LECTURE 1.2

Introducing the IS-MP-PC Model

ECON42550 Macroeconomics

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Autumn 2026

Where We Are

1. Short-Run Fluctuations

1.1 The Keynesian Multiplier

1.2 Introducing IS-MP-PC

1.3 Analysing IS-MP-PC

1.4 The Zero Lower Bound

1.5 Banks, Runs, the Cycle

2. NK Building Blocks

2.1 Expectations, Investment

2.2 Consumption, Fiscal Policy

2.3 Sticky Prices and the NKPC

3. Long-Run Growth

3.1 Growth Facts, Solow

3.2 The Fundamental Causes

3.3 Endogenous Growth

3.4 Schumpeterian Growth

Last Week's Lecture

Last week we built the **Keynesian multiplier**: demand sets output in the short run.

1. **Syllabus.**
   What we cover, how we cover it, how you are assessed.
2. **New Keynesian Economics.**
   What it keeps from Keynes, and what it adds.
3. **The Keynesian Multiplier.**
   The case for fiscal intervention.

Lecture Plan

Today we build a more detailed description of the economy. We introduce three pieces one at a time, combine them, and solve.

1. **Demand: The IS Curve.**
   How a higher real interest rate cuts spending.
2. **Supply: The Phillips Curve.**
   How a positive output gap raises inflation.
3. **Policy: The Monetary Policy Rule.**
   How the bank raises its rate when inflation rises.

> **Whelan's Chapter 2 Goes With Today**
> Whelan, chapter 2 (Whelan, 2023).

SECTION 1

Demand: The Investment-Savings (IS) Curve

1. Demand: The Investment-Savings (IS) Curve
2. Supply: The Phillips (PC) Curve
3. Policy: The Monetary Policy (MP) Rule
4. Putting the Model Together

What Determines Aggregate Demand?

- **The Interest Rate Channel:** higher rates cut borrowing, investment and consumption.
- **The Credit Channel:** higher rates cut borrowers' net worth and their collateral.
- **Fiscal Policy:** Last week's multiplier, in one term.

Two more, as asides for now:

- **Expectations:** What households think their lifetime income will be. More in Lecture 2.2.
- **Credit Constraints:** Who can borrow at all. More in Lecture 1.5.

From the Multiplier to the IS Curve

The interest rate was absent from the Keynesian multiplier; spending depended only on income. Two changes fix that:

- Short-run deviations in output must be re-written in terms of the real interest rate.
- We bundle everything else — fiscal policy, confidence, trade — into one shock term.

Our Basic Model in Logs

Everything so far has been in **levels**: Y, C, I, G, all in euros. From here output is written in lower case, $y_t = \log Y_t$, and last week's identity reads

$$\underbrace{y_t}_{\text{actual output}} = \underbrace{y_t^*}_{\text{long-run trend}} + \underbrace{(y_t - y_t^*)}_{\text{short-run deviation}} \tag{1}$$

Why Log?
Differences between logs approximate percentage changes. So $y_t - y_t^*$ reads in **percentage points**, not in euros.

Our Version of the IS Curve

Reformulating the short-run deviations:

$$y_t = y_t^* \overbrace{- \alpha \underbrace{(r_t - r^*)}_{\text{the real rate gap}} + \varepsilon_t^y}^{\text{the short-run deviation}} \tag{2}$$

Where:

- r_t: the real interest rate
- r^*: the natural rate of interest
- α: how much output falls as the real rate gap rises
- ε_t^y: a demand shock

Real Rates, Not Nominal

We replace r_t with the Fisher Equation:

$$r_t = i_t - \pi_t \tag{3}$$

Where:

- i_t: the nominal interest rate
- π_t: inflation

We prefer this form because the central bank sets i_t, not r_t.

The IS Curve in Nominal Terms

Replacing r_t with the Fisher Equation:

$$y_t = y_t^* - \alpha\,(i_t - \pi_t - r^*) + \varepsilon_t^y \tag{4}$$

The Natural Rate of Interest, r^*
The real rate at which output equals trend, with $\varepsilon_t^y = 0$. r^* is **unobservable**, and overstating it runs policy too tight.

