

Monetary Policy in a Macro Model

ECON 40364: Monetary Theory & Policy

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Readings

Mishkin Ch. 20, 21, 22

Mishkin Ch. 23, sections 23.1 and 23.2

Approach

Want to study role of monetary policy in the aggregate economy

We will not bother to “micro-found” the macro model of the economy

We will just posit a bunch of demand and supply relationships so as to get a useable demand-supply macro model

These demand and supply relationships (or something that looks like them) **can** be motivated from micro principles

Our focus is on monetary policy

Aggregate Demand

Aggregate demand is the sum of planned expenditure by the four primary actors in an economy:

1. Households (consumption)
2. Firms (investment)
3. Government (government purchases)
4. Rest of the world (net exports)

Income = Expenditure

Total (real) aggregate demand is the sum of planned expenditure by each of these actors:

$$Y^{ad} = C + I + G + NX$$

Must have $Y^{ad} = Y$ (expenditure equals income)

This is somewhat complicated because expenditure categories on right hand side may depend on Y

There are potential dynamic impacts but will follow the book in omitting time subscripts

Consumption

Aggregate consumption is governed by a consumption function:

$$C = \bar{C} + mpc \times (Y - T)$$

Y is income and T is taxes, so $Y - T$ is disposable income

mpc is the marginal propensity to consume and is between 0 and 1

Reflects desire to **smooth** consumption

Autonomous Consumption

$\bar{C}$ is **autonomous** consumption

“Autonomous” means the exogenous component of an endogenous variable. $\bar{C}$ is consumption independent of disposable income. Potential factors impacting it (which are not modeled explicitly):

- ▶ Future income
- ▶ Interest rates
- ▶ Uncertainty
- ▶ Government spending (via Ricardian Equivalence)

Investment

Investment: expenses on new physical capital (as well as new residential construction and inventory accumulation)

$$I = \bar{I} - dr$$

r is “the” real interest rate, d is a parameter governing sensitivity to the real interest rate, and $\bar{I}$ is autonomous investment (investment independent of the real interest rate). Possible factors:

- ▶ Expectations about the future
- ▶ Efficiency of producing new capital
- ▶ Government regulations and taxes

Book includes a “credit spread” variable ($\bar{f}$) here. We will return to that later

Government Spending and Taxes

Government spending and taxes are completely exogenous:

$$G = \bar{G}$$

$$T = \bar{T}$$

We do not think explicitly about government debt, future taxes, or future spending. Also, taxes are “lump sum”

Not modeling Ricardian Equivalence

Net Exports

Net exports depend on the exchange rate (how much one currency buys of another), as well as on other non-modeled things (like tariffs!!!)

A high US interest rate results in an appreciation of the dollar other things being equal (foreigners want to buy US assets, pushing up the value of the dollar relative to other currencies)

An appreciation of the dollar leads to more imports (cheaper for US citizens to buy foreign goods) and fewer exports (more expensive for foreigners to buy US goods) and hence reduces net exports

Net export function, where $\bar{NX}$ is autonomous net exports and x is a parameter governing sensitivity to real interest rate:

$$NX = \bar{NX} - xr$$

Putting it all together

Total planned (or desired) expenditure:

$$Y^{ad} = \bar{C} - mpc\bar{T} + \bar{I} + \bar{G} + \bar{N}X + mpcY - (d + x)r$$

Let $\bar{A} = \bar{C} - mpc\bar{T} + \bar{I} + \bar{G} + \bar{N}X$:

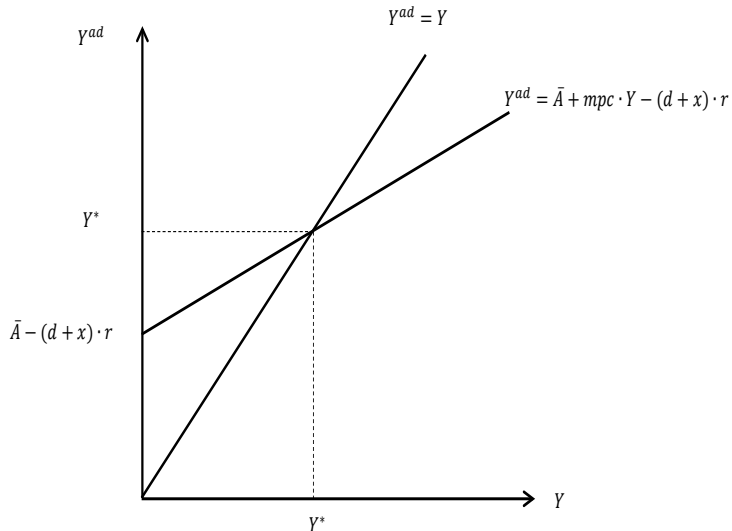
$$Y^{ad} = \bar{A} + mpcY - (d + x)r$$

One equation in three “unknowns” (Y^{ad} , Y , and r); d , x , and mpc are parameters; and $\bar{A}$ is exogenous

Imposing $Y = Y^{ad}$:

$$Y = \frac{1}{1 - mpc}\bar{A} - \frac{d + x}{1 - mpc}r$$

Keynesian Cross



The IS Curve

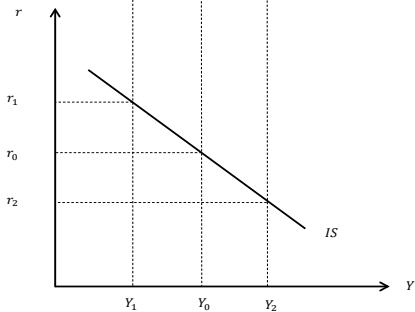
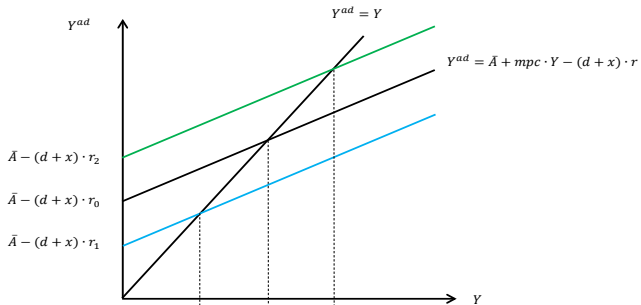
The condition:

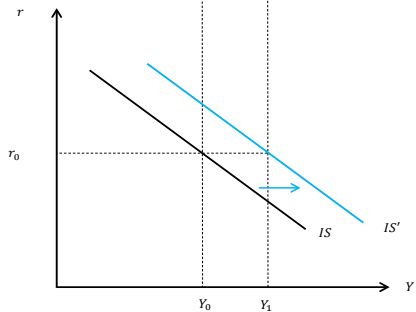
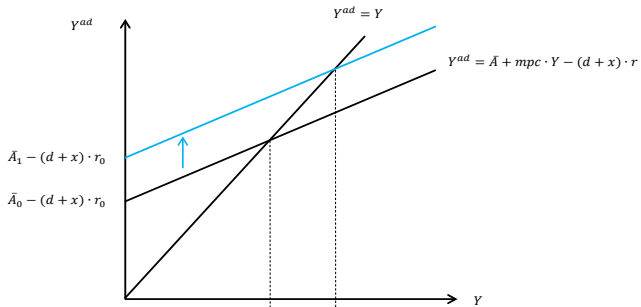
$$Y = \frac{1}{1 - mpc} \bar{A} - \frac{d + x}{1 - mpc} r$$

Is one equation in two endogenous variables, r and Y

The **IS curve** is the set of (r, Y) pairs where this condition holds (i.e., it is this equation). Graphically:

- ▶ It is downward sloping
- ▶ It shifts right whenever $\bar{A}$ increases





The LM Curve

To get an aggregate demand curve, which shows a relationship between aggregate output and the inflation **rate** or the aggregate price **level** (where $\pi = \frac{\Delta P}{P}$), we need to combine the IS curve with some description of monetary policy

Traditionally, this is done through something called the **LM curve**, which combines the liquidity preference of money demand with a money supply rule

With the LM curve, AD curve is downward-sloping in a graph with (P, Y)

The MP Curve

Given central bank's modern focus on interest rates rather than money supply, we instead do so with the **monetary policy curve (MP)**

Basically, a simplified Taylor (1993) rule

With MP curve, AD curve is downward-sloping with (π, Y)

We need not model money at all, though we could figure out how Fed must adjust M to meet money demand if we wanted – the economy is “cashless”

The MP Equation

Recall the Fisher relationship, $r = i - \pi^e$. Fed can control i , but not necessarily r

Assume **adaptive** expectations, so that $\pi^e = \pi$

Assume Fed sets nominal rate according to

$$i = \bar{r} + a\pi$$

Similar to the Taylor rule. $\bar{r}$ is “autonomous monetary policy” (movements in rates unrelated to inflation) $a > 1$ – the “Taylor Principle”

The MP Equation and the Taylor Principle

Can write the real interest rate as:

$$r = \bar{r} + \lambda\pi$$

Where $\lambda = (a - 1)$. Taylor principle requires $\lambda > 0$. Idea: when π increases, Fed responds by raising i by sufficiently much so as to raise r

The AD Curve

Combine the IS and MP curves. You get:

$$Y = \frac{1}{1 - mpc} \bar{A} - \frac{d + x}{1 - mpc} (\bar{r} + \lambda \pi)$$

