IS shifts leftwards

- Financial innovation or deregulation: ↑ household access to credit - IS shifts rightwards
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THE IS CURVE

Other factors shifting the IS:

- Investment
  increase in prices, increase in the marginal productivity of capital and reduction in the depreciation rate will shift the IS rightwards
Dynamic IS curve

To take into account the delayed impact of interest rates on output

\[ y_t = A_t - ar_{t-1} \]
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

How does a CB respond to an inflation shock?

Figure 3.8 Dynamic adjustment to an inflation shock.
How does a CB respond to an inflation shock?

\[ y_t = A_t - a r_{t-1} \]

\[ \pi_t = \pi_{t-1} + \alpha (y_t - y_e) \]

\[ (y_t - y_e) = -\alpha \beta (\pi_t - \pi^T) \]
How does a CB respond to an inflation shock?
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

How does a CB respond to an inflation shock?

**Period 0:**
- The economy is initially at point ‘A’ (the Bliss point)
- Inflation shock: PC shifts upwards (Economy moves to point ‘B’)
- The CB forecasts PC for the next period, which is PC \((\pi_{1E} = \pi_0)\)
- The CB chooses position on this PC which minimises its loss (point ‘C’ where the MR = PC); To achieve this, \(r_0\) is set (see IS curve)
- \(r\) affects \(y\) with a 1-period lag, so the economy ends with \((\pi_0, y_e \text{ and } r_0')\).
How does a CB respond to an inflation shock?

In the diagram, the IS curve (I = S) is shown with the equation $\pi = k - y$. The short run equilibrium is at point A, where the interest rate $r$ is $r_0$ and output $y$ is $y_e$. The long run equilibrium is at point C, where the interest rate $r$ is $r_1$ and output $y$ is $y_e$. The inflation shock is represented by the shift from $\pi_0$ to $\pi_1$, leading to a new short run equilibrium at point B'.
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How does a CB respond to an inflation shock?

**Period 1:**
The higher $r_0$ reduces output *below equilibrium* to $y_1$ by ↓ Investment (Economy moves to point ‘C’)
Again, the CB forecasts PC for period 2, i.e. PC ($\pi_{2E}=\pi_1$); Note that the PC shifts as $\pi^E$ is updated.
The optimal point as given by the MR is now ‘D’; To achieve this, $r_0$ is reduced to $r_1$.
Similarly, the economy ends with (‘$\pi_1$, $y_1$ and $r_1$’).
How does a CB respond to an inflation shock?

In the diagram, the IS curve represents the relationship between interest rates (r) and income (y). The PC curve shows the short-run Phillips curve, relating inflation (π) to income. The long-run equilibrium is marked by point A, where the short-run and long-run Phillips curves intersect. The inflation shock causes a shift in the PC curve from PC to PC', leading to a new long-run equilibrium at point B'.
Period 2:
The lower $r_1$ increases output to $y_2$, while inflation falls to $\pi_2$ (Economy moves to point ‘D’)
The same process repeats until the economy is back at its equilibrium ‘Z’
The economy moves down along MR curve: The CB gradually adjusts $r_1$ down to $r$, output rises slowly from $y_2$ to $y_e$ and inflation eventually falls from $\pi_2$ to $\pi^T$. 
How does a CB respond to an inflation shock?
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How does a CB respond to an inflation shock?

The Impulse Response Function:

It shows the time path of macroeconomic variables following a shock and the resulting policy responses.

Note that the impulse response of output only changes one period after the inflation shock. This is due to the 1 period lagged effect of $r$ on $y$. 
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How does a CB respond to an inflation shock?
Temporary demand shock

\[ y_t = A_t - ar_{t-1} \]

\[ \pi_t = \pi_{t-1} + \alpha(y - y_e) \]

\[ (y_t - y_e) = -\alpha\beta(\pi_t - \pi^T) \]
How does a CB respond to a temporary demand shock?