The Natural Rate of Interest

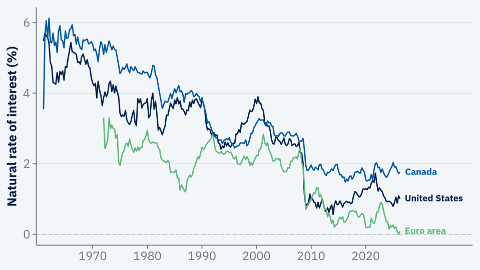

Figure 1: Estimates of the natural rate of interest for three advanced economies.

> **The Natural Rate Has Fallen for Decades**
> The natural rate has fallen for four decades across advanced economies. No central bank chose it. Estimates from Holston et al. (2017).

The IS Curve, Drawn

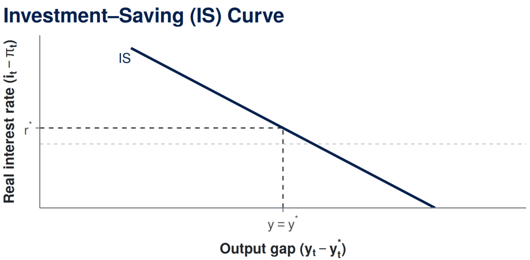

Figure 2: The IS curve: output against the real interest rate, with $\varepsilon_t^y = 0$.

> **A Higher Real Rate Cuts Output**
> Borrowing costs more, so investment and consumption fall: the IS curve slopes down.

Reading the IS Curve

- The **IS curve** slopes down, crossing y_t^* exactly where the real interest rate equals r^*.
- A **higher** real interest rate is a movement along the IS curve, not a shift of it: output falls.
- A **positive** demand shock ε_t^y shifts the **IS rightwards**: output increases.

Open the IS-MP-PC app and run the **AI Data Centre Boom** scenario. The IS curve shifts right of its dashed baseline. Raise α, and the same shock shifts it further.

> **A Rate Below r^* Boosts Output**
> A real rate below r^* puts output above trend. A real rate above r^* puts output below trend.

SECTION 2

Supply: The Phillips (PC) Curve

1. Demand: The Investment-Savings (IS) Curve

2. Supply: The Phillips (PC) Curve

3. Policy: The Monetary Policy (MP) Rule

4. Putting the Model Together

The Supply Side in the Short Run

Output is produced with capital, technology and labour. In the short run:

- **Capital** is fixed — property, plant and equipment. It takes time to build capacity.
- **Technology** is fixed too. Productivity growth is a long-run story.
- **Labour** can change, so a demand shock falls on the labour market.

> **The Short Run Is a Model of Wages and Prices**
> Capital and technology cannot absorb a demand shock, so wages and prices carry it.

How Higher Output Raises Inflation

Under a positive demand shock, output and employment rise. As the labour market tightens, wages rise. Firms reprice to protect their margins, leading to inflation.

$$\uparrow \text{output} \;\Rightarrow \uparrow \text{employment} \;\Rightarrow \uparrow \text{wages} \;\Rightarrow \uparrow \text{prices} \tag{5}$$

- Firms set prices as a **mark-up over cost**, and wages dominate costs.
- Workers have **more negotiating power** when jobs are easy to find.
- Each link **slows the pass-through**, so the chain runs in rounds rather than instantly.

The Phillips Curve

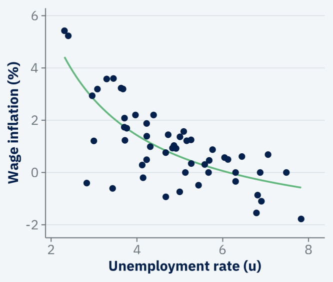

Figure 3: UK wage inflation and unemployment, 1861–1913, redrawn from the Bank of England's millennium dataset over Phillips's own fitted period.

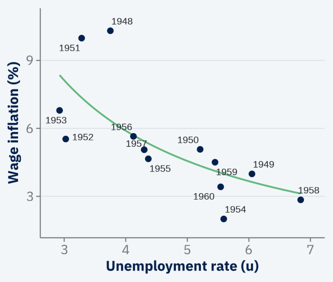

Figure 4: The American counterpart, 1948–1960: wage inflation in manufacturing against the household survey unemployment rate.