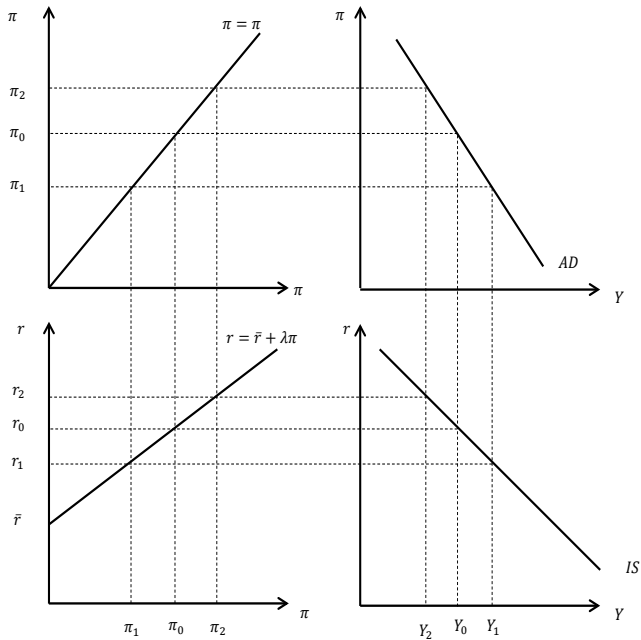
Can also re-arrange with π on LHS:

$$\pi = -\frac{1 - mpc}{(d + x)\lambda} Y + \frac{1}{(d + x)\lambda} \bar{A} - \frac{1}{\lambda} \bar{r}$$

Properties of the AD Curve

Provided $\lambda > 0$ (Taylor principle satisfied):

1. AD curve is downward-sloping
2. AD curve is flatter the bigger is λ
3. AD curve shifts out/up when $\bar{A}$ increases
4. AD curve shifts down/in when $\bar{r}$ increases



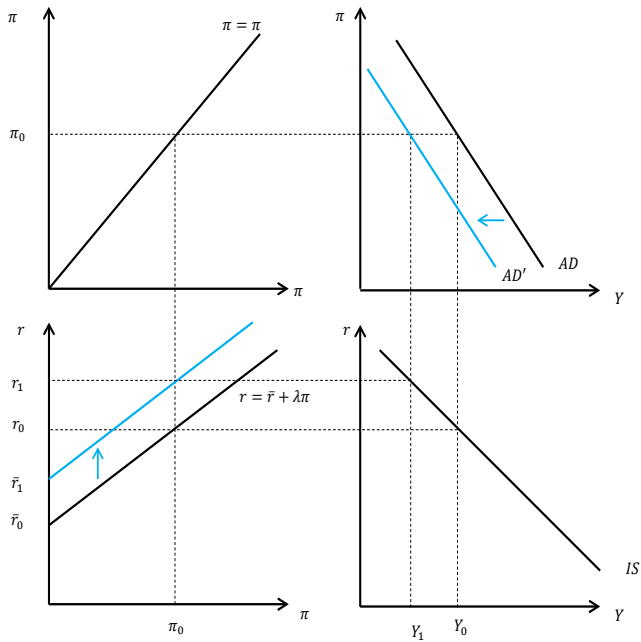
Shifts of the AD Curve

The AD curve is drawn holding $\bar{r}$ (which governs the position of the MP curve) and $\bar{A}$ (which governs the position of the IS curve) fixed

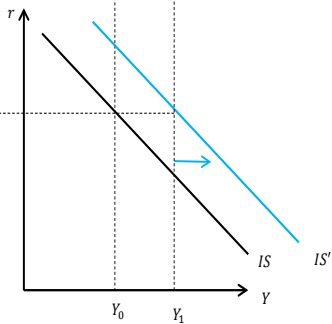
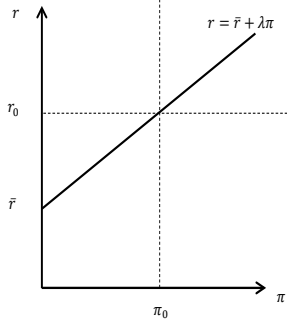
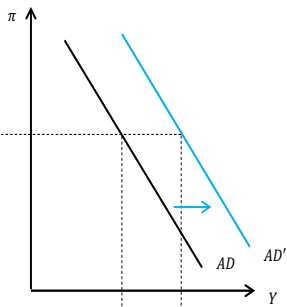
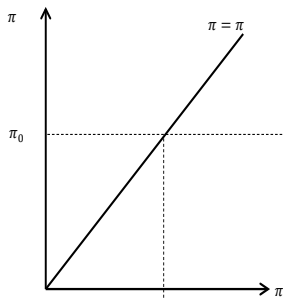
An increase in $\bar{r}$ will result in an increase in the real interest rate for a given inflation rate; from the IS curve, this results in a lower level of output. So the AD curve shifts left

An increase in $\bar{A}$ will shift the IS curve right. For a given inflation rate, the real interest rate is given, which means that output increases. So the AD curve shifts right

$\uparrow \bar{r}$



$\uparrow \bar{A}$



The Taylor Principle and the Slope of the AD Curve

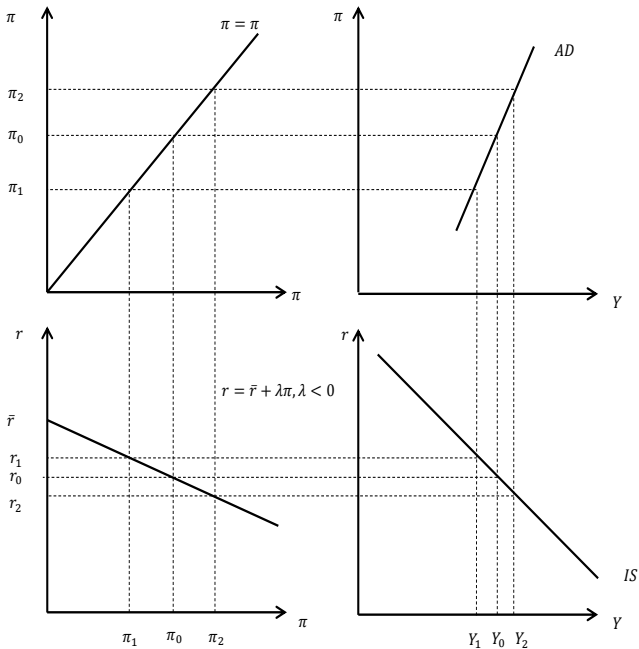
The Taylor principle ($a > 1$ or $\lambda > 0$) calls for the Fed to raise the real interest rate when inflation increases

The higher real interest rate causes output to decline from the IS curve, which makes the AD curve downward-sloping

What if the Taylor principle isn't satisfied? i.e. $\lambda < 0$?

Higher inflation results in lower real interest rates, which stimulates output from the IS curve

The AD curve becomes upward-sloping. For reasons we will talk about later, this is undesirable.



Aggregate Supply

Relationship between π and Y (or P and Y)

- ▶ Aggregate supply (AS) curve is vertical in the “long run” or “medium run.” The level of output where it’s vertical, or “potential output,” is determined by labor supply, available capital, and technology. Classical dichotomy: real variables independent of nominal
- ▶ Prices and/or wages are “sticky” in the short run, so “short run” AS curve is upward-sloping instead of vertical. Classical dichotomy breaks down

Many policy debates among macroeconomists are over the “shape” of the AS curve (i.e. how far from vertical is the AS curve in the short run) and how long it takes to transition from short run to medium/long run

Let Y^P denote potential output; take this to be exogenous (equilibrium concept in model without nominal rigidity)

Short Run AS

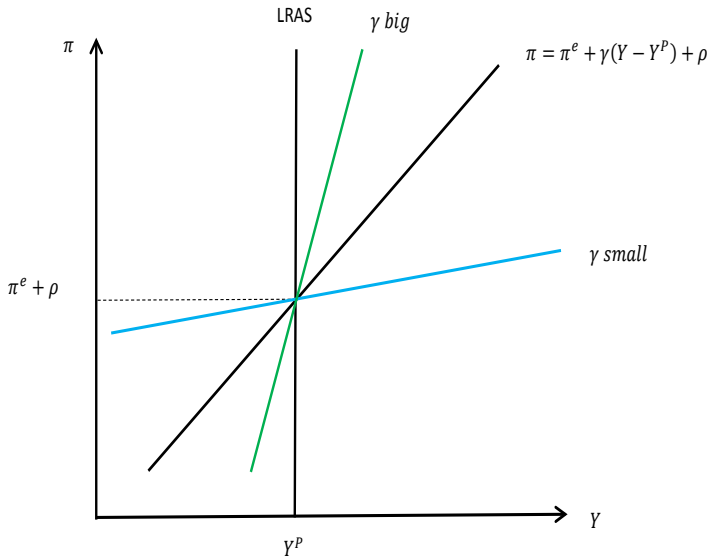
The assumed short run AS curve is:

$$\pi = \pi^e + \gamma(Y - Y^P) + \rho$$

Where:

1. π^e : how much inflation firms/households expected from “yesterday” to “today” (slightly different than π^e in the Fisher relationship, which is expected inflation from “today” to “tomorrow”)
2. γ : parameter governing how steep AS is (related to underlying price and/or wage stickiness)
3. ρ : “inflation shock” (e.g. increase in oil prices), also called “cost-push shock.” Zero on average; if it changes, only changes for one period (simplifying assumption)

If $Y > Y^P$, firms/households have pressure to increase prices/wages, which puts upward pressure on π . γ big: it's easy to do this. γ small: prices/wages are very sticky

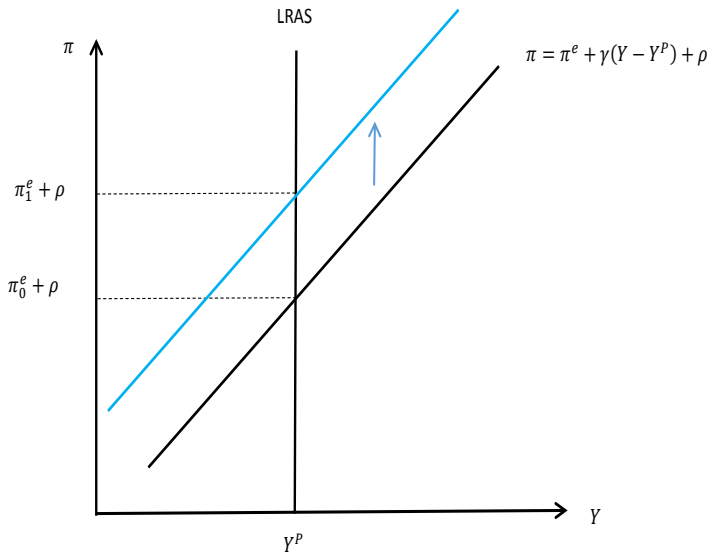


Short Run AS Curve (SRAS)

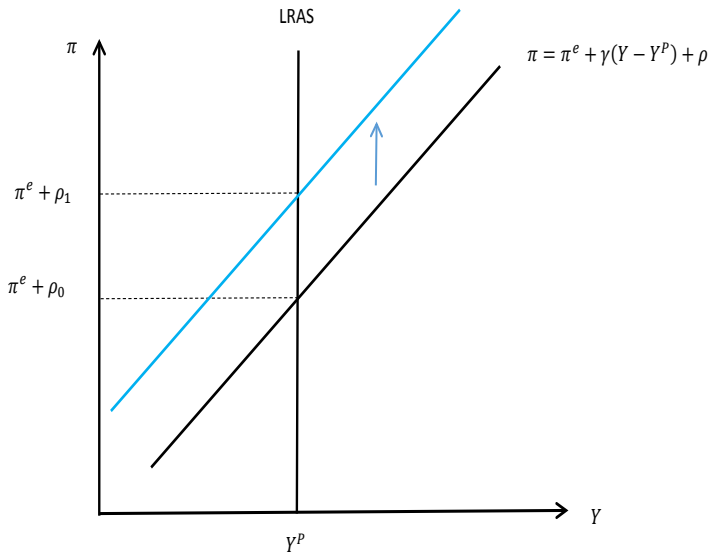
The following are relevant things to remember about the AS curve:

1. If $\gamma \rightarrow \infty$, no distinction between SRAS and LRAS
2. AS curve crosses point $Y = Y^P$ at $\pi = \pi^e + \rho$. The inflation shock ρ is zero on average, so we'll often think of this point as being where $\pi = \pi^e$. In other words, if households and firms are not surprised by inflation, then $Y = Y^P$ regardless of what γ is
 - ▶ In a sense, nominal rigidities matter only if agents are “fooled” (Lucas 1972)
3. The AS curve shifts up if π^e or ρ increase
4. The AS curve shifts right if Y^P increases

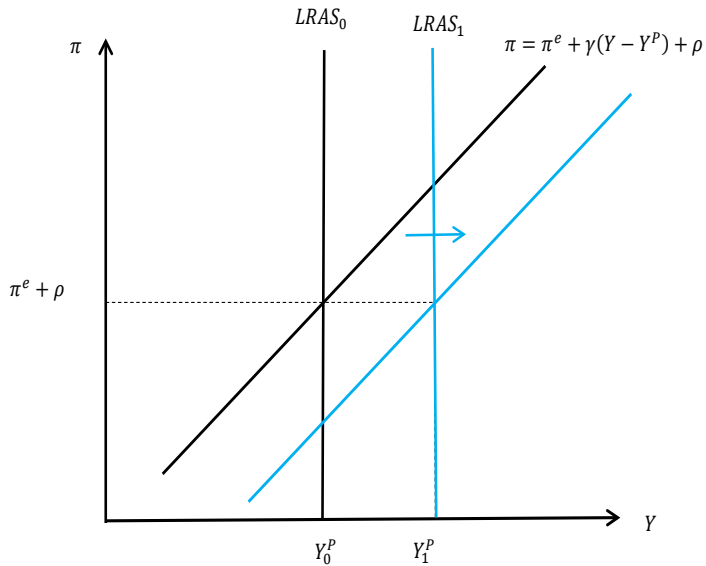
$\uparrow \pi^e$



$\uparrow \rho$



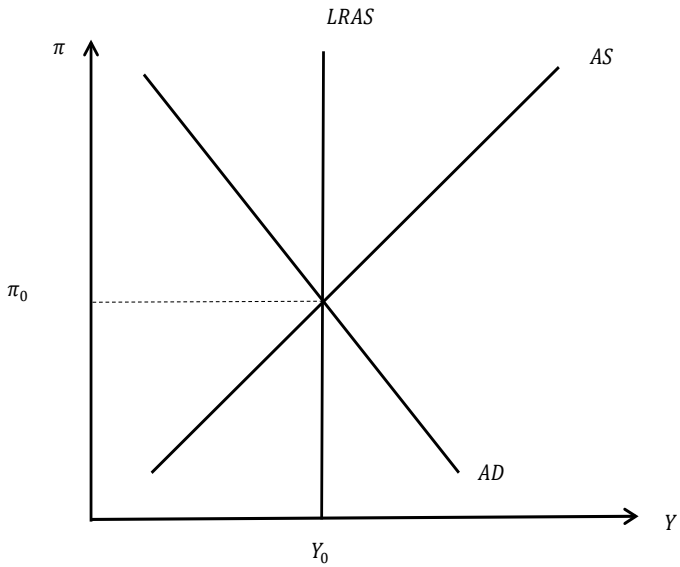
$\uparrow Y^P$



General Equilibrium

Equilibrium occurs where AD and AS intersect

For simplicity, assume these intersect initially at the LRAS

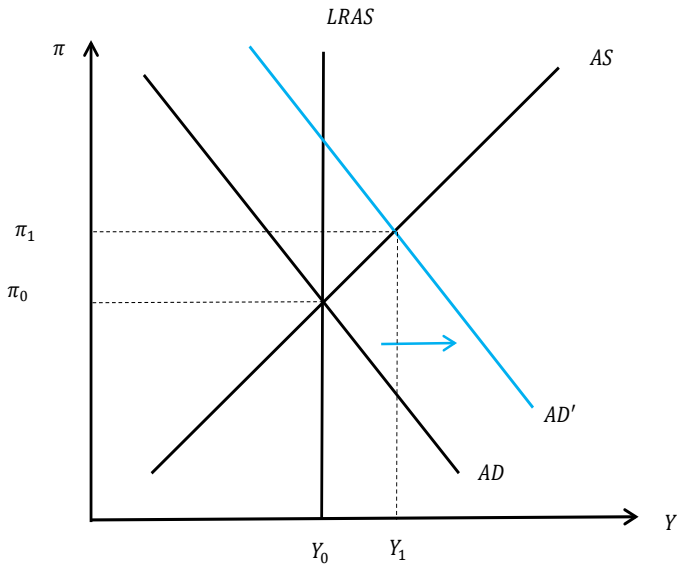


Effects of Shocks

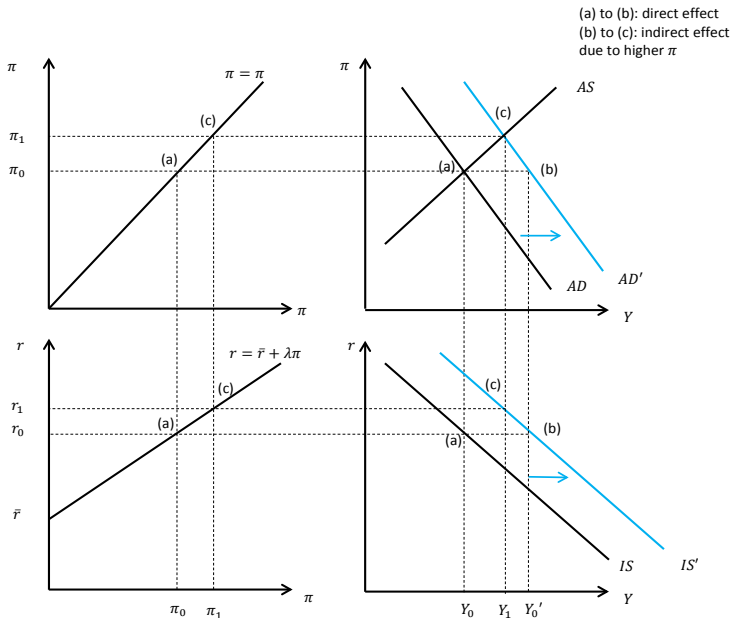
Exogenous variables cause curves to shift and change the equilibrium

