LECTURE 1.3

Analysing the IS-MP-PC Model

ECON42550 Macroeconomics

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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 **IS-MP-PC model**, one equation at a time, and solved it.

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.

Lecture Plan

1 **Expectations and Inflation Dynamics.**
Let expectations follow last year's inflation, and the model gives a path.

2 **The Taylor Principle.**
How hard the bank must lean for anything to settle.

3 **Scenario Tests.**
A demand shock, then COVID.

> **Whelan, Chapter 2**
> Whelan, chapter 2 (Whelan, 2023).

SECTION 1

Expectations and Inflation Dynamics

Why Expectations Are the Loose End

This section characterises inflation expectations in the IS-MP-PC model. Last week's solution left expected inflation (π_t^e) on the right-hand side:

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

- A rise in π_t^e alone raises inflation and cuts output.
- π_t^e is **exogenous**. The model never says where expectations come from.
- Inflation expectations contributed to the collapse of the Phillips curve from the late 1960s.

What if expectations depend on the inflation people have just lived through?

Adjustment Back

The solution so far covers one period. Linking periods needs a rule for expectations. Let them be backward-looking, $\pi_t^e = \pi_{t-1}$. People expect this year what they saw last year. With no shocks:

$$\pi_t = \theta\,\pi_{t-1} + (1-\theta)\,\pi^* \tag{2}$$

Written as a deviation from target, that solves to

$$\pi_t - \pi^* = \theta^{\,t}\,(\pi_0 - \pi^*) \tag{3}$$

Inflation Returns to Target Geometrically

A fraction $1-\theta$ of the remaining gap closes every period. A tougher bank has a smaller θ, so inflation returns faster.

The Failure of the Phillips Curve

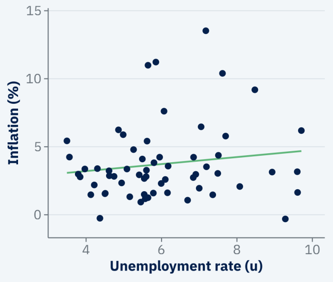

Figure 1: Inflation against unemployment, annual, 1955–2014.

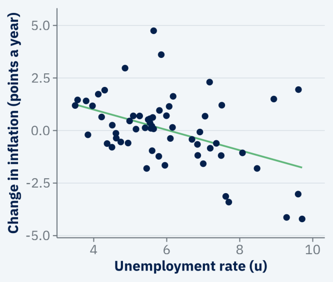

Figure 2: The change in inflation against unemployment, same years.

> **Unemployment Predicts the Change, Not the Level**
> Backward-looking expectations imply this pattern: with $\pi_t^e = \pi_{t-1}$, the output gap sets the **change** in inflation.

The Path, Drawn

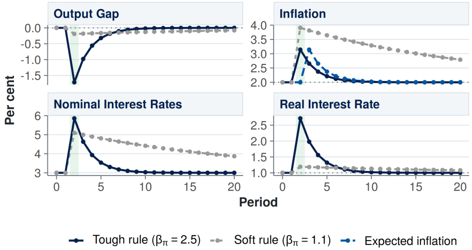

Figure 3: Four time paths after a one-period supply shock — the output gap, inflation, nominal interest rates and the real rate. Solid navy is the tough rule, $\beta_\pi = 2.5$; grey dashed is the soft rule, $\beta_\pi = 1.1$, as named in the legend below the panels.

> **Fast on Inflation, or Easy on Output**
> **Tough bank:** inflation back on target within a few periods, output far below trend. **Soft bank:** output near trend, inflation still off target years later.

Why the Scatter Is Not the Curve

The trade-off held in the data for a decade, then vanished:

- **Demand Shocks Dominant:** The scatter traces the Phillips curve.
- **Supply Shocks Dominant:** The scatter traces the IS-MP curve.

> **Structural and Reduced Form**
> **Structural:** a relationship the model posits, like the Phillips curve. **Reduced form:** what you observe once shocks and the bank have had their say.