> **The Trade-off Looked Exploitable**
> For about a decade the trade-off looked real, and looked exploitable by policy (Phillips, 1958; Samuelson & Solow, 1960).

The Expectations-Augmented Phillips Curve

Milton Friedman argued in 1968 that the Phillips trade-off — lower unemployment bought with higher inflation — would not survive being used (Friedman, 1968):

- **Expected Real Wages:** workers ask for increases above the inflation they expect.
- **Not Sustainable:** hold unemployment below its equilibrium and inflation accelerates.
- **What It Supposes:** a **natural rate of unemployment**, at which inflation is steady.

> **Is the Natural Rate Still There?**
> On whether the natural rate hypothesis still holds, see Blanchard (2018).

The Demise of the Basic Curve

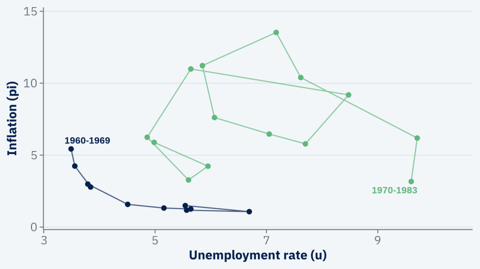

Figure 5: US inflation and unemployment: the scatter that was stable, then was not.

> **The Trade-off Broke in the Late 1960s**
> The trade-off held through the early 1960s, then broke. By the late 1960s inflation was rising **with** unemployment.

Our Version of the Phillips Curve

Our version of the Phillips curve is as follows:

$$\pi_t = \pi_t^e + \gamma \underbrace{(y_t - y_t^*)}_{\text{the output gap}} + \varepsilon_t^\pi \tag{6}$$

- π_t^e: expected inflation
- π^*: the inflation target
- γ: how much inflation rises with the output gap
- ε_t^π: an inflation shock

What the Phillips Curve Says

Three terms set inflation:

- **Expectations:** A one-point rise in π_t^e raises inflation by one point.
- **The Output Gap:** A one-point gap raises inflation by γ points.
- **Shocks:** An oil price spike, a broken supply chain — anything that changes prices once and then stops.

Lecture 2.3 derives the curve from firms that cannot reset prices at will.

> **Reading a Shock's Superscript**
> The superscript names the origin: y for demand, π for inflation.

One Picture, Two Stories

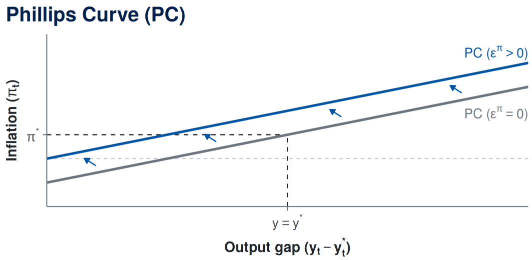

Figure 6: The Phillips curve before and after a two-point shift in expected inflation.

> **Expected Inflation Lifts the Whole Curve**
> Higher expected inflation lifts the whole curve, at every output gap.

Two Ways to Shift the Curve

Dashed grey, before. Solid blue, after. The slope determined by γ is unchanged — the whole curve has moved up, so at every level of output inflation is two points higher:

- An **inflation shock**, $\varepsilon_t^{\pi} = 2$.
- A two-point rise in **expected inflation**, π_t^e.

> **Two Routes, One Curve**
> Both give $\pi_t = \pi^* + 2 + \gamma(y_t - y_t^*)$, from a baseline of $\pi_t^e = \pi^*$ and $\varepsilon_t^{\pi} = 0$. An inflation shock fades; a rise in expected inflation need not.

Was 2021 a Supply Shock or Lost Credibility?

Inflation rose sharply across advanced economies from 2021. Was that mostly ε^{π}, or mostly π^{e}?

- Have a think, then argue it out with the person beside you.
- Then: what evidence would settle it?

Run both scenarios in the IS-MP-PC app: **Energy Shock**, then **Increase in Inflation Expectations**. The Phillips curve lifts in both. The static diagram cannot tell them apart.