- ▶ Demand shocks:
 - ▶ IS shocks: changes in $\bar{A}$ ($\bar{C}$, $\bar{I}$, $\bar{T}$, $\bar{G}$, $N\bar{X}$)
 - ▶ Monetary shocks: changes in $\bar{r}$
- ▶ Supply shocks:
 - ▶ Potential output shocks: changes in Y^P
 - ▶ Inflation shocks: changes in ρ
 - ▶ Expected inflation shocks: changes in π^e

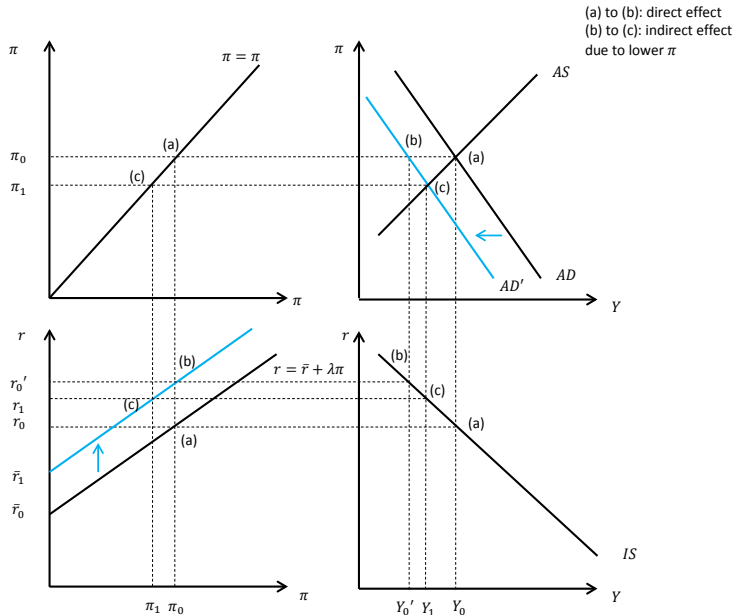
Demand Shock



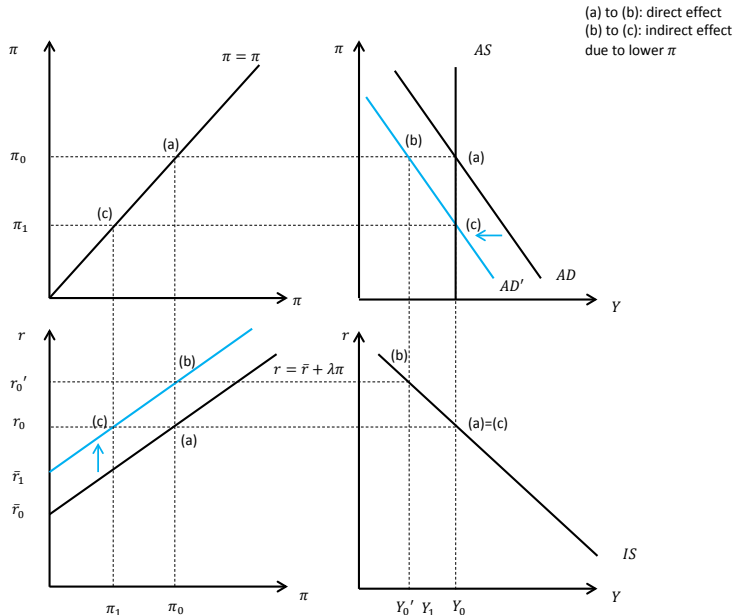
IS Shock: What Happens to r



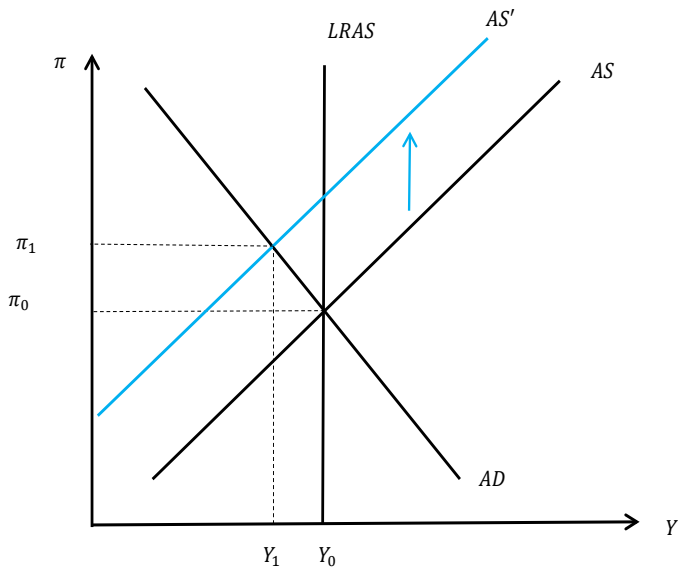
MP Shock: What Happens to r



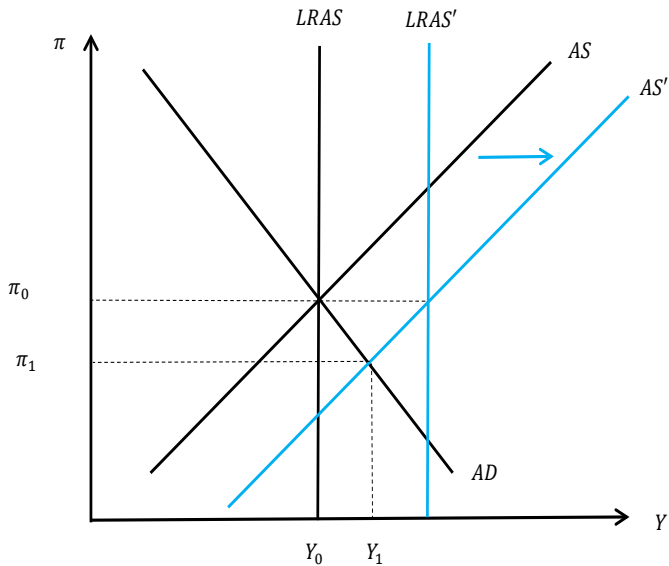
Monetary Neutrality: MP Shock When AS is Vertical



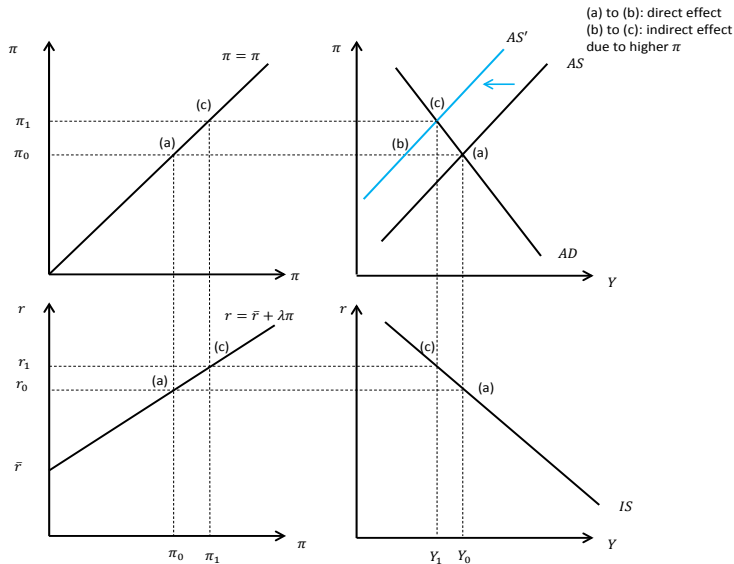
Supply Shock: Increase in π^e or ρ



Supply Shock: Increase in Y^P



Decrease in Y^P : Effect on r



Algebraically Solving for Equilibrium

AS with AD:

$$\pi = \pi^e + \gamma \left(\frac{1}{1 - mpc} \bar{A} - \frac{d + x}{1 - mpc} (\bar{r} + \lambda \pi) - Y^p \right) + \rho$$

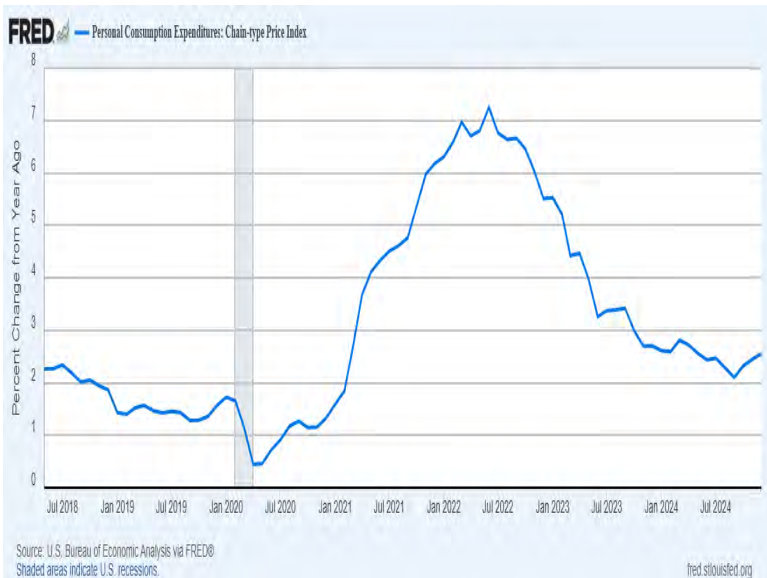
Solve for π :

$$\begin{aligned} \pi = & \frac{1 - mpc}{1 - mpc + (d + x)\lambda\gamma} (\pi^e + \rho) + \frac{\gamma}{1 - mpc + (d + x)\lambda\gamma} \bar{A} \\ & - \frac{(d + x)\gamma}{1 - mpc + (d + x)\lambda\gamma} \bar{r} - \frac{\gamma(1 - mpc)}{1 - mpc + (d + x)\lambda\gamma} Y^p \end{aligned}$$