The Bank Flattens the Scatter, but Only Half of It

The shock mix is not all that sits between γ and the slope:

- **Supply Shock:** A tougher bank flattens this arm, with slope $-1/[\alpha(\beta_\pi - 1)]$.
- **Demand Shock:** θ cancels, so the slope is exactly γ.
- **Post-Covid Evidence:** The scatter looked steeper, not flatter (Waller, 2023).

Three Explanations, One Scatter

A flatter scatter can mean a smaller γ (Blanchard, 2018), a different shock mix, or a tougher bank. No scatter separates the three.

What Makes θ Small?

Every result so far has run through θ. Three parameters build θ: α, γ and β_π.

> **Question**
> Which changes to α, γ or β_π shrink θ? What does a smaller θ buy the central bank?

Run **Increase in Inflation Expectations** and raise β_π. Inflation moves back towards target while output falls further below trend.

SECTION 2

The Taylor Principle

Raising the Rate by More Than Inflation

This section establishes the condition the policy rule must satisfy. Nobody borrows on the announced interest rate. What matters is the cost in goods — the rate net of inflation, the **real interest rate**.

Holding the rate steady through an inflation is not steady policy. The bank has loosened policy without deciding to.

> **Tightening Means the Real Rate Rises**
> To tighten, the bank must raise its rate by **more** than inflation rose. Only then does the real interest rate rise.

The Arithmetic, Once

Holding the Rate Loosens Policy

The policy rate is 3% and inflation is 2%, so the real rate is 1%. Inflation then rises to 6% and the central bank holds the rate. The real rate is now **$-$3%**, four points cheaper, in the middle of an inflation.

The Rule, Restated

The policy rule sets the nominal interest rate (i_t) from the inflation gap:

$$i_t = r^* + \pi^* + \beta_\pi \underbrace{(\pi_t - \pi^*)}_{\text{the inflation gap}} \tag{4}$$

What $r^* + \pi^*$ Is Doing There

The nominal rate that leaves the **real** rate at r^*, and the resting point of the rule. On target, the last term vanishes and the rule sets $i_t = r^* + \pi^*$.

A Star Is a Resting Point, Not an Optimum

Three starred symbols run through this lecture. The central bank picks π^*; the other two settle on their own:

- r^*: **exogenous.** Demographics and productivity set it, not the bank.
- π^*: the inflation target. Exogenous too, and the only star anyone chooses.
- y_t^*: **exogenous.** Where output settles when nothing is shocking it.

> **Optimisation Starts in Section 2**
> None of the three solves a maximisation problem. Elsewhere in economics x^* marks an optimum; in Section 1 of this module it never does.

Subtracting Inflation From Both Sides

The IS curve contains the real interest rate, so subtract inflation from both sides:

$$i_t - \pi_t = r^* + \pi^* + \beta_\pi(\pi_t - \pi^*) - \pi_t \tag{5}$$

The two end terms, π^* and $-\pi_t$, are one more inflation gap. That gap carries a minus in front: $\pi^* - \pi_t = -(\pi_t - \pi^*)$. So:

$$i_t - \pi_t = r^* + \beta_\pi(\pi_t - \pi^*) - (\pi_t - \pi^*) \tag{6}$$

What the Rule Does to the Real Interest Rate

Collecting the two inflation-gap terms puts monetary policy in one line:

$$\underbrace{(i_t - \pi_t)}_{\text{the real policy interest rate}} = r^* + (\beta_\pi - 1)(\pi_t - \pi^*) \tag{7}$$

The Real Rate Depends on $\beta_\pi - 1$

The real rate's **response** to inflation is $\beta_\pi - 1$, not β_π. Subtracting inflation costs the bank one point of its own response.

The Taylor Principle

$$\frac{\Delta(i_t - \pi_t)}{\Delta \pi_t} = \underbrace{\beta_\pi - 1}_{\text{the real interest rate response}} \quad (8)$$

Three cases, separated by what happens to the real interest rate:

- $\beta_\pi > 1$: the real rate **rises** with inflation. **Stabilising.**
- $\beta_\pi = 1$: the real rate holds still. The bank is a bystander.
- $\beta_\pi < 1$: the real rate **falls** as inflation rises. **Destabilising.**

> **Above One, or Inflation Does Not Come Back**
> $\beta_\pi > 1$: the condition under which inflation returns to target after a shock.

