Economics 704a Lecture 8: New Keynesian Model III, Optimal Monetary Policy in the NK Model I: Discretionary Policy

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New Keynesian Model: Outline

Does the NKPC Hold in the Data?

- NK Phillips Curve is at center of the NK model.
- Final critique / test: Does it hold in the data?

$$\hat{\pi}_t = \kappa \tilde{y}_t + \beta E_t \left\{ \hat{\pi}_{t+1} \right\}$$

  - How do we measure inflation expectations?
  - How do we measure "natural rate of output" and output gap?
- One approach: Are markups countercyclical?
  - Some progress in IO, but hard to measure markups.

Does the NKPC Hold in the Data?

- Idea: Rewrite NKPC as:

$$\hat{\pi}_t = \lambda \hat{mc}_t + \beta E_t \{\hat{\pi}_{t+1}\}$$

  and test whether inflation responds to *marginal costs*, which are in principle more observable.
  - Directly use unit labor costs from wages and productivity.
  - Or exploit FOC of C-D with Capital:

$$\frac{W_t}{P_t} = MC_t \alpha \frac{Y_t(i)}{N_t(i)} \Rightarrow MC_t = \frac{\frac{W_t N_t}{Y_t P_t}}{\alpha}$$

    so deviations of labor share from long-run level are MC shocks.
- What about $E_t\{\pi_{t+1}\}$?
  - Get instruments.
  - Or get expectations from model (either one equation or system), SMM on parameters, and test whether forward-looking component matters.

Does the NKPC Hold in the Data?

- Early literature finds support.
- Gali and Gertler (1999): Test for both forward-looking and backward-looking behavior
  - Real marginal costs are an important determinant of inflation.
  - Forward-looking behavior is important.
  - But backward-looking is not so important. Suggests inflation persistence from MC persistence, not π_{t-1} in Phillips.
- Sbordone (2002)
  - Marginal costs determine inflation in data.
  - Forward looking component is important.

Does the NKPC Hold in the Data?

- But in last 15 years, result shown to be fragile (summarized by Mavroeidis et al., 2014).
  - "Using a common dataset and a flexible empirical approach, we find that researchers are faced with substantial specification uncertainty, as different combinations of various *a priori* reasonable specification choices give rise to a vast set of point estimates."
  - Example: "Simply reestimating the benchmark NKPC in Gali and Gertler using the same data series, method, and time period, but with revised data, reduces the estimate on the activity variable (real marginal cost) by half and makes the coefficient no longer statistically significant."
  - Problem: Classic example of weak instruments and identification.
  - Limit on how much we can learn from time series.
- Left with not much direct time-series evidence on NKPC.

Does the NKPC Hold in the Data?

- Critique: If such a strong relationship between inflation and marginal cost, should not be so fragile and hard to find.
  - This is what the NK model model is all about!
- Furthermore, in medium-scale models, "wage markup" and "price markup" matter a lot quantitatively (explain up to 90% of inflation).
  - If NKPC is so central, why are shocks to reduce its residuals so crucial?
  - Ultimately, do we really understand inflation dynamics?
- But issue may be that Fed is good enough at stabilizing that relationship is hard to see.
  - Imagine a car going on a highway. Tends to go slower uphill and press accelerator on uphills.
  - Does this mean accelerator slows us down? Or we use it to stabilize speed imperfectly?

What Affects the Slope of the Phillips Curve? What Drives Inflation Expectations?

- Pre-pandemic, view that this model is too strongly influenced by 1970s stagflation.
  - We will talk about what this means for monetary policy in the next few classes.
- Leads to frontier questions in monetary economics:
  - What affects slope of the Phillips curve? Has it changed over time? Is it flatter now? Why?
    - Baseline NK model with θ, γ, and φ mattering is too simplistic.
  - Similarly, what drives inflation expectations? Are they "anchored"? What would it take to "unanchored" them?
  - Recent evidence from Hazell et al. (2022) using cross-state CPI data back to 1970s suggests that Phillps curve has always been flat but looked steep due to response of inflation expectations.

Where Does This Leave Us?

- New Keynesian model has its problems.
    - Agree need more research on what macro "shocks" are. Especially "demand shocks."
    - Lack of strong connection between marginal cost and inflation in data suggests models need more to explain inflation.
    - Agree medium-scale quantitative models overfit data.
    - Understand critiques of Taylor rule, current approaches to inflation persistence.
- But best model available to analyze monetary policy.
    - Tractable.
    - Microfounded.
    - Monetary non-neutrality.
    - Rational expectations and forward-looking inflation.