**Period 0:**
- Temporary AD shock: IS shifts to IS’, but stays at IS’ for 1 period only.
- The economy shifts from initial point ‘A’ to point ‘B’
- The CB forecasts the PC for period 1, which is PC ($\pi_1 E = \pi_0$)
- The CB knows that IS’ returns to IS at the beginning of period 1, and thus sets $r_0$ to achieve $y_1$ and $\pi_1$, in period 1.

**Period 1:**

The higher $r_0$ reduces $\pi$, and $y$ below equilibrium $y_e$ (Point ‘C’).

The CB forecasts PC for period 2 to be PC ($\pi_1 E = \pi_0$), so now, the optimal point is ‘D’; To achieve this, $r_0$ is reduced to $r_1$. 
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

How does a CB respond to a temporary demand shock?

Period 2 onwards:
The economy moves to point ‘D’ as demand increases from lower \( r \).
The same process repeats and \( r \) is gradually reduced until the economy reaches its equilibrium ‘Z’.
Note that the CB needs to forecast the IS and the PC curves

Forecasting the IS curve:
- Is the AD shock temporary or permanent?
- Vital since the persistence of shocks affects the CB’s optimal response.

Permanent shock: $IS'$ does not shift back to IS
A larger increase in $r$ is needed compared to a temporary shock.
The new equilibrium $r$ is higher.
**permanent demand shock**

- $r = r_0$
- $r = r_s$
- IS
- IS'

**temporary demand shock**

- $r = r_0$
- $r = r_s$
- IS
- IS'

**permanent inflation shock**

- $\pi = \pi_0$
- $\pi = \pi_1$
- $\pi = \pi_T$
- PC($\pi^e_1 = \pi_0$)
- PC($\pi^e_0 = \pi^I$)

**temporary inflation shock**

- $\pi = \pi_0$
- $\pi = \pi_1$
- $\pi = \pi_T$
- PC($\pi^e_1 = \pi_0$)
- PC($\pi^e_0 = \pi^I$)
permanent demand shock

temporary demand shock
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Monetary Rule and Taylor Rule

• The IS curve is used by the CB to find out what interest rate to set given its best response output-inflation combination in the Phillips diagram (once it has located the best available position on the MR line)

• best-response interest rate rule

• Taylor (1993): Rule which well described the FED’s historical interest rate behaviour

\[ r_0 - r_s = 0.5(\pi_0 - \pi^T) + 0.5(y_0 - y_e) \]
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Monetary Rule and Taylor Rule

\[ \pi_1 = \pi_0 + \alpha(y_1 - y_e) \]

\[ y_1 - y_e = -\alpha(r_0 - r_s) \]

\[ y_1 - y_e = -\alpha\beta(\pi_1 - \pi^T) \]

Substitute PC into MR:

\[ \pi_0 + \alpha(y_1 - y_e) - \pi^T = -\frac{1}{\alpha\beta}(y_1 - y_e) \]

\[ \pi_0 - \pi^T = -\left(\alpha + \frac{1}{\alpha\beta}\right)(y_1 - y_e) \]
substitute IS curve and rearrange:

\[
\begin{align*}
    r_0 - r_s &= \frac{1}{a \left( \alpha + \frac{1}{\alpha \beta} \right)} (\pi_0 - \pi^T) \\
    \text{if: } a &= \alpha = \beta = 1
\end{align*}
\]

\[
    r_0 - r_s = 0.5(\pi_0 - \pi^T)
\]
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Monetary Rule and Taylor Rule

\[ r_0 - r_s = 0.5(\pi_0 - \pi^T) \]

If inflation is 1% above the target, the real interest rate needs to be 0.5 percentage points higher.

