LECTURE 2.3

The Modern New Keynesian Model

ECON42240 Advanced Macroeconomics

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Where We Are

1. Time Series Methods

1.1 Time Series and Macro

1.2 Vector Autoregressions

1.3 VARs: Applications

1.4 The Kalman Filter

1.5 Solving RE Models

2. Structural Models

2.1 The RBC Model

2.2 The Phillips Curve

2.3 The New Keynesian Model

2.4 Estimating DSGE Models

2.5 The Smets-Wouters Model

3. Finance and Policy

3.1 Credit and Banking Crises

3.2 Fiscal Policy, and What Next

Last Week's Lecture

Last week built a Phillips curve from the pricing decisions of individual firms:

1. **The Expectations-Augmented Curve.**
   Friedman, and the 1970s.
2. **Calvo Pricing.**
   How a firm sets a price that may last years.
3. **The New Keynesian Curve.**
   Derived from Calvo pricing, then solved forwards.
4. **Inflation Persistence.**
   What the forward-looking curve misses.

Lecture Plan

1. **The Three Equations.**
   IS, Phillips curve, policy rule.
2. **The Taylor Principle.**
   What makes the equilibrium unique.
3. **Optimal Policy Under Commitment.**
   A promise to pull the price level back.
4. **Discretion and the Model Appraised.**
   Re-optimising every period, and the model’s record.

SECTION 1

The Three Equations

What the New Keynesians Set Out to Do

New Keynesians accepted rational expectations and kept a role for monetary policy:

- **The Critique:** Rational expectations seemed to make systematic policy powerless.
- **The Concession:** People optimise, and forecast without systematic error.
- **The Friction Kept:** Prices adjust slowly, so the bank sets the real rate.

> **Sticky Prices Make Policy Real**
> A bank that cannot alter any real price cannot alter any real quantity. In this model, price stickiness is the whole mechanism.

How Sticky Prices Became the Standard Policy Model

By the 1990s, sticky-price models yielded a Phillips curve like the traditional one:

> **Same Form, Different Behaviour**
> The New Keynesian curve looks like the expectations-augmented curve and behaves unlike it. No lagged inflation appears on its right-hand side.

Evidence of infrequent price changes made sticky-price models the policy standard.

The First Equation, Restated

Inflation rises with expected inflation, discounted by β, and with the output gap:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t \tag{1}$$

where:

- $x_t = y_t - y_t^n$: output gap
- y_t^n: flexible-price output
- κ: slope of the curve
- u_t: cost-push shock

Lecture 2.2 derived this curve from Calvo pricing.

> **Natural Output Is Not Trend**
> y_t^n is output with no pricing frictions and zero inflation.

Two Notations for One Model

Galí’s book and Whelan’s slides write one model in different letters:

Table 1: Three letters that differ between the slides and the reading.

Object	This module	Galí
elasticity of demand across goods	θ	ϵ
probability a price is not reset	α	θ
output gap	x_t	$\tilde{y}_t$

The full table adds σ, the reset price and the policy coefficients.

Galí’s Theta Is This Module’s Alpha
Today’s reading is Galí’s chapters 3 and 4, and the same swap runs through both.

FULL TABLE OF LETTERS

What the Slope of the Curve Is Made Of

Two forces set the slope, and stickier prices make it flatter:

$$\kappa = \underbrace{\frac{(1-\alpha)(1-\alpha\beta)}{\alpha}}_{\text{how often prices reset}} \times \underbrace{\eta}_{\text{how fast marginal cost rises}} \tag{2}$$

The Slope Alone Identifies Neither Friction
Economies with one κ can differ in α and in η. A flat curve need not mean sticky prices.

The Cost-Push Shock Creates the Trade-Off

The derived curve has no error term, so the literature adds one (u_t):

> **Cost-Push Shocks End the Divine Coincidence**
> A cost-push shock raises inflation at an unchanged output gap. A jump in desired mark-ups is one source.

Without u_t, a zero gap brings zero inflation, and policy faces no trade-off.

Inflation Carries No Memory of Itself

With no lagged inflation, a believed disinflation would cost no output:

$$\pi_t = \sum_{k=0}^{\infty} \beta^k E_t \left(\kappa x_{t+k} + u_{t+k} \right) \tag{3}$$

The curve is solved forward, as Lecture 1.5 taught.