Optimal Policy

Optimal Policy in the NK Model

- For the next few classes, we will examine optimal policy in the simple three-equation NK model we have developed:

$$\begin{aligned}\tilde{y}_t &= -\sigma E_t \left\{ \hat{i}_t - \hat{\pi}_{t+1} - \hat{r}^n_{t+1} \right\} + E_t \left\{ \tilde{y}_{t+1} \right\} \\ \hat{\pi}_t &= \kappa \tilde{y}_t + \beta E_t \left\{ \hat{\pi}_{t+1} \right\}\end{aligned}$$

- Goal: Understand key principles of conduct of monetary policy.
- Because both equations are forward looking, a key question is whether the central bank can affect expectations by committing *ex-ante* to policy rules that they may have an *ex-post* incentive to break.
  - Today: Discretionary policy (no credibility to commit to rules).
  - Lectures 9 and 10: Rules and benefits of commitment.
- Also constraint that $i_t \geq 0$, which will address in Lectures 10 and 11.

Optimal Policy in the NK Model: Outline

1. Optimal Discretionary Monetary Policy
   1.1 Welfare
   1.2 The "Divine Coincidence"
   1.3 Breaking the Divine Coincidence and the $\pi - Y$ Tradeoff
   1.4 Principles of Discretionary Monetary Policy
2. Monetary Policy In Practice, 2021-22
3. Optimal Monetary Policy With Commitment
   3.1 Time Inconsistency and the Gains From Commitment
   3.2 Inflation Bias and Commitment
   3.3 The $\pi - Y$ Tradeoff With Commitment: A Simple Rule
   3.4 The $\pi - Y$ Tradeoff With Commitment: The General Case
   3.5 Policy Rules and Communication

The Costs of Inflation

- People generally do not like high inflation.
- Many reasons why. Some commonly cited include:
  - "Shoe leather" costs.
  - Menu costs.
  - Inefficient allocation of resources.
  - Redistributes nominal debt from creditors to debtors.
  - Uncertainty for household and business financial planning.
  - General nuisance / cognitive costs.
  - Erosion of real wages (not in models but in practice).
- Given recent inflation, what do you think?

Getting to the Central Bank Objective Function

- Two ways to motivate the quadratic Central Bank objective function we will use:

$$\frac{1}{2}E_t\left\{\sum_{s=0}^{\infty}\beta^s\left[\vartheta\tilde{y}_{t+s}^2+\hat{\pi}_{t+s}^2\right]\right\}$$

1. Say people do not like inflation and output gaps and use this to motivate reduced-form quadratic objective function.
2. Microfound CB objective from the model.
    - Intellectually more satisfying, because CB is optimizing rep agent's utility.
    - But welfare costs of inflation in the model are unsatisfying and incomplete, so I find it hard to take it too seriously.
    - Let us go through this briefly before we take the objective function and run with it.

Welfare In the NK Model

- In the NK model, there are two sources of distortions.

1. Markups: Lead to inefficiently low Y_t and N_t.
2. Sticky Prices:
   2.1 Average markup varies over time and not equal to desired markup.
   2.2 With staggered pricing, inefficient price dispersion as prices vary in ways unwarranted by preferences and tech.

- See this in output:

$$Y_t = A_t N_t \left[\int_0^1 \left(\frac{N_t(i)}{N_t} \right)^{\frac{\varepsilon - 1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon - 1}}$$

  - Second order loss, so not in log-linearization.

Microfounding the Central Bank Objective Function

- Take "cashless limit" as $\zeta \to 0$ (ζ is weight on M/P).
    - Money in utility is shortcut; do not want in planner's problem.
- Assume markup distortion is corrected with subsidy scheme.
- Take second-order approximation to losses of representative household and use first-order model approximation to find losses are proportional to:

$$\frac{1}{2} E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left[\vartheta \tilde{y}_{t+s}^2 + \hat{\pi}_{t+s}^2 \right] \right\}$$

    - See Gali Appendix 4.1.
    - Inflation comes from price dispersion cost of inflation.
    - But setup accommodates other costs of inflation if ϑ is generalized weight on output gap relative to inflation.

The Central Bank Objective Function

- Generalize microfounded objective function to:

$$\frac{1}{2}E_t\left\{\sum_{s=0}^{\infty}\beta^s\left[\vartheta\left(\tilde{y}_{t+s}-k\right)^2+\left(\hat{\pi}_{t+s}-\pi^*\right)^2\right]\right\}$$

- k is generalized output gap target.
    - Could come from lack of subsidy to correct markup distortion or other sources.
    - $k = 0$ for now, relax next class.
- π^* is inflation target.
    - For this class, assume $\pi^* = 0$ to simplify algebra.