**Taylor principle**: The need to raise \( i \) sufficiently to push up \( r \), so that the CB’s interest rate response is actually stabilising.
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Monetary Rule and Taylor Rule

\[ r_{0} - r_{s} = \frac{1}{\alpha \left( \alpha + \frac{1}{\alpha \beta} \right)} \left( \pi_{0} - \pi^{T} \right) \]

• As \( \beta \) increases, the CB will respond to an inflation shock with a larger rise in the interest rate

• As \( \alpha \) increases, the CB’s interest rate response to an inflation shock will be smaller

• As \( \alpha \) increases the CB’s best response change in the interest rate to an inflation shock is reduced
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Monetary Rule and Taylor Rule

\[ r_0 - r_s = 0.5(\pi_0 - \pi^T) \]  
(interest rate rule)

\[ r_0 - r_s = 0.5(\pi_0 - \pi^T) + 0.5(y_0 - y_e) \]  
(estimated Taylor rule)

double-lag timing assumption

• Interest rate only affects output after one period

• It takes one period for output to affect inflation
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Monetary Rule and Taylor Rule

\[ r_0 - r_s = 0.5(\pi_0 - \pi^T) \]

\[ r_0 - r_s = 0.5(\pi_0 - \pi^T) + 0.5(y_0 - y_e) \]

(estimated Taylor rule)

(double-lag timing assumption)

\[ \pi_0 \rightarrow y_0 \rightarrow r_0 \]
\[ \pi_1 \rightarrow y_1 \]
\[ \pi_2 \]
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

Monetary Rule and Taylor Rule

\[ L = (y_1 - y_e)^2 + \beta(\pi_2 - \pi^T)^2 \]  
(CB’s loss function)

\[ y_1 - y_e = -a(r_0 - r_s) \]  
(IS)

\[ \pi_1 = \pi_0 + \alpha(y_0 - y_e) \]  
(PC)

\[ \pi_2 - \pi^T = -\frac{1}{\alpha\beta}(y_1 - y_e) \]  
(MR)
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

Monetary Rule and Taylor Rule

\[ L = (y_1 - y_e)^2 + \beta(\pi_2 - \pi^T)^2 \]  \hspace{1cm} \text{(CB’s loss function)}

\[ y_1 - y_e = -a(r_0 - r_s) \]  \hspace{1cm} \text{(IS)}

\[ \pi_1 = \pi_0 + \alpha(y_0 - y_e) \]  \hspace{1cm} \text{(PC)}

\[ \pi_2 - \pi^T = -\frac{1}{\alpha \beta} (y_1 - y_e) \]  \hspace{1cm} \text{(MR)}

\text{PC into MR and then into IS:}

\[ r_0 - r_s = \frac{1}{a \left( \alpha + \frac{1}{\alpha \beta} \right)} (\pi_0 - \pi^T) + \frac{\alpha}{a \left( \alpha + \frac{1}{\alpha \beta} \right)} (y_0 - y_e) \]
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

Monetary Rule and Taylor Rule

\[ r_0 - r_s = \frac{1}{a \left( \alpha + \frac{1}{\alpha \beta} \right)}(\pi_0 - \pi^T) + \frac{\alpha}{a \left( \alpha + \frac{1}{\alpha \beta} \right)}(y_0 - y_e) \]

\[ a = \alpha = \beta = 1 \]

\[ r_0 - r_s = 0.5(\pi_0 - \pi^T) + 0.5(y_0 - y_e) \]

(estimated Taylor rule)
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

Monetary Rule and Taylor Rule

Bank of Japan Act (2012):
The Bank’s monetary policy should be ‘aimed at achieving price stability, thereby contributing to the sound development of the national economy’.

Federal Reserve Act:
The Congress established the statutory objectives for monetary policy -maximum employment, stable prices and moderate long-term interest rates-.

Bank of England:
The Bank’s monetary policy objective is to deliver price stability-low inflation-and subject to that, to support the Government’s economic objectives including those for growth and employment. Price stability is defined by the Government’s inflation target of 2%
3 EQUATION MODEL AND THE BANKING SYSTEM
\[ y_t = A_t - \alpha r_{t-1} \]

\[ \pi_t = \pi_{t-1} + \alpha (y - y_e) \]

\[ (y_t - y_e) = -\alpha \beta (\pi_t - \pi^T) \]
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

• The modern financial system in the macro-economy

• New elements to be introduced:
  
  • Distinction between policy rate and lending rate
  
  • Banks which set the lending rate; Credit rationing.
  
  • Money market: Borrowing and lending among banks, market for government bonds.
  