Once you have this, you can get Y from the AS curve:

$$Y = Y^p + \frac{1}{\gamma} (\pi - \pi^e - \rho)$$

Inflation During the Pandemic



COVID-19 Inflation

Initially, inflation fell

- ▶ Near cessation of economic activity (drop in demand)
- ▶ Some reduction in potential output (drop in supply)
- ▶ Net result: fall in inflation, big drop in output

Post-COVID-19 Inflation

Inflation began to rise in 2021, reaching highest levels in 40 years

Why?

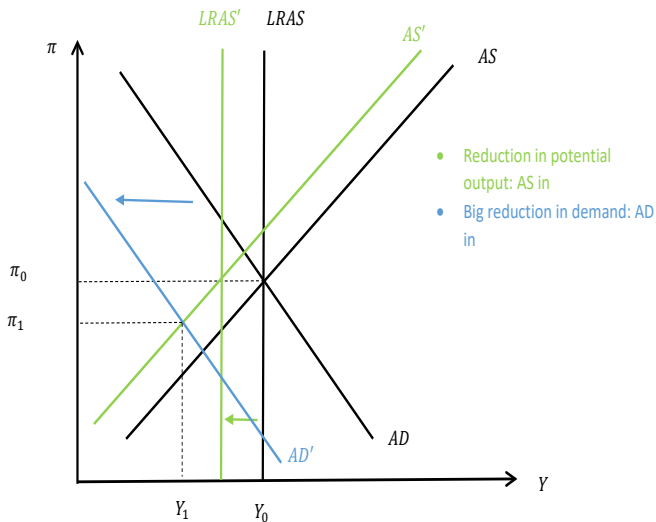
1. Massive increase in demand

- ▶ $\uparrow \bar{G}, \downarrow \bar{T}, \downarrow \bar{r}$

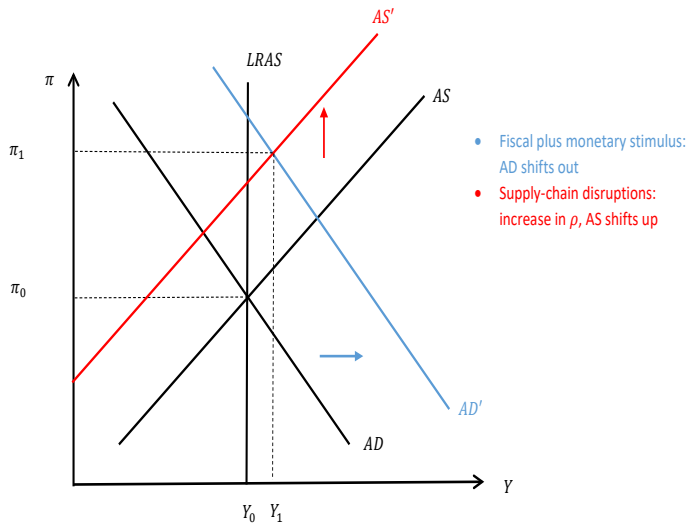
- ▶ Central bank asset purchases (not modeled yet)

2. Supply-chain pressures ($\uparrow \rho$)

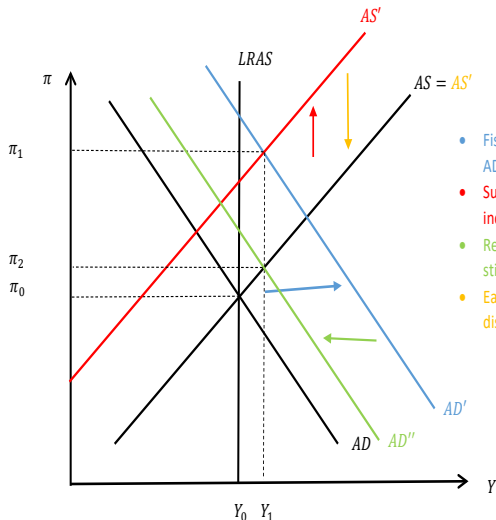
AD-AS Interpretation: COVID-19 Early On



AD-AS Interpretation: COVID-19 Inflation



AD-AS Interpretation: Bringing Inflation Down



- Fiscal plus monetary stimulus: AD shifts out
- Supply-chain disruptions: increase in ρ , AS shifts up
- Removal of much of demand stimulus, AD shifts in
- Easing of supply-chain disruptions, AS shifts down
- Favorable AS shift plus inward shift of AD: not much output decline but inflation has fallen

Dynamics and the “Self-Correcting Mechanism”

Assume $\rho = 0$ (its average value)

If $Y \neq Y^P$, then $\pi \neq \pi^e$

$Y > Y^P \Rightarrow \pi > \pi^e$: agents were surprised with more inflation than they expected

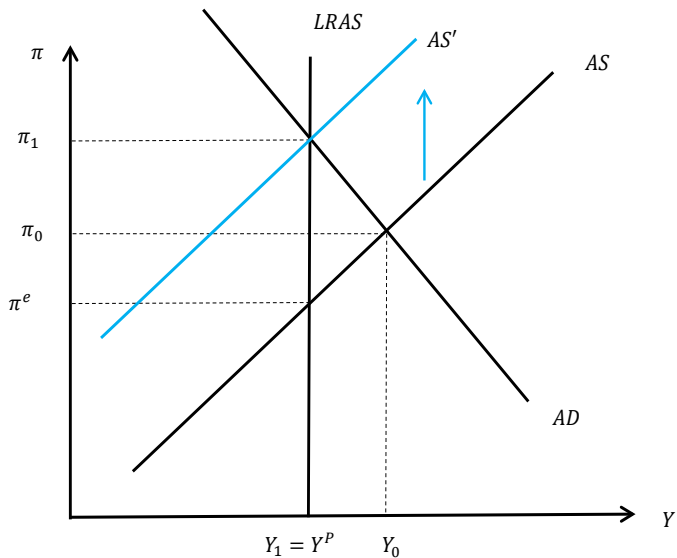
Stands to reason that, going forward in time, they will then revise up expectations

π^e going up: shifts AS curve up, which makes Y fall with no effect on Y^P

This process will continue until $Y = Y^P$ and inflation stops change

And vice-versa in the other direction

Adjustment from Positive Gap: Qualitative



Being More Specific

Put time subscripts on all variables: t is present, $t - 1$ is one period in past, $t + 1$ one period in future, and so on

Assume adaptive expectations, so that π^e in the AS curve is π_{t-1} :

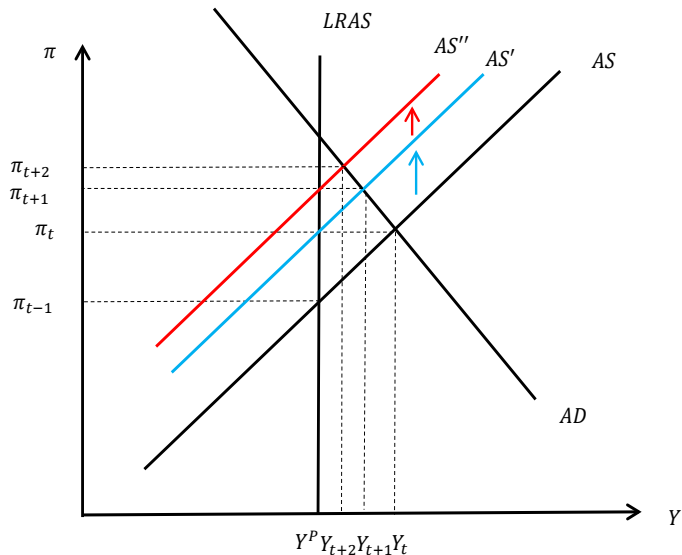
$$\pi_t = \pi_{t-1} + \gamma \left(Y_t - Y_t^P \right) + \rho_t$$

$$Y_t = \frac{1}{1 - mpc} \bar{A}_t - \frac{d + x}{1 - mpc} (\bar{r}_t + \lambda \pi_t)$$

The dynamics are on the supply side. As π_t changes, the position of the AS curve will change dynamically over time. Assume $\rho_t = 0$ (unconditional mean)

Adjustment occurs slowly, only eventually do you get to Y^P

Adjustment from Positive Gap: More Specific



Quantitative Dynamics

Create an Excel file

Assume the following parameters and exogenous variables:

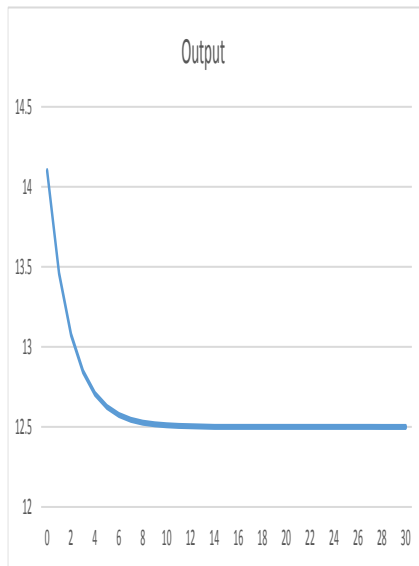
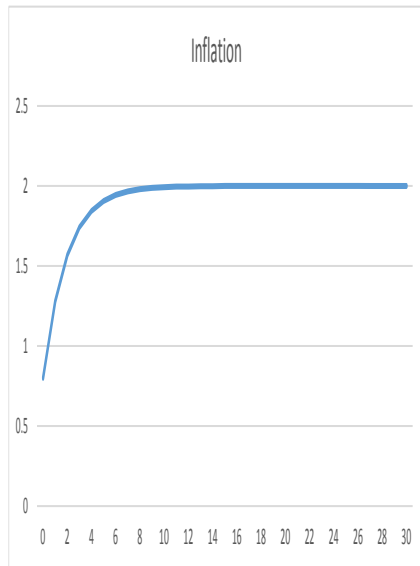
$$mpc = 0.7, d = 0.3, x = 0.1, \bar{r} = 1, \lambda = 1, \bar{A} = 4.95, \gamma = 0.5, Y^P = 12.5$$

Assume $\pi_{t-1} = 0$

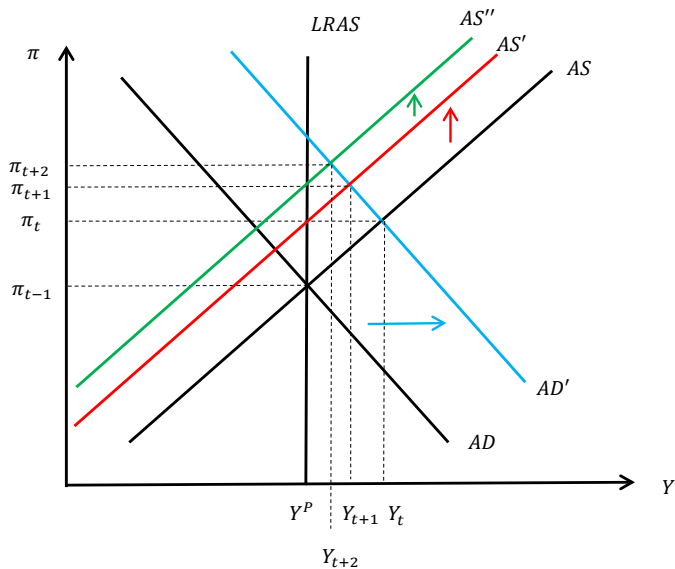
Implies that $\pi_t = 0.8$ and $Y_t = 14.1$

Use Excel to trace out dynamic paths

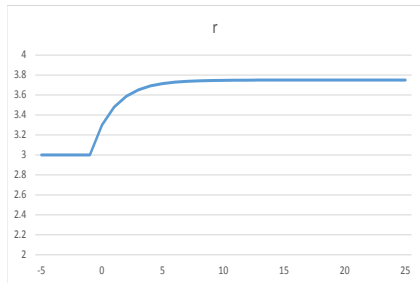
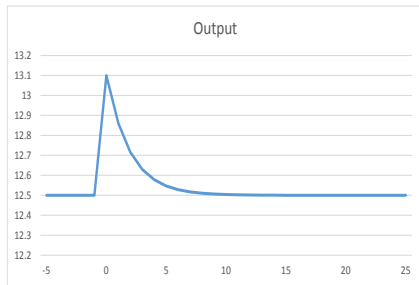
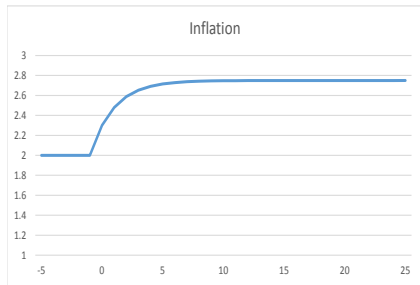
Adjustment from Positive Gap: Quantitative



Positive IS Shock: Dynamic Adjustment



Quantitative Adjustment from Positive IS Shock



Monetary Shock

An exogenous monetary tightening (increase in $\bar{r}$) has effects in terms of output and inflation similar to an IS shock (exogenous increase in $\bar{A}$)

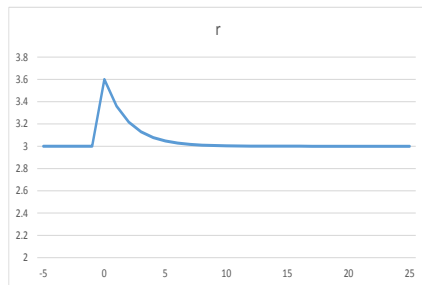
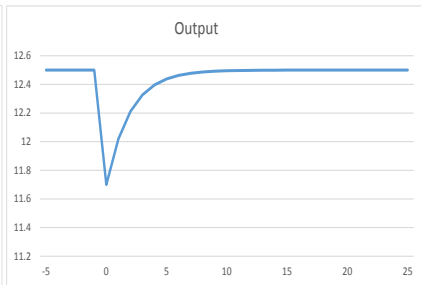
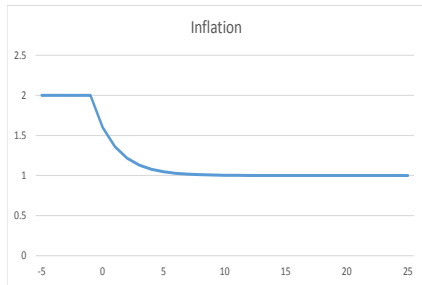
Difference: monetary shock does not affect r_t in medium/long run

“Natural rate of interest”: r consistent with IS curve holding at Y^P . Call it r^P (potential or long run real interest rate):

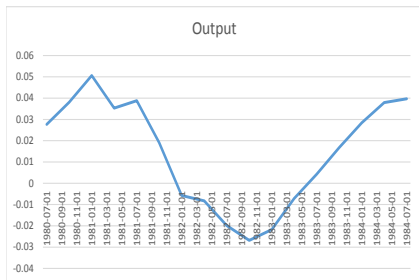
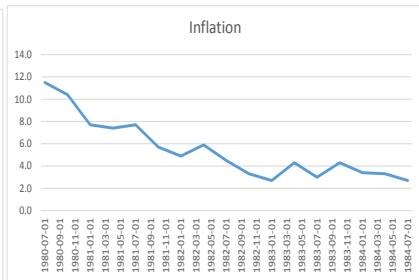
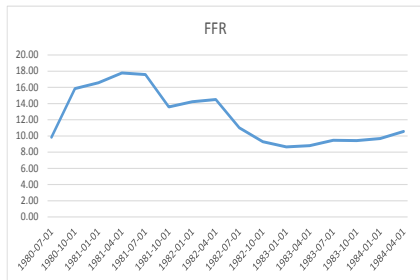
$$r^P = -\frac{1 - mpc}{d + x} Y^P + \frac{1}{d + x} \bar{A}$$

Does *not* depend on $\bar{r}$

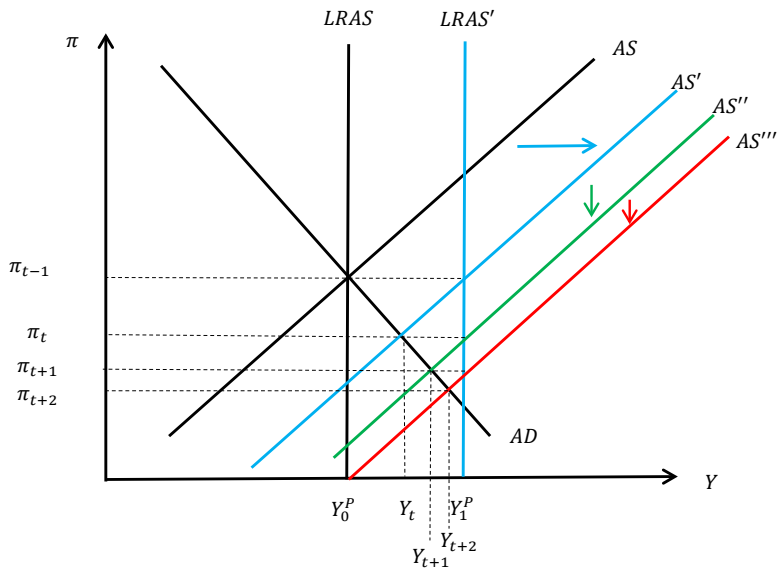
Adjustment from Positive $\bar{r}$ Shock