The Planning Problem

$$\min_{\{i_{t+s},\tilde{y}_{t+s},\pi_{t+s}\}_{s=0}^{\infty}} \frac{1}{2} E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left[\vartheta \left(\tilde{y}_{t+s} - k \right)^2 + \left(\pi_{t+s} - \pi^* \right)^2 \right] \right\}$$

subject to

$$\begin{aligned} \tilde{y}_t &= -\sigma E_t \left\{ \hat{i}_t - \hat{\pi}_{t+1} - \hat{r}^n_{t+1} \right\} + E_t \left\{ \tilde{y}_{t+1} \right\} \\ \hat{\pi}_t &= \kappa \tilde{y}_t + \beta E_t \left\{ \hat{\pi}_{t+1} \right\} \end{aligned}$$

The Planning Problem: Strategy

- Split problem into two parts:
- First, solve for $\{\tilde{y}_{t+s}, \pi_{t+s}\}_{s=0}^{\infty}$

$$\min_{\{\tilde{y}_{t+s}, \pi_{t+s}\}_{s=0}^{\infty}} \frac{1}{2} E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left[\vartheta \tilde{y}_{t+s}^2 + \hat{\pi}_{t+s}^2 \right] \right\}$$

subject to

$$\hat{\pi}_t = \kappa \tilde{y}_t + \beta E_t \{\hat{\pi}_{t+1}\}$$

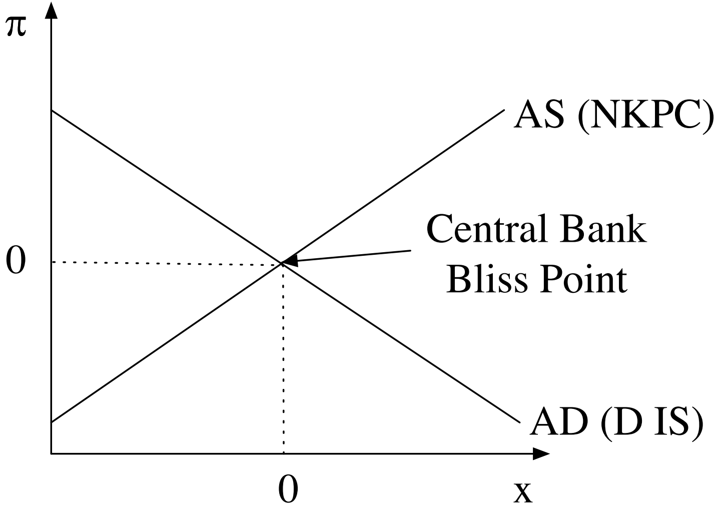
- Second, given $\{\tilde{y}_{t+s}, \pi_{t+s}\}_{s=0}^{\infty}$, find $\{i_{t+s}\}_{s=0}^{\infty}$ that satisfies:

$$\tilde{y}_t = -\sigma E_t \left\{ \hat{i}_t - \hat{\pi}_{t+1} - \hat{r}_{t+1}^n \right\} + E_t \{\tilde{y}_{t+1}\}$$

The Divine Coincidence

- The solution is simple: $\tilde{y}_t = 0$, $\hat{\pi}_t = 0$, $\hat{i}_t = \hat{r}^n_{t+1}$.
- Lessons for optimal policy:
  1. The optimal policy *stabilizes the output gap*, not output.
  2. The central bank faces *no tradeoff between stabilizing output gap and inflation*. This is known as the "**divine coincidence**."
- Intuition: Zero inflation simultaneously avoids relative price distortions and gives flexible price allocation, which is optimal.
- This does *not* rely on particulars of Calvo. General argument:
  - Flexible price equilibrium is optimal.
  - Nominal rigidities are the constraint on firms and only source of distortions.
  - No distortion if constraint does not bind, which occurs with zero inflation.
  - So price stability implies output gap stability

The Divine Coincidence



The Divine Coincidence: Implications

- Demand shocks and technology shocks are completely offset by monetary policy.
  - They only affect IS curve through r_t^n (tech shocks) and directly through discount factor (demand shocks).
  - They thus do not enter the "first stage" of the planner's problem and the optimal choice of $\tilde{y}_t$ or π_t.
  - Can offset their effect on economy simply by adjusting i_t in response to shocks.
- Intuitively, monetary shock and demand shock both affect aggregate demand, while tech shock affects full employment real rate. All can be exactly offset by policy.
- Gali Ch. 4 explores more under the divine coincidence.

Creating an Inflation-Output Tradeoff

- The divine coincidence is not very realistic.
  - Central banks see themselves as facing significant tradeoffs between stabilizing output and inflation in the short run.
- Intuition of divine coincidence suggests that adding other frictions will eliminate it.
  - Stabilizing inflation does not remove only friction in model and stabilize output.