  • Governance structure of the financial system: Relationship between govt (and taxpayers), the CB, and banks; Solvency and liquidity problems.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Money Supply and Demand

• Money supply is created by both CB and commercial banks.

  • **Narrow Money:** Central Bank money; most liquid

  • **Broad Money:** Central Bank money and commercial bank money

• CB and commercial bank money are equivalent in normal times, but this breaks down in a financial crisis.

  • CB money is legal tender while commercial bank money is not.

• Banks choose liquidity ratios (reserves: deposits), and create money by extending loans when profitable.

• Stock of commercial bank money measured by size of current accounts, which depends on money demand.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

• An independent, inflation targeting CB has direct control over the policy rate of interest
  - Monetary Policy Committee at the BoE

• The policy rate is the rate at which the CB lends to financial institutions and pays on reserves
  - Arbitrage opportunities make money markets rate stay close to policy rate

• CB knows the mark-up
The Banking mark-up:

\[ r = r_s \]
\[ r = r_p \]

Banking Mark-up

\[ \frac{M^D}{P}(y_e, \Phi'') \]
\[ \frac{M^D}{P}(y_e, \Phi) \]
\[ \frac{M^D}{P}(y_e, \Phi') \]
The Banking mark-up:

$r = r_s$

Banking Mark-up

$r = r_p$

New Banking Mark-up

$\pi = 2\%$

$\pi^e = 2\%$

$y_e$

$y$

$r$

$r$

$y$

$y$

IS

IS
The Banking mark-up:

Stable relationship between policy rate and lending rate disrupted by the financial crisis: Key transmission mechanism of MP broke down.

Figure 5.4 UK Official Bank Rates and 5-yr fixed mortgages rates (75% LTV): Jan 2000–Aug 2013.

THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

- (most) banks are privately owned
- Banks face a demand for new loans from the private sector
- Banks face a cost of funding when their new deposits are not sufficient

Simple model of profit maximisation bank’s behaviour:

Profits depend on:
- the expected return on the loans they make
- the rate they pay for borrowing in the money market
- opportunity cost of holding bank capital (or equity)
The Banking mark-up:

Policy rate set by CB

Short-term money market rate

Banking mark-up depends on:
(a) riskiness of loans
(b) risk tolerance
(c) Bank equity
(d) *market power*

Lending rate
Why Banks Ration Credit?

• understanding the determinants of the lending rate is important, but we need to understand why banks ration credit too

• **Credit risk**
  - banks will adjust the lending rate to reflect the average credit risk of their loan portfolio

• the weight of credit constraint affects the size of the multiplier and the slope of the IS curve

• changes in asset prices relax the borrowing constraint

• **Information problems**
  - moral hazard
  - adverse selection
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Effects of credit rationing:

• borrowers who do not possess the wealth to provide an equity stake in their project will be denied credit - even if their project is good

• Collateral
  use of an asset as guarantee for a loan - secured loans - banks still bear credit risk on the loan
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Information problems:

- Attributes of borrower and project
- Amount borrower is willing to contribute to project
- If borrower is willing to provide high equity stake or collateral
- Bank’s decision based on signal from borrower’s equity stake

Wealth of borrower

Quality of project (known to borrower, but not to lender)

Borrower’s equity stake in project or collateral

Incentive for borrower to work hard and make prudent choices

Signal of quality of project

Bank’s loan decision

Figure 5.7 Credit constraints: the role of borrower wealth in the lending decisions of banks.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Potential Risks for the Banks

- **Liquidity risk**
  - risk that a bank has inadequate reserves to meet the demand by depositors to withdraw money from their accounts
  - reserve holdings by commercial banks
  - banking panic and bank run
  - central bank insurance - Lender of Last Resort (LOLR)
  - system of deposit insurance: bank deposits below a certain level will be honoured in full
  - moral hazard problem: incentives for the banks to avoid prudential behaviour

- **Solvency Risk**
  - the bank is insolvent or bankrupt when the value of its assets is less than the value of its liabilities
  - negative effects for bank’s stakeholders
  - bank will go out of business if it is not bailed out by the government
  - Spillover effects: problems of interconnection through chains of lending and borrowing
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