> **The Data Show Lagged Inflation**
> Inflation in every industrial country depends on its own lags. Last week's persistence problem is this prediction failing.

The Second Equation Needs a Household

Linking output to policy needs a decision the real interest rate can change:

> **Only Intertemporal Substitution Carries Policy**
> With no capital, output equals consumption each period. The real rate is the price of consuming now.

No investment, labour-supply or credit channel exists; later lectures add them back.

The Household's Intertemporal Problem

The household maximises discounted utility over consumption paths (C_t). One lifetime constraint ties spending to wealth and income (Y_t):

$$\max \sum_{k=0}^{\infty} \beta^k U(C_{t+k}) \qquad \text{subject to} \qquad \sum_{k=0}^{\infty} \frac{E_t C_{t+k}}{\prod_{m=1}^{k} R_{t+m}} = A_t + \sum_{k=0}^{\infty} \frac{E_t Y_{t+k}}{\prod_{m=1}^{k} R_{t+m}} \tag{4}$$

where:

- A_t: financial wealth entering t
- R_t: gross real return

The Euler Equation: Higher Real Rates Cut Output

Log-linearising the household's optimality condition sets log output (y_t) against the real rate:

$$U'(C_t) = E_t\left[\beta R_{t+1} U'(C_{t+1})\right] \quad\Longrightarrow\quad y_t = E_t y_{t+1} - \sigma\,(i_t - E_t\pi_{t+1} + \log\beta) \tag{5}$$

where:

- σ: elasticity of intertemporal substitution

Lecture 2.1 derived this condition.

> **Galí Inverts This Sigma**
> Galí's σ divides the real rate; this module's σ multiplies it.

The Natural Rate of Interest

Subtracting natural output from both sides leaves the gap and expected natural growth:

$$x_t = E_t x_{t+1} + E_t \Delta y^n_{t+1} - \sigma \left(i_t - E_t \pi_{t+1} + \log \beta \right) \tag{6}$$

Growth and time preference combine into the natural rate (r^n_t):

$$x_t = E_t x_{t+1} - \sigma \left(i_t - E_t \pi_{t+1} - r^n_t \right), \qquad r^n_t = \sigma^{-1} E_t \Delta y^n_{t+1} - \log \beta \tag{7}$$

Policy Neither Loose nor Tight

With the real rate at r^n_t, the gap equals its expected value. No bank sets r^n_t, and no series measures it.

Two Ways to Find the Same Rate

A filter and this model reach one unobserved rate by two routes:

The Filtered Route: Lecture 1.4's r^*, from data plus an identifying model.

The Model Route: Today's r_t^n, from preferences plus forecast potential growth.

> **The Two Rates Differ in Frequency**
> Both routes need an untestable view of potential output. The filtered rate varies over decades, the model's every quarter.

Output Depends on the Whole Path of Rates

Iterating forward leaves no lagged output, and expected tightness at any horizon lowers today's gap:

$$x_t = -\sigma \underbrace{\sum_{k=0}^{\infty} E_t \left(i_{t+k} - \pi_{t+k+1} - r^n_{t+k} \right)}_{\text{sum of expected future rate gaps}} \tag{8}$$

The gap equation is solved forward, as Lecture 1.5 taught.

Why Central Bankers Talk So Much

With the whole expected path in the equation, communication is policy:

- **A Weak Instrument:** Today's rate weighs no more than any one later rate.
- **Forward Guidance:** Expected later rate cuts raise output now.
- **Long Rates:** Under the expectations theory, long rates average the expected path.

The Third Equation: What the Bank Does

Closing the model needs a rule for the nominal interest rate (i_t):

$$i_t = r_t^n + \phi_\pi \pi_t + \phi_x x_t \tag{9}$$

where:

- ϕ_π: response to inflation
- ϕ_x: response to the output gap

Taylor Used a Fixed Intercept
Taylor wrote a constant in place of r_t^n (Taylor, 1993). Tracking an unobservable rate is an assumption, not a description.

The Canonical Model: One Equation per Decision

Firms, households and the bank each supply one equation; u_t and r_t^n come from outside:

$$
\begin{aligned}
\pi_t &= \beta E_t \pi_{t+1} + \kappa x_t + u_t && \text{firms} \\
x_t &= E_t x_{t+1} - \sigma \underbrace{\left(i_t - E_t \pi_{t+1} - r_t^n\right)}_{\text{real rate less natural rate}} && \text{households} \\
i_t &= r_t^n + \phi_\pi \pi_t + \phi_x x_t && \text{the bank}
\end{aligned}
\tag{10}
$$

Which Announcement Raises Output More?