Time-Varying Efficient Output Gap

- Let the natural rate of output be y_t^n and efficient level be y_t^e.
  - These are now no longer the same.
- Let $x_t = \hat{y}_t - \hat{y}_t^e$ be the gap between output and efficient output that the planner wishes to stabilize.
  - Then $\tilde{y}_t = (\hat{y}_t - \hat{y}_t^e) + (\hat{y}_t^e - \hat{y}_t^n)$
  - The Phillips Curve is then

$$\hat{\pi}_t = \kappa x_t + \beta E_t \{\hat{\pi}_{t+1}\} + u_t$$

    where $u_t = \kappa (\hat{y}_t^e - \hat{y}_t^n)$ is exogenous with respect to policy.
  - Assume u_t follows AR(1):

$$u_t = \rho_u u_{t-1} + \varepsilon_t$$

- We call u_t a "cost-push shock."
  - Exogenous increase in marginal costs.

Cost Push and the Labor Wedge

- What are cost push shocks?
  - Anything that moves the labor wedge beyond sticky prices.
  - From medium-scale NK models, accounts for a lot of inflation.
- Start with labor market frictions.
- Let μ_t^W be the log wage markup:

$$\hat{w}_t - \hat{p}_t = \hat{\mu}_t^w + \varphi \hat{n}_t + \gamma \hat{c}_t$$

- With $\hat{w}_t - \hat{p}_t$ sticky and $\hat{n}_t$ and $\hat{c}_t$ pro-cyclical, $\hat{\mu}_t^W$ must be countercyclical.
  - For this class $\hat{\mu}_t^W$ is exogenous.
  - Can microfound with Calvo assumption.

Cost Push and the Labor Wedge

- Plug into

$$\begin{aligned} \hat{mc}_t &= \hat{w}_t - \hat{p}_t - \hat{a}_t \\ &= (\gamma + \varphi)\,\hat{y}_t - (1+\varphi)\,\hat{a}_t + \hat{\mu}_t^W \end{aligned}$$

- Subtract off flexible prices:

$$(\gamma + \varphi)\,\hat{y}_t^{flex} = (1+\varphi)\,\hat{a}_t$$

to get

$$\hat{mc}_t = (\gamma + \varphi)\,\tilde{y}_t + \hat{\mu}_t^W$$

Cost Push and the Labor Wedge

- Go back to the log-linearization of the optimal pricing condition but insert a variable markup $\hat{\mu}_t^P$ which represents "markup shocks."
- Gali Appendix 5.2 shows

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \lambda \hat{mc}_t + \lambda \hat{\mu}_t^P$$

- Combining with $\hat{mc}_t$, we see

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \kappa \tilde{y}_t + \lambda \hat{\mu}_t$$

  where $\hat{\mu}_t = \hat{\mu}_t^P + \hat{\mu}_t^W$ are shocks to the labor wedge through prices or wages.
- Labor wedge shocks are thus cost push shocks.
  - Since large and variable, cost push shocks are important.

The Planning Problem With A Tradeoff

$$\min_{\{i_{t+s}, x_{t+s}, \pi_{t+s}\}_{s=0}^{\infty}} \frac{1}{2} E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left[\vartheta \left(x_{t+s} - k \right)^2 + \left(\pi_{t+s} - \pi^* \right)^2 \right] \right\}$$

subject to

$$\begin{aligned} x_t &= -\sigma E_t \left\{ \hat{i}_t - \hat{\pi}_{t+1} - \hat{r}^e_{t+1} \right\} + E_t \left\{ x_{t+1} \right\} + g_t \\ \hat{\pi}_t &= \kappa x_t + \beta E_t \left\{ \hat{\pi}_{t+1} \right\} + u_t \end{aligned}$$

- First stage is optimizing objective function subject to NKPC.
  - Cost push shock increases $\hat{\pi}_t$.
  - To offset it, can push output relative to efficient output x_t below its steady state.
  - Thus there is now a tradeoff.
  - Intuitively, monetary policy shifts aggregate demand but u_t is a shock to aggregate supply, so there is a tradeoff.

The Planning Problem: Rules vs. Discretion

- Standard quadratic loss function with linear constraints.
  - But targets depend on expectations of future policy.
  - To see this, iterate forward to get:

$$
\begin{aligned}
\pi_t &= E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left(\kappa x_{t+s} + u_{t+s} \right) \right\} \\
x_t &= E_t \left\{ \sum_{s=0}^{\infty} \left[-\sigma \left(\hat{i}_{t+s} - \hat{\pi}_{t+s+1} - \hat{r}^e_{t+s+1} \right) + g_{t+s} \right] \right\}
\end{aligned}
$$

- This raises issues of credibility and time consistency of policy.
  - Central bank can influence outcomes today by "promising" outcomes tomorrow.
  - But are those promises credible? Or would it want to renege on promises? How would "optimal promises" look and how would they help?
  - We will discuss these issues next class.