The Slope Has Not Been Stable

- Many authors documented a **flattening**: a given gap raised inflation less than before (see Blanchard, 2018).
- Post-COVID evidence points to a **steeper** curve when the economy runs hot.
- Waller (2023) tests two explanations for the instability — **de-anchored expectations**, or a genuine rise in γ — and finds for the second.

Both candidates are in the app. The γ slider changes price-setting behaviour, and λ sets how anchored expectations are.

SECTION 3

Policy: The Monetary Policy (MP) Rule

1. Demand: The Investment-Savings (IS) Curve
2. Supply: The Phillips (PC) Curve
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4. Putting the Model Together

What the Policy Rule Has to Deliver

- **An Inflation Target:** The bank announces π^* — 2% at the ECB and the Fed — and is judged against it.
- **Lean Against the Inflation Gap:** Above target, the bank raises the policy rate; below, it cuts.
- **Neutral When On Target:** the real rate at r^*, the nominal rate at $r^* + \pi^*$.

The Monetary Policy Rule

We first consider a monetary policy rule of the form:

$$i_t = r^* + \pi^* + \beta_\pi \underbrace{(\pi_t - \pi^*)}_{\text{the inflation gap}}, \qquad \beta_\pi > 0 \tag{7}$$

- β_π: how hard the bank leans against the inflation gap

> **The Bank Raises Rates by More Than Inflation**
> We assume $\beta_\pi > 1$ for now. Lecture 1.3 shows why.

Why a Rule Like This Is a Good Idea

- If the public understands the target and the central bank is credible, they will expect inflation to equal the target on average.
- The Phillips curve then puts inflation at π^* on average, provided output is at trend.
- And the IS curve puts output at trend on average when $i_t - \pi_t = r^*$ — which is exactly what the rule delivers without an inflation gap.

> **Real Rules Also Watch Output**
> This rule answers inflation alone. The Fed also raises its rate when output exceeds trend, adding $\beta_y(y_t - y_t^*)$.

SECTION 4

Putting the Model Together

1. Demand: The Investment-Savings (IS) Curve

2. Supply: The Phillips (PC) Curve

3. Policy: The Monetary Policy (MP) Rule

4. Putting the Model Together

The Full Model

Thus far the model consists of three equations.

$$\text{IS:} \quad y_t = y_t^* - \alpha\left(i_t - \pi_t - r^*\right) + \varepsilon_t^y \tag{8}$$

$$\text{PC:} \quad \pi_t = \pi_t^e + \gamma\left(y_t - y_t^*\right) + \varepsilon_t^\pi \tag{9}$$

$$\text{MP:} \quad i_t = r^* + \pi^* + \beta_\pi(\pi_t - \pi^*) \tag{10}$$

Three variables cannot be drawn on two axes. The policy rule writes the interest rate as a function of inflation. Substitute it into the IS curve and only **output and inflation** are left.

What the Model Determines

Three symbols are **endogenous** — determined inside the model:

- y_t, π_t, i_t: output, inflation and the policy rate

Everything else is **exogenous** — handed to the model from outside it:

- y_t^*, r^*, π^*, π_t^e
- ε_t^y, ε_t^π
- α, γ, β_π

The Policy Rule Inside the IS Curve

The IS curve and the policy rule share the policy rate i_t, so line them up:

$$\text{IS:} \quad y_t = y_t^* - \alpha\,(i_t - \pi_t - r^*) + \varepsilon_t^y \tag{11}$$

$$\text{MP:} \quad i_t = r^* + \pi^* + \beta_\pi(\pi_t - \pi^*) \tag{12}$$

The rule fixes i_t as a function of inflation. Substitute it into the real rate gap and the policy rate disappears.

The IS-MP Curve

The rule goes in where i_t was:

$$i_t - \pi_t - r^* = \boxed{r^* + \pi^* + \beta_\pi(\pi_t - \pi^*)} - \pi_t - r^* \qquad (13)$$

The r^* terms cancel, and $\pi^* - \pi_t$ is $-(\pi_t - \pi^*)$:

$$i_t - \pi_t - r^* = \underbrace{(\beta_\pi - 1)(\pi_t - \pi^*)}_{\text{the real-rate gap the rule delivers}} \qquad (14)$$

Put that back into the IS curve:

$$y_t = y_t^* - \alpha(\beta_\pi - 1)(\pi_t - \pi^*) + \varepsilon_t^y \qquad (15)$$

Output as a Function of Inflation Alone

The interest rate has not stopped mattering; the rule ties it to inflation.