Putting the Rule Into Demand

The IS curve from lecture 1.2, and the real rate the rule delivers:

$$y_t = y_t^* - \alpha\,(i_t - \pi_t - r^*) + \varepsilon_t^y \tag{9}$$

$$i_t - \pi_t - r^* = (\beta_\pi - 1)(\pi_t - \pi^*) \tag{10}$$

The rule's gap goes in where the gap stood:

$$y_t = y_t^* - \alpha\,\boxed{(\beta_\pi - 1)(\pi_t - \pi^*)} + \varepsilon_t^y \tag{11}$$

The Slope Flips Below One

The **IS-MP curve** slopes **down** in inflation only if $\beta_\pi > 1$. Below one it slopes **up**.

And Into Supply

The Phillips curve is unchanged from lecture 1.2:

$$\pi_t = \pi_t^e + \gamma(y_t - y_t^*) + \varepsilon_t^\pi \tag{12}$$

Solve the two together, and every shock reaches inflation multiplied by θ:

$$\theta = \frac{1}{1 + \alpha\gamma(\beta_\pi - 1)} \tag{13}$$

Damped, Passed Through, or Amplified

Above $\beta_\pi = 1$, $0 < \theta < 1$ and the bank damps each shock's effect on inflation. At $\beta_\pi = 1$ shocks pass through untouched; just below one the model amplifies them.

Stability, Drawn

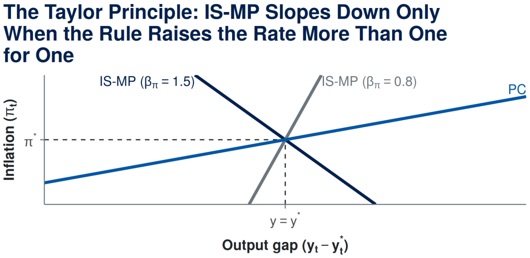

Figure 4: Two panels of the IS-MP and Phillips curves. Left, β_π = 1.5, and IS-MP slopes down; right, β_π = 0.8, and IS-MP slopes up, meeting the Phillips curve from the other side.

> **Stable Above One, Explosive Below**
> With β_π above one, a shock is pulled back to the crossing. Just below one, a shock is pushed away.

When the Condition Fails

A bank that sets $\beta_\pi < 1$ amplifies the shock, round after round:

1. A shock pushes inflation above target.
2. The bank raises its rate by less than inflation rose. The real interest rate **falls**.
3. Cheaper borrowing lifts demand, and output rises above trend.
4. The Phillips curve turns the output gap $(y_t - y_t^*)$ into more inflation.
5. Workers and firms revise π_t^e upward, lifting inflation and returning to step 2.

> **Ignoring Expectations Accelerates Inflation**
> Friedman (1968) argued that ignoring what people come to expect ends in accelerating inflation. The Taylor principle reverses step 2, so each round is smaller.

The Evidence: The Fed Before and After Volcker

The principle would be a curiosity if no bank had broken it. The Federal Reserve appears to have:

- Clarida, Galí and Gertler (2000) estimated the rule the Fed followed.
- They split the sample at Volcker's arrival as chairman in 1979.
- **Before** Volcker the response to inflation is **0.83**, below one.
- **After**, the response is comfortably above one.

> **A Rule Below One May Have Made the Great Inflation**
> US inflation reached double digits twice in the 1970s. Clarida, Galí and Gertler argue a rule with $\beta_\pi < 1$ **could have been responsible** for that decade.

What the Estimates Settle, and What They Do Not

The result reorganised how central banks talk about themselves. It is not strong enough to read as a measurement:

- **The Rule Is a Description, Not a Decision Procedure:** No committee has ever voted on β_π. The estimate summarises behaviour after the fact.
- **They Used Today's Data, Not the Fed's Data:** Output gaps get revised heavily.
- r^* **Is Unobservable and Not Constant:** Believe r^* is two points too **low**, and policy runs loose whatever β_π is (see Holston et al., 2017).