The Discretionary Problem

- For today, we assume that the central bank follows a *discretionary optimal policy*.
  - Cannot make credible commitments about future actions (will talk about why next class).
  - So optimize *taking expectations of future actions as given*.
- Solve

$$\min_{\pi_t, x_t} \frac{1}{2}\left[\pi_t^2 + \vartheta x_t^2\right] + F_t \text{ s.t. } \pi_t = \kappa x_t + f_t$$

where

$$\begin{aligned} F_t &= \frac{1}{2} E_t \left\{ \sum_{s=1}^{\infty} \beta^s \left(\pi_{t+s}^2 + \vartheta x_{t+s}^2 \right) \right\} \\ f_t &= \beta E_t \left\{ \pi_{t+1} \right\} + u_t \end{aligned}$$

are functions of expectations of future actions.

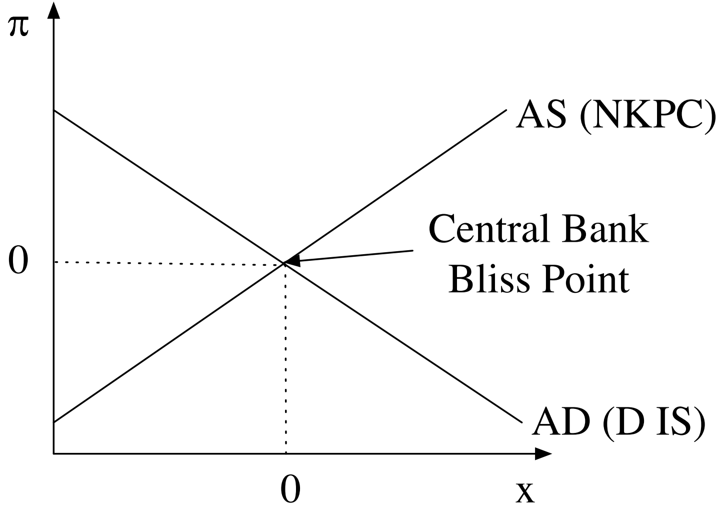
The Discretionary Problem

$$\min \frac{1}{2}\left[\pi_t^2 + \vartheta x_t^2\right] + F_t \text{ s.t. } \pi_t = \kappa x_t + f_t$$

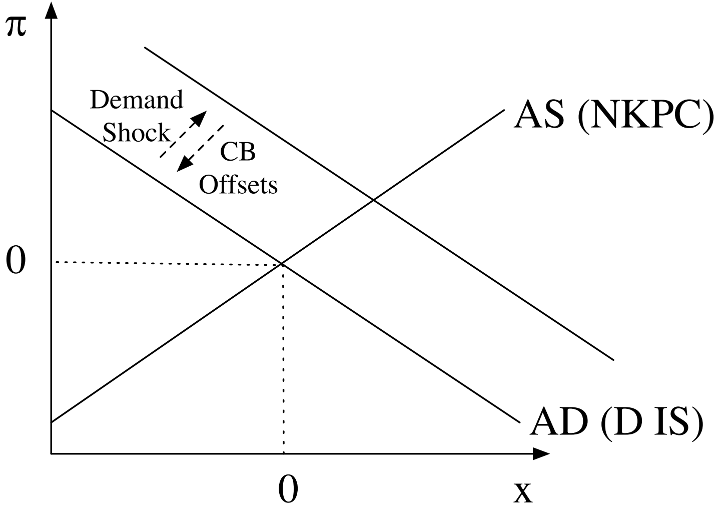
- The first order condition is:

$$x_t = -\frac{\kappa}{\vartheta}\pi_t$$

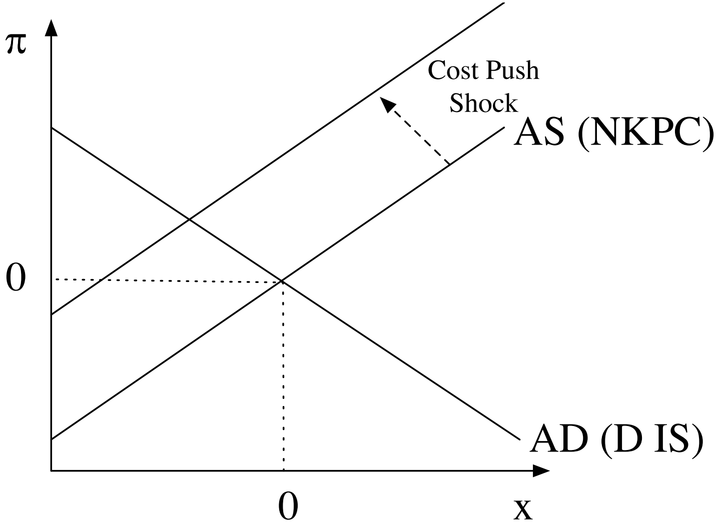
Diagrammatic Treatment of Discretionary Policy