Why the IS-MP Curve Slopes Down

The IS-MP curve's slope in the (y, π) plane is set by $\alpha(\beta_\pi - 1)$. Everything turns on whether β_π exceeds one.

Assume $\beta_\pi > 1$ for Now
The bank raises the policy rate by **more** than inflation, so the real interest rate rises and output falls: the curve slopes down. That assumption has a name — the **Taylor principle** — and Lecture 1.3 asks what goes wrong without it.

IS-MP and PC Together

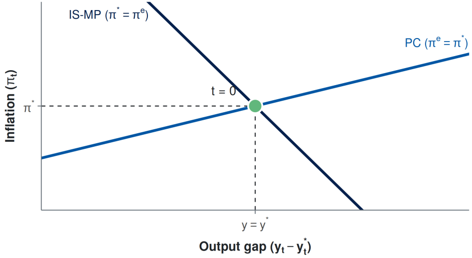

Figure 7: The downward-sloping IS-MP curve and the upward-sloping Phillips curve, each labelled in the panel, crossing at a zero output gap with inflation at the target π^* marked on the right axis.

> **The Curves Cross Once**
> The two curves cross once, and that crossing is where the economy settles.

Reading the Two Curves

- **The Axes:** output on the horizontal, inflation on the vertical.
- **IS-MP Slopes Down:** higher inflation brings a tighter policy response and less output.
- **The Phillips Curve Slopes Up:** more output brings more inflation.
- **The Crossing:** output and inflation where both curves hold at once.

A Change in Inflation Expectations

Suppose people simply come to expect more inflation than the central bank is targeting. Does that expectation, on its own, change inflation and output?

- The Phillips curve shifts **up**: at every level of output, inflation is higher because expected inflation is higher.
- The IS-MP curve does **not** shift: no term in it contains π_t^e.
- So the crossing slides up and to the **left**. Inflation rises, and output falls below trend.

> **Belief Alone Raises Inflation and Cuts Output**
> Nothing real has changed — only what people expect. That is why central banks spend so much time talking.

Try It: Where the Curves Cross

Five minutes in the IS-MP-PC app. Run **Increase in Inflation Expectations**: the Phillips curve lifts and IS-MP stays put.

Question

Which changes **shift** a curve, and which **rotate** one? The bank sets only i_t — why is it not on these axes?

The Diagram Gives Signs, Not Sizes

Inflation up, output down — but by how much?

- The size depends on α, γ and β_π, which the picture cannot show.
- Nor can the picture say what happens when two shocks arrive at once.

So we solve the system properly, and get output and inflation in closed form.

The Two Curves We Have Left

After the substitution, two equations in two unknowns:

$$\text{IS-MP:} \quad y_t - y_t^* = -\alpha(\beta_\pi - 1)(\pi_t - \pi^*) + \varepsilon_t^y \tag{16}$$

$$\text{PC:} \quad \pi_t = \pi_t^e + \gamma\,(y_t - y_t^*) + \varepsilon_t^\pi \tag{17}$$

- IS-MP has the **output gap alone on the left**.
- The Phillips curve has that same output gap **on the right**.

Substituting One Into the Other

Substitute IS-MP into the Phillips curve, since IS-MP already has the output gap by itself:

$$\pi_t = \pi_t^e + \gamma \left[-\alpha(\beta_\pi - 1)(\pi_t - \pi^*) + \varepsilon_t^y \right] + \varepsilon_t^\pi \tag{18}$$

Collect the π_t terms on the left:

$$\pi_t \left[1 + \alpha\gamma(\beta_\pi - 1) \right] = \pi_t^e + \alpha\gamma(\beta_\pi - 1)\pi^* + \gamma\varepsilon_t^y + \varepsilon_t^\pi \tag{19}$$

One equation, one unknown. Everything on the right is exogenous or a parameter.