> **Two Failures, One Inflation**
> Two failures end in inflation above target: the wrong slope β_π, or the right slope around the wrong level of r^*. The model separates them; the data cannot tell them apart.

What Happens When the Taylor Principle Fails?

The condition is $\beta_\pi > 1$. The Fed's estimated rule sat below it before 1979.

> **Question**
> With $\beta_\pi < 1$, which way does the IS-MP curve slope? What happens to inflation after a shock?

Take answers first. Then run the app's **Great Inflation** scenario, which sets $\beta_\pi = 0.8$, and watch inflation drift up for good.

SECTION 3

Scenario Tests

A Temporary Demand Shock

This section runs the model on a demand shock, then on COVID. Take one period of unexpectedly strong demand: set $\varepsilon_t^\pi = 0$ and $\pi_t^e = \pi^*$. Let $\varepsilon_t^y > 0$, and the two solutions collapse to:

$$y_t - y_t^* = \theta\,\varepsilon_t^y, \qquad \pi_t - \pi^* = \theta\gamma\,\varepsilon_t^y \tag{14}$$

Both Rise, Both Damped by θ

Output and inflation both rise. Each rises by θ times what a bank with $\beta_\pi = 1$ would allow.

What the Central Bank Does About It

The policy rule now says by how much the bank raises the rate. Feed the inflation solution back through it:

$$i_t - (r^* + \pi^*) = \beta_\pi \, \theta\gamma \, \varepsilon_t^y \tag{15}$$

The bank raises the policy rate by more than inflation rose. That is what $\beta_\pi > 1$ means. That is why output rose by $\theta\varepsilon_t^y$, not by ε_t^y.

A Demand Shock Has No Trade-off

A demand shock raises output and inflation together, so one rate rise leans against both. A supply shock raises inflation and cuts output, and forces a choice.

The Shock, Traced Through the Diagram

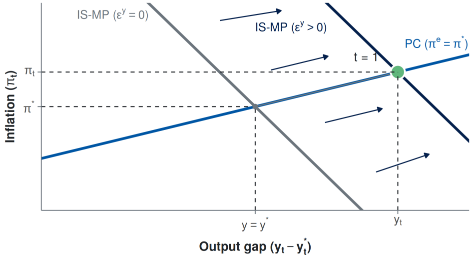

Figure 5: IS-MP has shifted right after a positive demand shock, and the economy now sits further up the Phillips curve, at a positive output gap and higher inflation. Dashed: the IS-MP curve before the shock.

> **The Crossing Slides Up Along the Phillips Curve**
> IS-MP shifts right and the Phillips curve stays put.

Same Country, Two Different Pictures

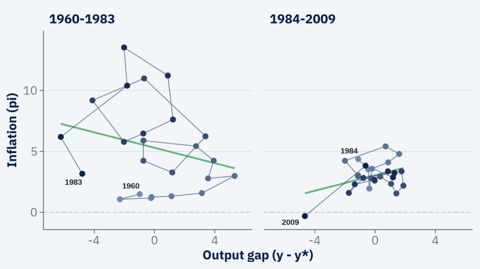

Figure 6: US inflation against the output gap: 1960–1983, then 1983–2009.

> **A Scatter Cannot Say Which of the Three Changed**
> The shock mix and the policy rule both changed between the two eras. Whether γ changed as well is what the scatter cannot settle.

Designing a Central Bank

θ decides how much of every shock reaches inflation. Who chooses θ, and what else can a bank do?

- θ is built from α, γ and β_π, and β_π is the bank's decision.
- A bank that is **believed** holds π_t^e at π^*, so $\theta\pi_t^e + (1-\theta)\pi^*$ collapses to π^*.

> **Two Levers, Two Costs**
> Raising β_π shrinks θ, costing output under a supply shock and none under a demand shock. Credibility works on the expectations term instead, and costs no output.

Making the Promise Stick

β_π is easy to announce and easy to abandon. What makes the announcement credible in advance?

- Independence, a published target, non-renewable terms, a price-stability mandate.
- A kept promise about β_π is not enough: a bank that believes r^* is two points higher than it is runs policy tight (Holston et al., 2017).