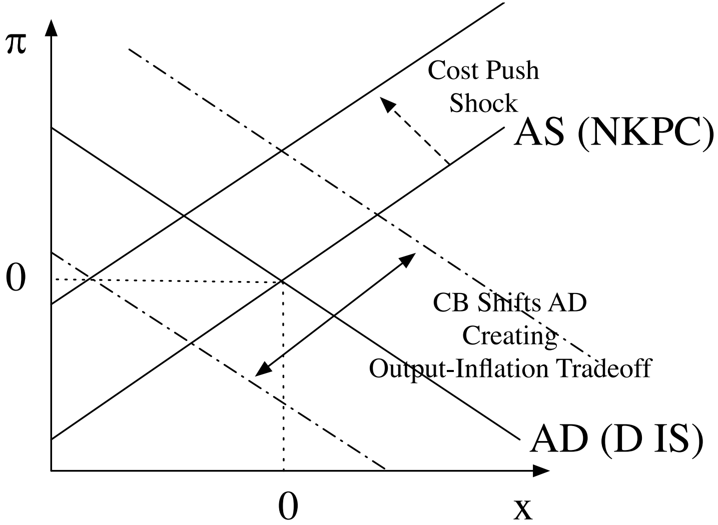
Demand Shock



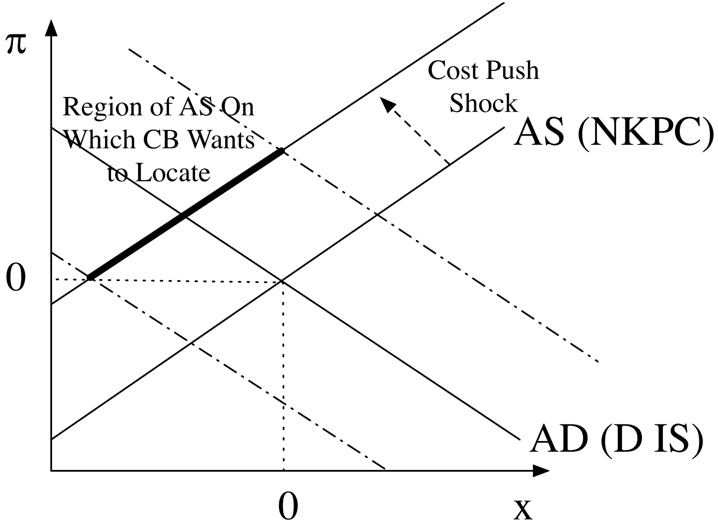
Cost-Push Shock



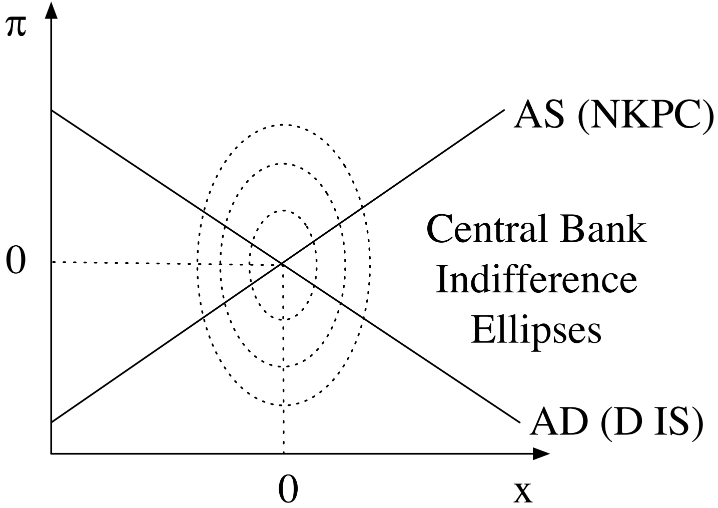
Cost-Push Shock Creates Output-Inflation Tradeoff