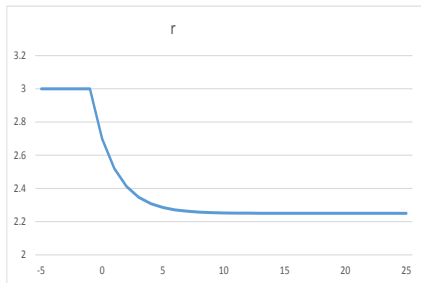
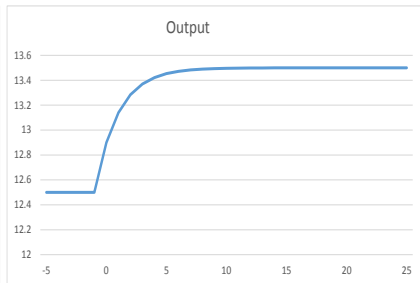
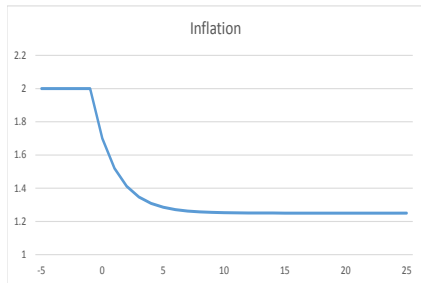
Application: Volcker Disinflation



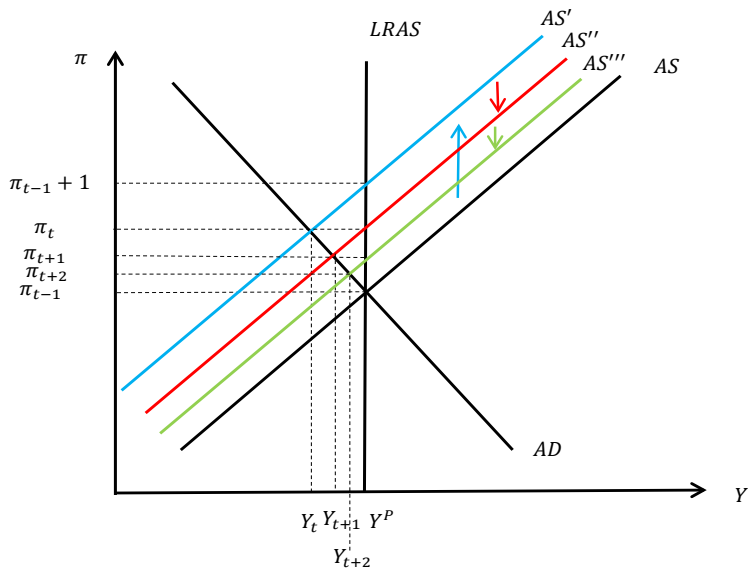
Adjustment from Positive Y^P Shock



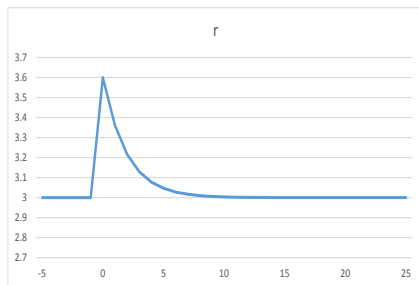
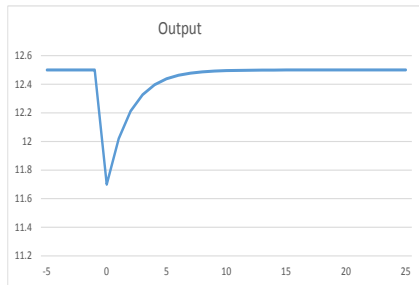
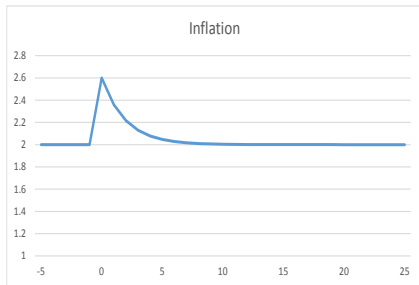
Quantitative Adjustment from Positive Y^P Shock



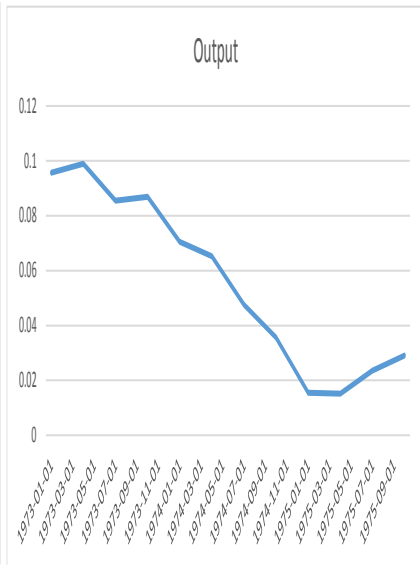
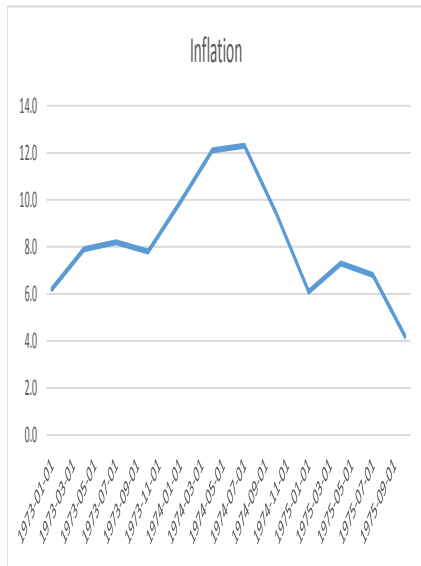
Adjustment from One Period ρ Shock



Quantitative Adjustment from Positive ρ Shock



Application: Oil Shocks and Stagflation



Monetary Policy Objectives

When it comes to the business cycle, monetary policy has a dual mandate: it wants to stabilize inflation around some low and stable rate and achieve “maximum employment”

In the context of our model, we can think about the first half of the mandate as keeping π_t close to constant, and the second half as keeping Y_t close to Y_t^P

Define the output gap as $X_t = Y_t - Y_t^P$

NOTE: in August 2020 Fed announced changes in operating framework:

- ▶ Have inflation be stable on average (average inflation targeting)
- ▶ Focus more on shortfalls from “full employment” more so than deviations

Monetary Policy Tools

The primary tool of monetary policy (in this simple model) is the parameter λ

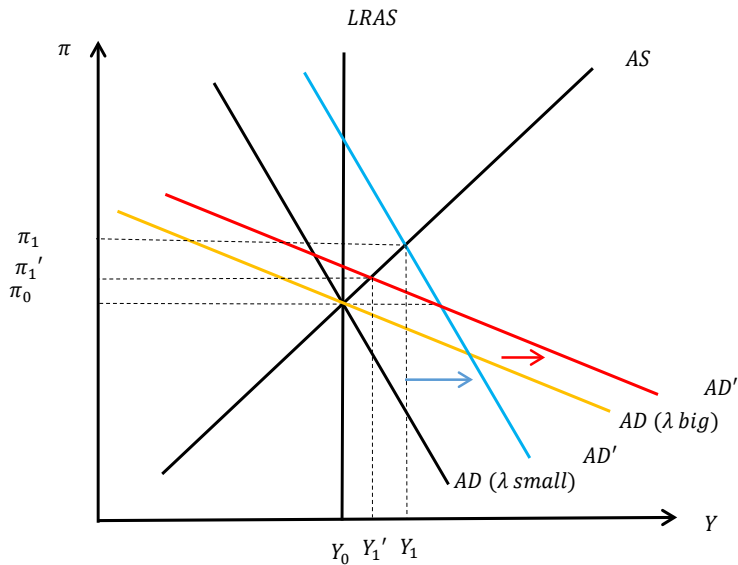
Governs how strongly policy reacts to inflation

$$\pi = -\frac{1 - mpc}{(d + x)\lambda} Y + \frac{1}{(d + x)\lambda} \bar{A} - \frac{1}{\lambda} \bar{r}$$

λ influences two things:

- ▶ Slope of AD curve (bigger λ and AD curve is flatter)
- ▶ Shift of AD curve conditional on IS shock, $\bar{A}$ (bigger λ and AD curve shifts up less; horizontal shift of AD curve unaffected by λ)

λ and the Effects of IS Shocks



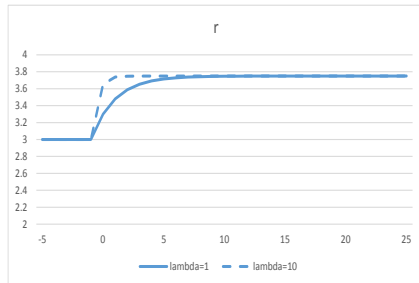
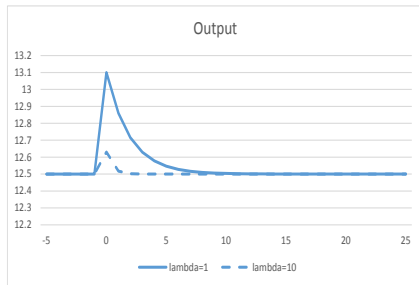
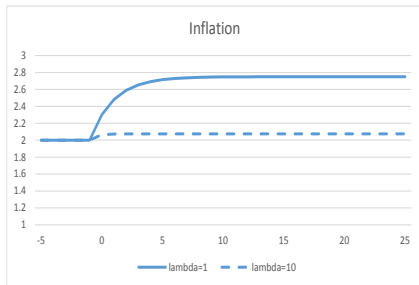
λ and IS Shocks