Two announcements, both from a central bank with this model in mind.

> **Question**
> One bank cuts today and says nothing about later. The other holds today and promises two years of cuts. Which raises output by more?

Take answers from the room.

SECTION 2

The Taylor Principle

What Pins Down Inflation

Two forward-looking equations can admit many paths consistent with rational expectations:

> **Expected Inflation Can Validate Itself**
> If everyone expects higher inflation and the bank accommodates, the expectation comes true.

This section derives the restriction on the rule that removes the multiplicity.

Two Equations, One System

Substituting the Euler equation into the Phillips curve gives one two-variable system:

$$\begin{bmatrix} x_t \\ \pi_t \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & \sigma \\ \kappa & \beta + \kappa\sigma \end{bmatrix}}_{A} \begin{bmatrix} E_t x_{t+1} \\ E_t \pi_{t+1} \end{bmatrix} + \begin{bmatrix} \sigma(r_t^n - i_t) \\ \kappa\sigma(r_t^n - i_t) + u_t \end{bmatrix} \tag{11}$$

Solving Forward Needs Every Root Inside the Circle

Neither variable is fixed by the past, so one stable path needs a condition on A:

- **The Condition:** Every eigenvalue of A lies inside the unit circle.
- **The Failure:** A root outside it leaves many bounded paths, not one.

Lecture 1.5 derived this condition.

Two Evaluations Put One Eigenvalue Above One

The eigenvalues (λ) of A solve a quadratic that opens upward:

$$P(\lambda) = \lambda^2 - (1 + \beta + \kappa\sigma)\lambda + \beta \tag{12}$$

Positive at zero and negative at one, P has one root in $(0, 1)$ and one above one:

$$P(0) = \beta > 0, \qquad P(1) = -\kappa\sigma < 0 \tag{13}$$

Its coefficients are A's trace, $1 + \beta + \kappa\sigma$, and determinant, β.

Without a Rule, the Model Predicts Nothing

One eigenvalue above one leaves many bounded paths, each consistent with every equation:

> **Determinacy: One Stable Equilibrium**
> A determinate model predicts one path. An indeterminate one admits many, some driven by beliefs alone.

A sunspot, a shock unrelated to fundamentals, can then raise inflation.

Cochrane's Route: Keep the Multiplicity

One response accepts many equilibria and asks what a rate rise does across them:

- **The Finding:** On that reading, higher rates raise inflation in this model.
- **The Label:** The claim is called the neo-Fisherian prediction.
- **The Fisher Logic:** At a fixed real rate, a higher nominal rate means higher inflation.

> **A Live Dispute, Not Settled**
> Cochrane's conclusion surprised the literature and the debate continues. The module takes no side (Cochrane, 2015).

A Rule That Selects an Equilibrium

Substituting a rule for the still-exogenous i_t removes both interest rates:

$$x_t = E_t x_{t+1} + \sigma E_t \pi_{t+1} - \sigma \phi_\pi \pi_t - \sigma \phi_x x_t \tag{14}$$

New Matrix, Same Behaviour

Households and firms behave as before. Only the system's coefficients change.

The System Under the Taylor Rule

Collecting terms gives the system matrix (A) and the shock loading (B):

$$A = \frac{1}{D}\begin{bmatrix} 1 & \sigma(1-\beta\phi_\pi) \\ \kappa & \sigma\kappa + \beta(1+\sigma\phi_x) \end{bmatrix}, \qquad B = \frac{1}{D}\begin{bmatrix} 1 & -\sigma\phi_\pi \\ \kappa & 1+\sigma\phi_x \end{bmatrix} \tag{15}$$

where:

- $D = 1 + \sigma\phi_x + \kappa\sigma\phi_\pi$: common denominator

Zero Coefficients Return the No-Rule Matrix

Set $\phi_\pi = \phi_x = 0$: then $D = 1$ and A is the no-rule matrix.