Feasible Region For Responding to Cost-Push Shock



Central Bank Indifference Ellipses



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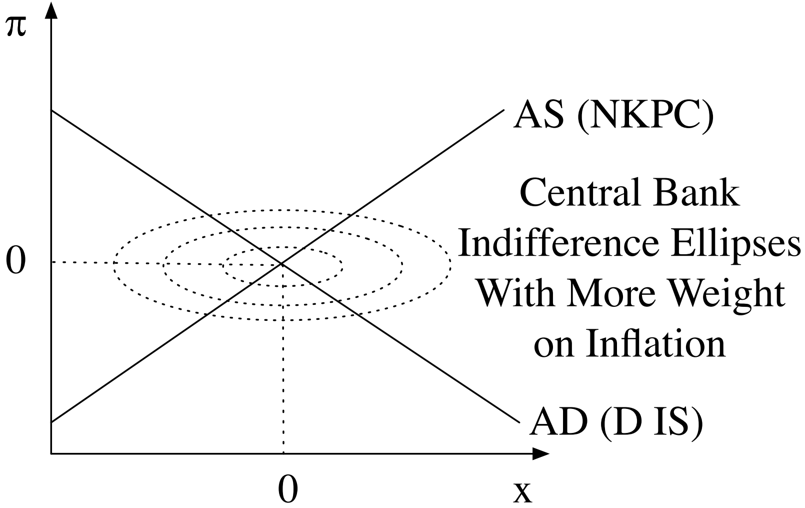
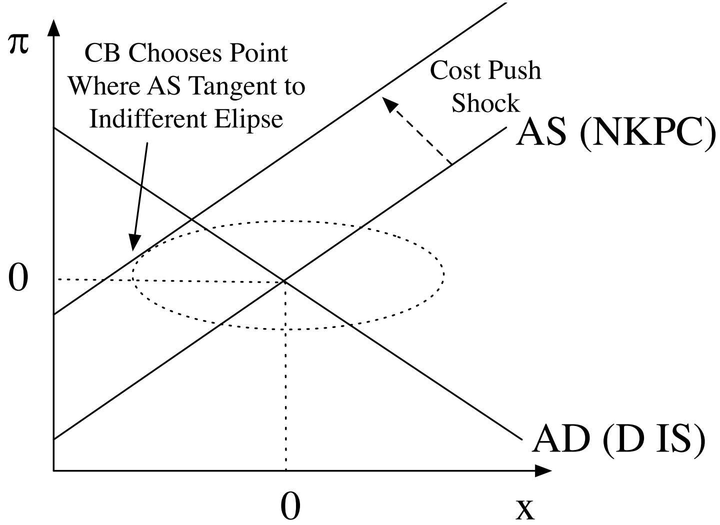
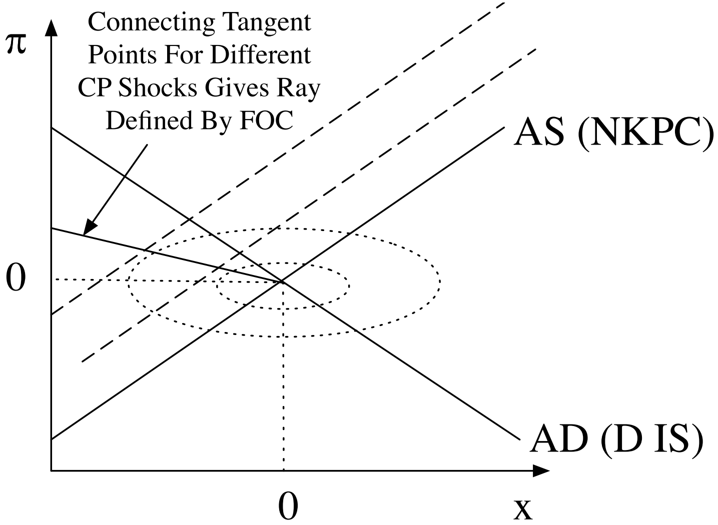


What Point Does Central Bank Choose?



Central Bank's Preferences Define Optimal Ray



"Lean Against the Wind" Policy

$$\min \frac{1}{2}\left[\pi_t^2 + \vartheta x_t^2\right] + F_t \text{ s.t. } \pi_t = \kappa x_t + f_t$$

- The first order condition is

$$x_t = -\frac{\kappa}{\vartheta}\pi_t$$

- "Lean Against The Wind" Policy.
  - In face of inflationary pressures from cost push shocks, *drive output below its efficient level to dampen rise in inflation*.
  - Extent to which it does so depends on:
    - κ, which determines reduced inflation per unit of output loss.
    - ϑ, the relative weight placed on output loss.
- Flip from "Old Keynesian" logic where stabilizing output at cost of inflation.

Inflation and Output Under Discretion

- Plug policy into Phillips:

$$\hat{\pi}_t = \frac{\vartheta\beta}{\vartheta + \kappa^2} E_t \left\{\hat{\pi}_{t+1}\right\} + \frac{\vartheta}{\vartheta + \kappa^2} u_t$$

- And iterate forward to get:

$$\hat{\pi}_t = \frac{\vartheta}{\kappa^2 + \vartheta \left(1 - \beta\rho_u\right)} u_t$$

- Combine with optimality condition to get

$$x_t = -\frac{\kappa}{\kappa^2 + \vartheta \left(1 - \beta\rho_u\right)} u_t$$

- So central bank lets output gap and inflation fluctuate in proportion to current value of cost push shock.
    - Intuition: Cost push increases inflation, central bank wants to smooth both so trades some inflation for output.