> **Credibility Is Assumed, Not Modelled**
> Nothing in the model makes announcements change π_t^e. Credibility is argued for here, and assumed away in the equations. Section 2.1 is where expectations stop being exogenous.

COVID: What Kind of Shock Was It?

The demand shock was clean, and the model was built for it. COVID was not clean. A shock can hit the demand side, the supply side, or both, and the model prices those cases differently. So the first question about any downturn is which side was hit.

The Comovement Test

Output and inflation moving **together** points to a demand shock. Moving **apart** points to a supply shock, or to expectations coming unanchored.

Both Sides Were Hit at Once

In the first half of 2020 governments closed workplaces and restricted movement across Europe and North America:

- **Demand:** Spending needing physical proximity stopped, and saving rose. A large negative ε_t^y.
- **Supply:** Workplaces could not operate, and supply chains broke. A positive ε_t^π.
- **Trend Output:** y_t^* fell. The model takes that as given; it does not explain it.

Demand, Supply, or Both?

Through 2020 and into 2022, output fell sharply and then recovered, and euro-area inflation went from near zero to 10.6% in October 2022.

> **Which Shock Was It, and When?**
> Was that episode mostly a **demand** shock, mostly a **supply** shock, or a demand shock followed by a supply shock?

The Model's Answer

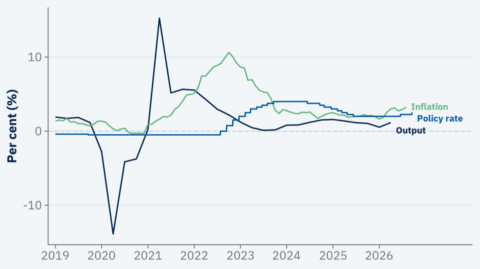

Figure 7: Euro-area output and inflation, 2019–2024, with the policy rate.

> **2020 Demand, 2021–22 Supply**
> 2020: output and inflation fell together, which reads as demand. 2021–22: they moved apart, which reads as supply (di Giovanni et al., 2022).

Where the Model Struggles

The signs came out right. Three things the model still misses:

- **A Pandemic Is Sectoral:** Hospitality shut while logistics boomed.
- **Trend Output Fell:** y_t^* is exogenous here, and in 2020 it was not even approximately fixed.
- **Fiscal Policy Is Only a Shock:** Fiscal policy enters through ε_t^y, so the model cannot make it a choice.

And Two the Model Cannot Even Ask

The last two are not missing pieces. Both are assumptions we set by hand and then argue about:

- **Expectations Are Set by Hand:** The model cannot ask whether π_t^e stayed anchored.
- γ **May Not Be a Constant:** The evidence points to a steeper Phillips curve when the economy runs hot (Waller, 2023).

> **Sharp on the Question, Silent on the Date**
> The model makes the demand-versus-supply question sharp enough to argue about, and says what each answer implies for policy. The model does not date the recovery, and was never going to.

What the Model Says

1. **Expectations and Inflation Dynamics.**
   Backward-looking expectations give a geometric path, not a number.
2. **The Taylor Principle.**
   $\beta_\pi > 1$, or inflation does not come back.
3. **Scenario Tests.**
   A demand shock needs no trade-off; COVID hit both sides.

Before Lecture 1.4

1. **Play:**
   The IS-MP-PC app, at β_π = 1.2 and then 2.5.

2. **Apply:**
   Problem set 2, due before Lecture 1.4. It covers today.

3. **Review:**
   Whelan, chapter 4, before Lecture 1.4 (Whelan, 2023).

> **Muddiest Point**
> One line before you go: what was the muddiest point today? The answers open Lecture 1.4.

Next Week

Next week the policy interest rate runs into a floor:

- **Why There Is a Bound:** Cash exists, so the rate stops near zero.
- **The Trap:** At the bound the IS-MP curve slopes **up**.
- **Policy at the Bound:** Forward guidance and the balance sheet.

Thank you

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BACKUP

Appendix

Notes and Tools

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

Whelan is the only required reading.

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