The Condition on the Policy Coefficients

Both roots lie inside the circle exactly when $P(1) > 0$, which reduces to one inequality:

$$\phi_\pi + \frac{(1-\beta)\phi_x}{\kappa} > 1 \tag{16}$$

The Gap Term Is Small

With β near one the second term is small. Pulling ϕ_π below one takes a very large ϕ_x.

Why the Real Rate Must Rise with Inflation

Spending falls only if the real rate rises, so inflation must raise it:

ϕ_π **Below One:** Inflation rises, the real rate falls, and inflation rises further.

ϕ_π **Above One:** The real rate rises, spending falls, and inflation is contained.

A Positive Response Is Not Enough

The Taylor principle: the nominal rate must rise by more than the inflation that prompted it.

Determinacy and the Taylor Principle Are One Statement

With inflation constant, the Phillips curve fixes the long-run gap:

$$x = \frac{(1-\beta)\pi}{\kappa} \tag{17}$$

Putting that gap into the rule, the nominal rate's response is the condition's left-hand side:

$$\Delta i = \left(\phi_\pi + \frac{(1-\beta)\phi_x}{\kappa}\right)\Delta\pi \tag{18}$$

Determinacy in the Policy Parameter Space

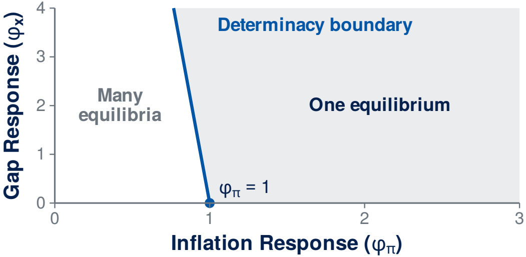

Figure 1: Determinate region shaded; Galí's baseline, β = 0.99, κ = 0.17.

Boundary Crosses the Axis at One

Right of the line the equilibrium is unique. With no gap response, it needs exactly ϕ_π > 1.

Estimated Rules Before and After Volcker

Estimates of the policy rule split at Paul Volcker's appointment (Clarida et al., 2000):

Before Volcker: A response below one. Nominal rates rose less than inflation, so real rates fell.

Volcker and Greenspan: Estimated responses comfortably above one.

The Great Inflation as Indeterminacy

On this reading, policy was not stabilising. That may have contributed to the Great Inflation.

Orphanides and the Data the Fed Actually Had

Orphanides re-estimated the rule on the data the Fed had at the time:

- **Real-Time Output Gaps:** The Fed's gap estimates then were far more negative.
- **The Re-Estimate:** On real-time data the Fed believed it satisfied the principle.
- **His Reading:** The failure lay in measuring potential output, not in the rule.

What Would You Need to Believe?

A central bank announces a rule with a coefficient on inflation of 0.8.

> **Question**
> The bank insists the economy is stable. What must the rest of the rule satisfy, and how plausible is that?

Take answers from the room.

SECTION 3

Optimal Policy Under Commitment

What "Optimal" Requires Before It Means Anything

A policy is optimal only against a stated objective and constraint:

- **The Objective:** A loss the bank minimises, written down next.
- **The Constraint:** The Phillips curve, which the bank cannot step outside.
- **The Regime:** Whether the bank can bind its future self.

The Central Bank's Quadratic Loss Function

Squared deviations give linear first-order conditions, so the loss is quadratic:

$$L_t = \frac{1}{2} \sum_{k=0}^{\infty} \beta^k E_t \left[\pi_{t+k}^2 + \lambda x_{t+k}^2 \right] \tag{19}$$

where:

- L_t: central bank's loss
- λ: weight on the output gap

Lambda Now Weighs the Gap Against Inflation
The Taylor-principle section used λ for a root of P. The same letter here is a different object.

Woodford's Derivation of the Objective

The loss was assumed for decades; Woodford derived it from household utility:

- **The Gap Term:** Risk-averse households prefer smooth consumption, near its natural level.
- **The Inflation Term:** Sticky prices make symmetric goods sell at different prices.
- **The Weight:** $\lambda = \kappa/\theta$, the curve's slope over the elasticity of demand.

Galí derives the weight from a second-order approximation to welfare.

> **Inflation Misallocates Symmetric Goods**
> Households want equal amounts of symmetric goods. Dispersed prices make them buy unequal amounts.

Two Regimes: Commitment and Discretion

The two regimes differ only in whether today's bank can bind tomorrow's:

Commitment: The bank chooses a state-contingent plan once and is held to it.