Every Result Divides by the Same Bracket

The reciprocal of $1 + \alpha\gamma(\beta_\pi - 1)$ gets a symbol:

$$\theta = \frac{1}{1 + \alpha\gamma(\beta_\pi - 1)} \tag{20}$$

- θ: the share of a shock that reaches inflation after the bank leans against it
- With $\beta_\pi > 1$, θ lies strictly between zero and one

The One Substitution Every Solution Uses

$1/\theta = 1 + \alpha\gamma(\beta_\pi - 1)$, so $\alpha\gamma(\beta_\pi - 1) = (1 - \theta)/\theta$.

The Solution for Inflation

$$\pi_t = \theta\, \pi_t^e + (1-\theta)\, \pi^* + \theta\left(\gamma\, \varepsilon_t^y + \varepsilon_t^\pi\right) \qquad (21)$$

Inflation is pulled between two anchors and pushed by two shocks:

- **What People Expect:** π_t^e, with weight θ.
- **What the Bank Targets:** π^*, with weight $1-\theta$.
- **The Two Shocks:** $\gamma\varepsilon_t^y + \varepsilon_t^\pi$, with weight θ.

The two weights add to one. A smaller θ pulls inflation towards the target, away from expectations.

Assume No Shocks

$$\pi_t = \theta\,\pi_t^e + (1-\theta)\,\pi^* + \theta\left(\gamma\,\cancel{\varepsilon_t^y} + \cancel{\varepsilon_t^\pi}\right) \tag{22}$$

which leaves

$$\pi_t = \theta\,\pi_t^e + (1-\theta)\,\pi^* \tag{23}$$

Inflation Is a Weighted Average

Inflation is a **weighted average** of what people expect (π_t^e) and what the central bank targets (π^*), with weights θ and $1-\theta$.

What θ Does

- **A Tough Bank:** θ is small and inflation sits near target. An inflation shock costs output instead.
- **A Soft Bank:** θ is near one and inflation is whatever people expect. A demand shock reaches output in full.
- **A Small** θ Damps Both Shocks: θ multiplies $\gamma\varepsilon_t^y + \varepsilon_t^\pi$.

The Solution for Output

Put the solution for inflation back into the IS-MP curve:

$$y_t - y_t^* = \theta\,\varepsilon_t^y - \alpha\theta(\beta_\pi - 1)\left[(\pi_t^e - \pi^*) + \varepsilon_t^\pi\right] \quad (24)$$

The bracket holds what the bank must lean **against**: drifted expectations and an inflation shock. Each calls for a higher real interest rate, so the two enter together.

> **The Same θ Appears in Both Solutions**
> A demand shock raises output by $\theta\varepsilon_t^y$, not by ε_t^y. The difference is what the bank took back.

There Is No Free Lunch in a Supply Shock

- A **demand** shock pushes output and inflation **both up**, or both down, so leaning against it helps on both counts at once.
- An **inflation** shock pushes inflation up and output down. β_π only decides which of the two absorbs it.
- A **flatter** Phillips curve — a smaller γ — costs a tough bank about ε_t^π/γ in output.

In the app, run **Energy Shock** twice: β_π at 1.5, then at 3. The tougher bank holds inflation down and gives up more output. In the **AI Data Centre Boom**, output and inflation both rise instead.

Before Lecture 1.3

1. **Play:**
   The IS-MP-PC app, at $\gamma = 0.2$ and then 0.8.

2. **Apply:**
   Problem set 1, due before Lecture 1.3. It covers 1.1 and today.

3. **Review:**
   Whelan, chapters 2 and 3, and the handout on difference equations (Whelan, 2023).

Next Week

Next week we take the model we have just solved and **push on it**:

- **Expectations and Inflation Dynamics:** Expectations stop being exogenous, and the model acquires a time path.
- **The Taylor Principle:** What goes wrong when $\beta_\pi < 1$.
- **Scenario Tests:** A demand shock, then COVID, traced through both solutions.

Thank you

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BACKUP

Appendix

Appendix: How Interest Rates Reach Demand

The Interest Rate Channel
A higher policy rate raises the cost of borrowing. Firms drop the projects whose return no longer clears it, and households borrow less and save more. Investment and consumption both fall, so demand falls.