How to prevent liquidity problems

• Schemes to prevent liquidity problems (LOLR facility and deposit guarantees) have to be designed to tread the fine line between:
  • Protecting the public from the spillovers of liquidity problems
  • Avoiding moral hazard
  • Such schemes make banks less prudent in their lending behaviour, and households less prudent in their savings behaviour (Households might save in unsound banks, since their deposits are guaranteed anyway)
• Solvency risk: when the value of assets is less than that of debts or liabilities → bankruptcy if not bailed out by the government.
• Interconnectedness in the banking sector: Solvency problem for a small no. of banks → banks unsure about safety in borrowing from one another → widespread liquidity problems
• Insolvency has direct negative effects on bank depositors, creditors, shareholders and bondholders.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Government Arrangements in dealing with liquidity and solvency problems:

1. Central Bank: LOLR to banking system; Provides emergency liquidity

2. Government (ie. Taxpayers): Responsible for solvency of the banking system; If banks are to be bailed out, this is done by the govt.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Government Arrangements in dealing with liquidity and solvency problems:

- Central Bank: LOLR to banking system; Provides emergency liquidity

- Government (ie. Taxpayers): Responsible for solvency of the banking system; If banks are to be bailed out, this is done by the govt.

- CB is the LOLR to the government:
  Govt. bails out failing banks → Large increase in sovereign debt → Bond holders lose confidence and sell bonds → Bond prices drop and interest rates increase → Sovereign default risk → CB (LOLR) can step in to buy govt. bonds to support bond price and prevent interest rates from rising.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Government Arrangements in dealing with liquidity and solvency problems:

• Mutual confidence between the govt. and CB is important for the governance system:

  • Confidence that CB acts as LOLR to govt. helps stabilise expectations. If the system deemed credible by the financial markets, a sovereign default risk premium will not arise and int. rates stay low.

  • e.g. the ECB was not a LOLR to Eurozone governments → during the crisis, default risk rose and bond int. rates spiked, unlike countries outside the Eurozone with similar debt levels.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

**Eurozone:**

**Governance solutions:**

**Gov't to gov't:** “No bail out” clause broken during crisis, enabling bail outs by creditor nations; Introduction of Fiscal Compact.

**ECB to gov't:** ECB changed role to be a LOLR to member gov’ts (Draghi: ECB ‘ready to do whatever it takes to preserve the euro’) → Default risk ↓ → Gov’t borrowing cost ↓.

**Banks to governments:** Banking union (Single Resolution Mechanism) proposed so EA member countries are jointly responsible for bank solvency;

Replicating the governance structure of nation states via further integration might help (e.g. the political & fiscal union among US states) → However, little appetite & scope for such integration.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Eurozone:

Perhaps they will be lucky. It may be that events, as they turn out in the next 10 or 20 years, will be common to all the countries; there will be no shocks, no economic developments that affect the different parts of the Euro area asymmetrically. In that case, they'll get along fine and perhaps the separate countries will gradually loosen up their arrangements, get rid of some of their restrictions and open up so that they're more adaptable, more flexible.

On the other hand, the more likely possibility is that there will be asymmetric shocks hitting the different countries. That will mean that the only adjustment mechanism they have to meet that with is fiscal and unemployment: pressure on wages, pressure on prices. They have no way out.

Milton Friedman, 1998
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Eurozone:

- No lender of last resort to member governments

- No bail-out

- Member Government

- Joint responsibility in cross-border bank solvency

- Key difference vs nation state

- Separation

- European Central Bank (lender of last resort to the banking system)

Commercial bank (domestic)

Commercial bank (domestic)

Commercial bank (cross-border)

Figure 12.12 Governance arrangements in the Eurozone prior to the crisis.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Eurozone:

Governance arrangements in pre-crisis Eurozone:

• Crisis: ECB provided liquidity to banks, but bank insolvency dealt with by member country governments
  → gov’t debt burden ↑.