Discretion: The bank re-optimises every period, taking the past as given.

A Rate for Every Future State

A state-contingent plan names the rate for each possible future, not one fixed path. Promises can then survive shocks.

The Commitment Problem as a Lagrangian

The bank minimises the loss with a multiplier (μ_{t+k}) on each date's curve:

$$\mathcal{L} = \frac{1}{2} \sum_{k=0}^{\infty} \beta^k E_t \left[\pi_{t+k}^2 + \lambda x_{t+k}^2 + 2\mu_{t+k} \left(\pi_{t+k} - \beta \pi_{t+k+1} - \kappa x_{t+k} - u_{t+k} \right) \right] \tag{20}$$

The Multiplier Is a Shadow Price

μ_{t+k} is the marginal loss from the curve binding harder at $t + k$. The shock u_{t+k} is given, not chosen.

The Commitment Plan's First-Order Conditions

Two conditions follow, and the second links each date's multiplier to the one before:

$$\lambda x_{t+k} = \kappa \mu_{t+k}, \qquad \pi_{t+k} + \mu_{t+k} - \mu_{t+k-1} = 0, \qquad \mu_{t-1} = 0 \tag{21}$$

No constraint binds before the plan begins, so μ_{t-1} is zero.

Differencing the Conditions Eliminates the Multiplier

The multiplier sits in adjacent conditions, so differencing the first removes it:

$$x_{t+k} - x_{t+k-1} = \frac{\kappa}{\lambda}\left(\mu_{t+k} - \mu_{t+k-1}\right) = -\frac{\kappa}{\lambda}\pi_{t+k} \tag{22}$$

The First Period Fixes the Level

With $\mu_{t-1} = 0$, the first period gives $x_t = -(\kappa/\lambda)\pi_t$. Later periods fix only the change in the gap.

Optimal Commitment Leans Against the Price Level

Inflation is the change in the log price level (p_t), so period zero sets:

$$x_0 = \frac{\kappa}{\lambda}\left(p_{-1} - p_0\right) \tag{23}$$

Period one adds its change in the gap, and p_0 cancels:

$$x_1 = x_0 - \frac{\kappa}{\lambda}\left(p_1 - p_0\right) = \frac{\kappa}{\lambda}\left(p_{-1} - p_1\right) \tag{24}$$

Price-Level Targeting Makes Policy History Dependent

Every date repeats the cancellation, so today's gap depends on every past shock:

$$x_k = \frac{\kappa}{\lambda}\left(p_{-1} - p_k\right) \tag{25}$$

Promised Tightening Lowers Inflation Now

Expected tightening lowers $E_t \pi_{t+1}$, so a shock raises inflation less. Average inflation is zero.

Would a Bank Keep This Promise?

A cost-push shock hit last quarter and has now passed.

> **Question**
> The plan still says hold output below its natural level. Would a bank free to choose again do so?

Take answers from the room.

SECTION 4

Discretion and the Model Appraised

Discretion Re-Solves Every Period

A bank that cannot bind its future self re-solves the period-zero problem:

- **Every Period Is Period Zero:** The level condition $x_t = -(\kappa/\lambda)\pi_t$ always applies.
- **Time Inconsistency:** Once expectations have formed, the promise only costs output.
- **Foreseen:** The public expects the promise to lapse, so expectations never fall.

Discretion Still Leans Against Inflation

Both regimes lean at κ/λ. Only commitment ties the leaning to the inherited price level.

Leaning Harder Damps Inflation Under Discretion

Substituting $x_t = -(\kappa/\lambda)\pi_t$ into the Phillips curve leaves an equation in inflation alone:

$$\pi_t = \beta E_t \pi_{t+1} - \frac{\kappa^2}{\lambda}\pi_t + u_t \tag{26}$$

Adding $(\kappa^2/\lambda)\pi_t$ to both sides, the leaning multiplies today's inflation:

$$\left(1 + \frac{\kappa^2}{\lambda}\right)\pi_t = \beta E_t \pi_{t+1} + u_t \tag{27}$$

Solving this forward, as Lecture 1.5 taught, sums expected future shocks.

With a Persistent Shock, a Closed Form

With $u_t = \rho u_{t-1} + v_t$, v_t white noise, the forward sum collapses:

$$\pi_t = \frac{u_t}{1 + \kappa^2/\lambda - \beta\rho} \tag{28}$$

The sum is Lecture 1.5's geometric series.