The Credit Channel
A higher rate also works through balance sheets. Interest expense rises, cutting borrowers' net worth; and asset prices fall, cutting the collateral they can pledge. Lenders then extend less credit at any given policy rate, so the same rate move does more than the first channel alone suggests.

The credit channel is Lecture 1.5's subject, where a banking sector is added to the model explicitly.

Appendix: The LM Curve

Traditionally the model is closed with an **LM curve**. Demand for real money balances rises with income and falls with the interest rate:

$$\frac{m_t}{p_t} = \delta - \mu\, i_t + \vartheta\, y_t \qquad (25)$$

- m_t: the nominal money stock
- p_t: the price level
- δ: autonomous money demand
- μ: how far money demand falls when the interest rate rises
- ϑ: how far money demand rises with income

Appendix: Solving the LM Curve for Output

Take δ and μi_t across:

$$\vartheta\, y_t = \frac{m_t}{p_t} - \delta + \mu\, i_t \tag{26}$$

Divide through by ϑ:

$$y_t = \frac{1}{\vartheta}\left(\frac{m_t}{p_t} - \delta + \mu\, i_t\right) \tag{27}$$

- LM slopes **up**, and its crossing with the downward-sloping IS fixes both.
- The central bank sets m_t to position the LM curve.
- No central bank has worked that way for decades, so we model the rule.

Appendix: The Real Rate Gap, Line by Line

Start from the real rate gap and substitute the rule:

$$i_t - \pi_t - r^* = \underbrace{r^* + \pi^* + \beta_\pi(\pi_t - \pi^*)}_{i_t} - \pi_t - r^* \tag{28}$$

The r^* terms cancel:

$$= \pi^* + \beta_\pi(\pi_t - \pi^*) - \pi_t \tag{29}$$

Write $\pi^* - \pi_t = -(\pi_t - \pi^*)$ and collect:

$$= \beta_\pi(\pi_t - \pi^*) - (\pi_t - \pi^*) = (\beta_\pi - 1)(\pi_t - \pi^*) \tag{30}$$

Appendix: The Solutions, Line by Line

From the collected line, divide by the bracket and use $\theta = 1/[1 + \alpha\gamma(\beta_\pi - 1)]$:

$$\pi_t = \theta\,\pi_t^e + \theta\,\alpha\gamma(\beta_\pi - 1)\,\pi^* + \theta\left(\gamma\varepsilon_t^y + \varepsilon_t^\pi\right) \tag{31}$$

Since $\alpha\gamma(\beta_\pi - 1) = (1 - \theta)/\theta$, the middle coefficient is $\theta \cdot (1 - \theta)/\theta = 1 - \theta$:

$$\pi_t = \theta\,\pi_t^e + (1 - \theta)\,\pi^* + \theta\left(\gamma\varepsilon_t^y + \varepsilon_t^\pi\right) \tag{32}$$

For output, substitute that into the IS-MP curve and use the same identity; the ε_t^y coefficient collapses to θ because $1 - \alpha\gamma\theta(\beta_\pi - 1) = 1 - (1 - \theta) = \theta$.

Appendix: What Makes θ Small

$\theta = 1/[1 + \alpha\gamma(\beta_\pi - 1)]$, so with $\beta_\pi > 1$ every one of the three parameters pushes θ down:

1. γ rises. A steeper Phillips curve provokes the bank sooner, so θ falls and shocks are damped harder.
2. α rises. Demand answers the real rate more, so the same rate rise costs more output. θ falls.
3. β_π rises. The bank leans harder for a given inflation gap, and θ falls towards zero.

> **α and β_π Cannot Be Separated**
> All three enter θ only through that product, but the full solutions do better: γ is read off inflation's response to a demand shock. What nothing separates is α from β_π, which appear only as $\alpha(\beta_\pi - 1)$.

Notes and Tools

- **Whelan's lecture notes** — the notes for this module. Chapter 2 goes with today.
- **The IS-MP-PC app** — all three equations, in your browser, nothing to install.
- **The New York Fed's r^* page** — Holston–Laubach–Williams estimates, revised quarterly.

Whelan is the only required reading.

References

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