• Key difference: Member countries cannot rely on ECB as LOLR to support govt. bond sales if required.

• Govt. debt was issued in Euro (which member gov’ts have no control over) + ECB was prevented by mandate to act as LOLR → Fear of gov’t illiquidity → Gov’t bond int. rate ↑

• Further: Eurozone banks are major holders of gov’t bonds → If gov’t bond prices ↓, bank solvency problems may arise.

• Also, high levels of public debt for Eurozone members vs US states. US debt is mainly federal (more resilient as US Fed is LOLR to federal gov’t)
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Banks and Macro-stabilisation

3-equation model adjustment process: Investment boom

- Investment boom → Banks make new loans to households and firms, thus needing to replenish reserves at the CB.

- Higher income from the investment boom → Households increase deposits and bond purchases

- Because of bond purchases by households, the increase in deposits is insufficient to fund the new loans made by the bank → Banks borrow from the money market

- CB wants to bring inflation back to target → raises policy rate

- Higher policy rate → Higher cost of funding → Banks pass this on in a higher lending rate → Interest-sensitive spending decreases → Economy adjusts back to equilibrium output and target inflation.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Banks and Macro-stabilisation

**start here, clockwise

Figure 5.12 The flows of funds in the economy as the result of a boom in investment.
The increase in investment shifts the IS curve to the right. The central bank responds by raising the policy rate to $r^{P'}$ to achieve a lending rate of $r_0$. Policy rate then lowered over following periods until the lending rate reaches $r_s'$. 

Figure 5.13 An investment boom in the 3-equation model with the banking system.
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Monetary Transmission Mechanisms
THE THREE-EQUATION MODEL AND THE BANKING SYSTEM

Monetary Transmission Mechanisms

CB affects $AD$ using $i$, working through 4 main channels:

- Market rates: $i \downarrow \rightarrow$ Borrowing desirable, saving less $\rightarrow AD \uparrow$.
- Asset prices: $i \downarrow \rightarrow$ Asset price $\uparrow \rightarrow$ household wealth $\uparrow \rightarrow C \uparrow$ (via PIH).
- Expectations/confidence: $i \downarrow$ might show CB commitment to accommodative policy in the future (policy stance) $\rightarrow AD \uparrow$.
- Exchange rate channel: $i \downarrow \rightarrow e \uparrow \rightarrow Q \uparrow \rightarrow (X-M) \uparrow \rightarrow AD \uparrow$.

In reality, CB’s differ by mandates: Dual mandates on $\pi$ and $y$ (US Fed); price stability as a priority, employment as secondary etc.

Different CB objectives translated into different int. rate behaviour: e.g. BoE and ECB react more strongly to inflation as opposed to the US Fed (see Castro, 2011).
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

Summary:

The IS curve models the demand side, the PC curve models the supply side and the MR curve models the policy maker.

Private sector determines the equilibrium output
AD determines actual output
Banking system determines lending rate
CB determines policy rate to achieve desired output gap and inflation target

Stabilisation policy: Low & stable inflation minimises the negative effects of inflation on the economy.
Note that the CB needs to forecast the IS and the PC curves

Forecasting the IS curve:
- Is the AD shock temporary or permanent?
- Vital since the persistence of shocks affects the CB’s optimal response.

Permanent shock: $\text{IS}'$ does not shift back to IS
A larger increase in $r$ is needed compared to a temporary shock.
The new equilibrium $r$ is higher.
THE 3-EQUATION MODEL AND MACROECONOMIC POLICY

Summary:

The banking mark-up is influenced by loan riskiness, risk-tolerance and the bank’s capital cushion.

The inflation-targeting CB does not actively manage money supply.

Money supply is simply determined by the demand for money at a given policy rate.

The CB reacts to economic shocks in the same way as before.

The banking system simply provides a more thorough explanation for this adjustment mechanism.
SOME READINGS

• Carlin & Soskice, Chapters 3, 5 & 13 (1 & 2 if you need to refresh basic macro)


• The transmission mechanisms of monetary policy. Bank of England (last accessed 6th November 2015)