Persistence Raises Inflation Under Discretion
A larger ρ shrinks the denominator, so one u_t brings more inflation. The sum converges since $\beta\rho < 1$.

The Interest Rate Rule Discretion Implies

Discretion implies a rule once both expectations equal ρ times today's values:

$$i_t = r_t^n + \left(\rho + \frac{(1-\rho)\kappa}{\sigma\lambda}\right)\pi_t \tag{29}$$

Optimal Discretion Meets the Taylor Principle

The coefficient exceeds one whenever $\kappa/(\sigma\lambda) > 1$. Whelan expects that under all reasonable parameter values.

Commitment Lowers the Loss Through Expected Inflation

For a transitory shock, commitment shrinks the shift in today's trade-off:

Under Discretion: The trade-off shifts by the shock itself, u_t.

Under Commitment: The shift is $u_t + \beta E_t \pi_{t+1}$, smaller as expected inflation turns negative.

> **Only a Believed Promise Helps**
> The plan is optimal only if believed. Whether a bank can be held to it lies outside the model.

Responses Under Commitment and Under Discretion

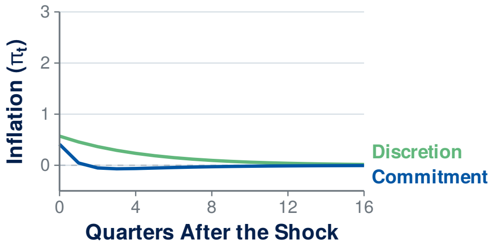

Figure 2: Inflation, per cent, after a 1 per cent shock.

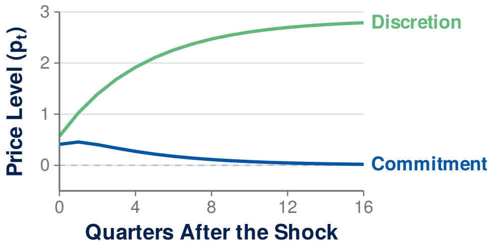

Figure 3: Log price level, per cent; ρ = 0.8.

> **Only Commitment Restores the Price Level**
> Under commitment the price level returns to where it started. Under discretion it settles 2.85 per cent higher.

Where the Three Equations Fit the Data

Each behavioural equation carries its own empirical record:

Table 2: The three equations against the data.

Equation	Record in the data
Phillips curve	Forward terms carry little weight
Euler equation	Imprecise estimates; asset pricing fails
Policy rule	Estimated rules fit well

> **The Best Fit Has No Microfoundation**
> The policy rule describes behaviour. The two derived equations fit worst.

The US Labour Share of Income

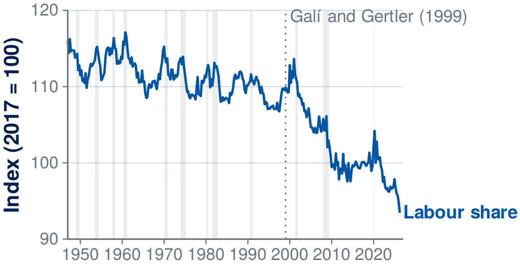

Figure 4: US nonfarm business labour share, index 2017 = 100, 1947–2026; recessions shaded.

> **A Cyclical Proxy Should Not Trend**
> The share has drifted down for decades, most visibly since Galí and Gertler (1999). It also spikes in recessions.

The Paper: Clarida, Galí and Gertler

The Section B paper for this block sets out today's framework (Clarida et al., 1999):

- **What It Does:** Assembles the New Keynesian model for policy analysis.
- **The Central Result:** The nominal rate must rise by more than inflation does.
- **The Structure:** Baseline model, then discretion, then commitment, then rules.

> **A Survey of Pre-Crisis Consensus**
> The survey states what the profession believed before the 2008 crisis.

Appraising the Paper: Four Lines of Criticism

Section B asks for criticism, and this module supplies four lines of attack:

- **No Financial Sector:** No banks and no spreads, which Lecture 3.1 makes central.
- **The Empirical Curve:** The Phillips curve at its heart fits badly.
- **Lucas Applies Here Too:** The loss function is assumed, not derived.
- **The Zero Bound:** A minor concern in 1999, and the binding one after 2008.