After an increase in $\bar{A}$, a bigger λ results in:

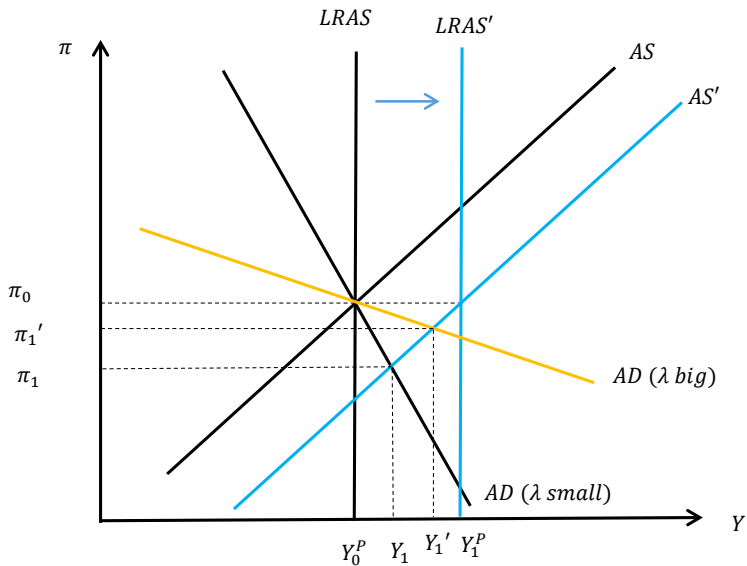
1. Smaller increase in π
2. Smaller increase in Y . Since Y^P doesn't change, this means that the gap, X , goes up by less

Bigger λ is a “win-win” from perspective of dual mandate conditional on IS shocks

IS Shock: $\lambda = 1$ vs. $\lambda = 10$



λ and the Effects of Y^P Shocks



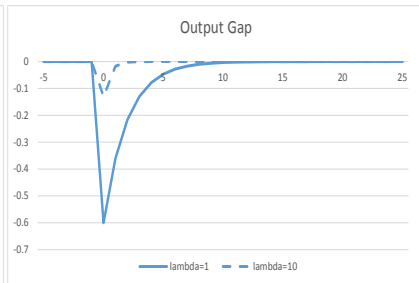
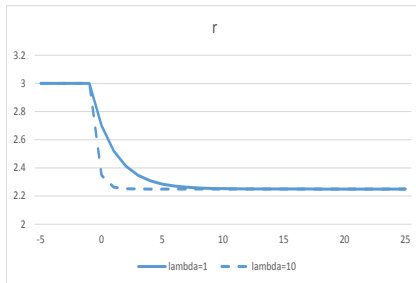
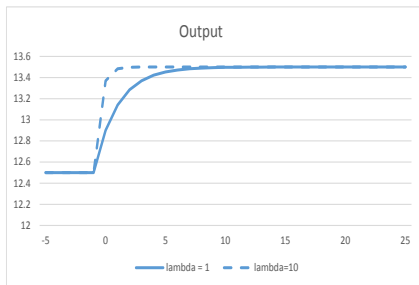
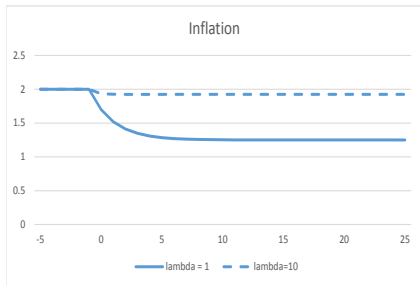
λ and Potential Output Shocks

After an increase in Y^P , a bigger λ results in:

1. Smaller increase in π
2. Bigger increase in Y . Since Y^P increases, this means that the gap, X , goes down by less the bigger is λ

Bigger λ is a “win-win” from perspective of dual mandate conditional on potential output shocks

γ^P Shock: $\lambda = 1$ vs. $\lambda = 10$



Divine Coincidence

Divine Coincidence: there is no tradeoff between objectives of monetary policy

Responding strongly to inflation both stabilizes inflation and the output gap

So named by **Blanchard and Gali (2007)**

Forms the basis of the call for “inflation targeting,” either implicitly or explicitly done by several leading central banks

Average Inflation Targeting

In August 2020, in conclusion of its comprehensive **review** of its tools and strategies, the Fed has adopted average inflation targeting

Basic idea of average inflation targeting: targets average inflation rate of, say, 2 percent, over a several-year window

- ▶ e.g., if inflation runs at 1 percent one year, the Fed targets 3 percent the next year

Basically a way for the Fed to promise future monetary stimulus (i.e. future low value of $\bar{r}$)

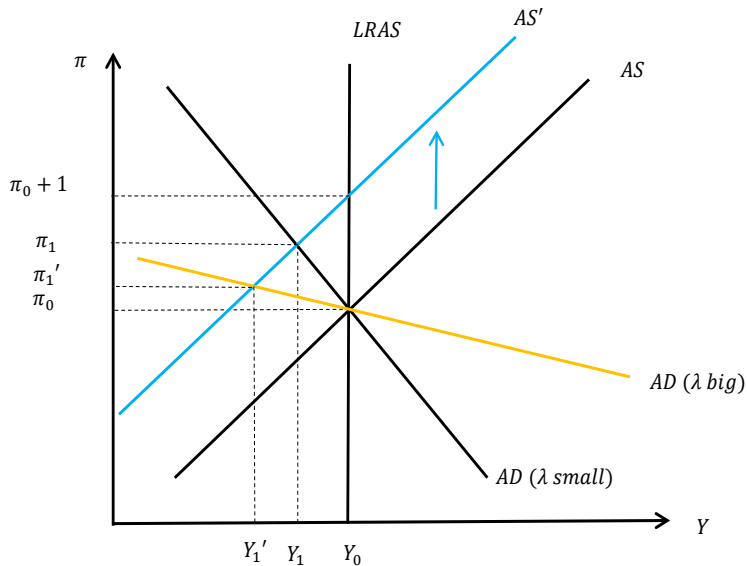
In current AD-AS model, which isn't forward-looking, not obvious why this would matter. But in forward-looking model, credible promise of future stimulus could lower long-term rates today, providing stimulus in present and helping to achieve inflation target in present (particularly relevant when ZLB binds)

Breakdown of Divine Coincidence

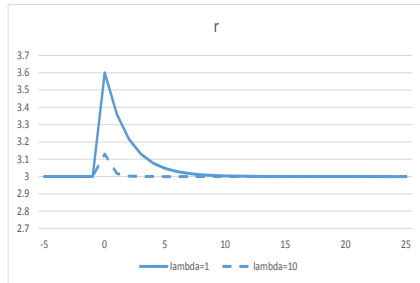
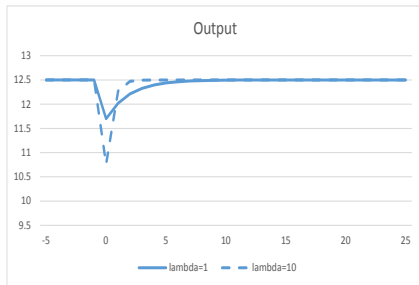
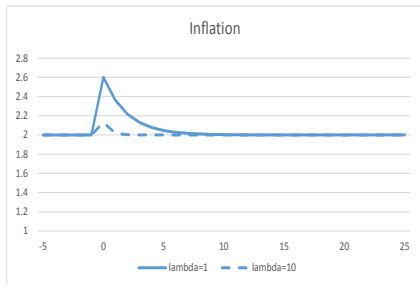
Divine coincidence does not hold conditional on inflation shocks (ρ)

- ▶ Sometimes called “inefficient supply shocks” (do not affect Y^p)
- ▶ Here, there is a tradeoff between the two aspects of the dual mandate

λ and the Effects of ρ Shocks



ρ Shock: $\lambda = 1$ vs. $\lambda = 10$



Inflation Shocks and the Inflation-Gap Tradeoff

Big λ : flat AD, little change in inflation, but big drop in output

Small λ : steep AD, little change in output, but big increase in inflation

Central bank faces a tradeoff: cannot simultaneously achieve stable inflation and stable output gap conditional on inflation shocks

Rules vs. Discretion

Lots of academic and public debate about rules vs. discretion

Rules: specify a rule (i.e., a value of λ) and stick with that

Discretion: have a rule (i.e., a value of λ), but deviate based on conditions via $\bar{r}$

In this model, can generate identical outcomes with “small” vs. “big” value of λ by adjusting $\bar{r}$ in response to shocks

Hence, there is no real benefit to an inflation-targeting rule (i.e., big λ) relative to using discretion

Gains from Commitment to a Rule

Two issues with model as laid out that eliminate gains from rule-based policy:

1. Central bank can perfectly observe shocks
2. There are no forward-looking elements

If one or both of these are different, there can be gains from committing to a rule relative to discretion

- ▶ Harder to make mistakes when you just react to inflation instead of shocks
- ▶ If agents are forward-looking, you get better anchored inflation expectations, which keeps the AS curve stable