Interest Rate Under Discretion

- Plugging into dynamic IS:

$$x_t = E_t\left\{x_{t+1}\right\} - \sigma E_t\left\{i_t - \pi_{t+1} - r^e_{t+1}\right\} + g_t$$

obtains

$$i_t = E_t\left\{r^e_{t+1}\right\} + \phi_\pi E_t\left\{\pi_{t+1}\right\} + \frac{g_t}{\sigma}$$

where $\phi_\pi = 1 + \frac{\kappa(1-\rho_u)}{\vartheta\sigma\rho_u} > 1$.

Principle 1: Short Run Tradeoff

- Clarida, Gali, and Gertler (1999) cite four principles of discretionary policy that are robust to model specification and that can be seen in this model.
- There is a short-run tradeoff between inflation and output volatility:

$$
\begin{aligned}
\sigma_\pi &= \frac{\vartheta}{\kappa^2 + \vartheta\left(1 - \beta\rho_u\right)}\sigma_u \\
\sigma_x &= \frac{\kappa}{\kappa^2 + \vartheta\left(1 - \beta\rho_u\right)}\sigma_u
\end{aligned}
$$

  - As $\vartheta \to 0$, $\sigma_x \to \sigma_u/\kappa$ and $\sigma_\pi \to 0$.
  - As $\vartheta \to \infty$, $\sigma_x \to 0$ and $\sigma_\pi \to \sigma_u/\left(1 - \beta\rho_u\right)$.
- Intuition: Monetary policy shifts aggregate demand, and u is a shock to aggregate supply.

Principle 2: Inflation Targeting

- Optimal policy with discretion incorporates *inflation targeting*.
  - Aim for convergence of inflation to its target over time.
  - In this sense, "flexible" inflation targeting.
  - "Strict" inflation targeting (adjust to π^* immediately) is optimal only if $u = 0$ or $\vartheta = 0$.
- Intuition: Only shocks that central bank cannot offset perfectly are cost push shocks, and because of concern for output ($\vartheta > 0$) it offsets cost-push shocks only partially but asymptotically gets back to target.

Principle 3: Taylor Principle

$$i_t = E_t\left\{r^e_{t+1}\right\} + \phi_\pi E_t\left\{\pi_{t+1}\right\} + \frac{g_t}{\sigma}$$

$$\text{where } \phi_\pi = 1 + \frac{\kappa\left(1-\rho_u\right)}{\vartheta\sigma\rho_u} > 1$$

- In response to expected inflation, nominal rates should rise more than one for one in order to increase real rates.
- Intuition:
  - Because of dual mandate, push output below trend to stabilize inflation in presence of cost push shock.
  - From IS curve, real rate must increase to contract aggregate output.

Principle 4: Offset Demand, Accommodate Supply

$$i_t = E_t\left\{r^e_{t+1}\right\} + \phi_\pi E_t\left\{\pi_{t+1}\right\} + \frac{g_t}{\sigma}$$

- Perfectly offset demand shocks g_t.
  - Monetary policy shifts aggregate demand (both increase output and inflation).
  - This means there is no short run output-inflation tradeoff for demand shocks.
  - So perfectly offset effects of demand with policy.
- Perfectly accommodate permanent shocks to potential output.
  - Permanent rise in productivity raises potential output and output together and leaves x_t unchanged.
    - No inflation, no tradeoff.
  - Because $r^n_t = \gamma\frac{1+\varphi}{\gamma+\varphi}E_t\left\{\Delta\hat{a}_{t+1}\right\}$, a permanent change in $\hat{a}_t$ with no mean reversion leaves r^n_t unchanged, so leave i_t unchanged.
    - If shock affects r^e_{t+1} (e.g. mean reverting productivity shock), adjust i_t in response to change in r^e_{t+1}.

Monetary Policy in Practice

- First half of next class we will discuss how these principles are put into practice, and then turn to commitment.
- In addition to broadly talking about what central banks do, I want to talk about recent monetary policy from 2021 to 2023.
    - 40 years of low inflation suddenly leads to a surge in inflation.
    - Monetary policy response hotly debated.
- We will have a class discussion focusing on two questions:
    - What did Fed do and why?
    - What should Fed have done? In other words would you do differently?
    - To prepare **read the 2021-2022 Fed press conference excerpts, Shadow Open Market Committee Critique, and think about the discussion questions (see instructions)**.