What the Literature Built Next

Each extension of the canonical model is a later lecture in this module:

- **Lectures 2.4 and 2.5:** Capital, wage rigidity, and estimation of the whole system.
- **Lecture 3.1:** Financial frictions, splitting the policy rate from borrowing rates.
- **Still Unsettled:** The zero bound, the natural rate, and model uncertainty.

What Would Make You Abandon the Model?

The model fits badly in two equations and is used everywhere.

> **Question**
> What evidence would persuade a central bank to stop using this model? Name the evidence, not the failing.

Take answers from the room.

Before Lecture 2.4

1. **Play:**
   Solve the three-equation model in R at two values of ϕ_π.
2. **Apply:**
   Answer Question 3 of the 2015 paper, parts (a) to (c).
3. **Read:**
   Ljungqvist and Sargent, sections 2.6 to 2.9, before Lecture 2.4 (Ljungqvist & Sargent, 2018).

Next Lecture

Lecture 2.4 takes this model to data:

1. **From Calibration to a Likelihood.**
   Why estimate, and what a likelihood needs.
2. **Singularity and the Filter.**
   Too few shocks, and the filter as the likelihood.
3. **Priors and Posterior.**
   What a prior adds, and how a sampler draws the posterior.
4. **Judging the Estimate.**
   Reading a posterior, and holding the model against the VAR.

Thank you

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BACKUP

Appendix

Notation, Part I

Symbol	What it is	First met
π_t	inflation	Lecture 1.2
E_t	expectation at t	Lecture 1.5
β	discount factor	Lecture 1.5
κ	slope of the curve	Lecture 1.5
x_t	output gap	The First Equation, Restated
y_t^n	flexible-price output	The First Equation, Restated
y_t	log output	Lecture 1.1
u_t	cost-push shock	The First Equation, Restated
θ	elasticity of demand across goods	Two Notations for One Model
α	probability a price is not reset	Lecture 2.2
η	how fast marginal cost rises	What the Slope of the Curve Is Made Of
C_t	consumption	Lecture 2.1

Notation, Part II

Symbol	What it is	First met
Y_t	income	Lecture 2.1
$U(\cdot)$	utility	Lecture 2.1
A_t	financial wealth entering t	The Household's Intertemporal Problem
R_t	gross real return	The Household's Intertemporal Problem
σ	elasticity of intertemporal substitution	The Euler Equation: Higher Real Rates Cut Output
i_t	nominal interest rate	Lecture 1.2
r_t^n	natural rate of interest	The Natural Rate of Interest
r^*	filtered natural rate	Lecture 1.4
ϕ_π	response to inflation	The Third Equation: What the Bank Does
ϕ_x	response to the output gap	The Third Equation: What the Bank Does
A	system matrix	Two Equations, One System
B	shock loading	The System Under the Taylor Rule

Notation, Part III

Symbol	What it is	First met
D	common denominator	The System Under the Taylor Rule
λ	eigenvalue of A	Lecture 1.5
$P(\lambda)$	characteristic polynomial of A	Two Evaluations Put One Eigenvalue Above One
λ	weight on the output gap	The Central Bank's Quadratic Loss Function
L_t	central bank's loss	The Central Bank's Quadratic Loss Function
$\mathcal{L}$	Lagrangian	The Commitment Problem as a Lagrangian
μ_t	multiplier on the curve	The Commitment Problem as a Lagrangian
p_t	log price level	Optimal Commitment Leans Against the Price Level
ρ	persistence of the shock	Lecture 1.1
v_t	white-noise innovation	With a Persistent Shock, a Closed Form

Galí's Letters Against Whelan's

Galí's textbook, this lecture's reading, writes the same model in other letters:

Object	This module	Galí	Note
elasticity of demand	θ	ϵ	fixed first
probability of no reset	α	θ	the dangerous swap
output gap	x_t	$\tilde{y}_t$	Whelan reuses x_t
reset price	$p_t^{\#}$	p_t^*	$*$ is taken here
intertemporal elasticity	σ	$1/\sigma$	reciprocal
policy coefficients	ϕ_π, ϕ_x	ϕ_π, ϕ_y	agree
rate of time preference	$-\log\beta$	ρ	ρ is taken here

Only the Reciprocal Changes an Equation's Shape

Galí's σ divides the real rate and this module's multiplies it. Nothing else on the list changes an equation's shape.

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