Introductory Macroeconomics

Lecture 11: AD-AS model, part one

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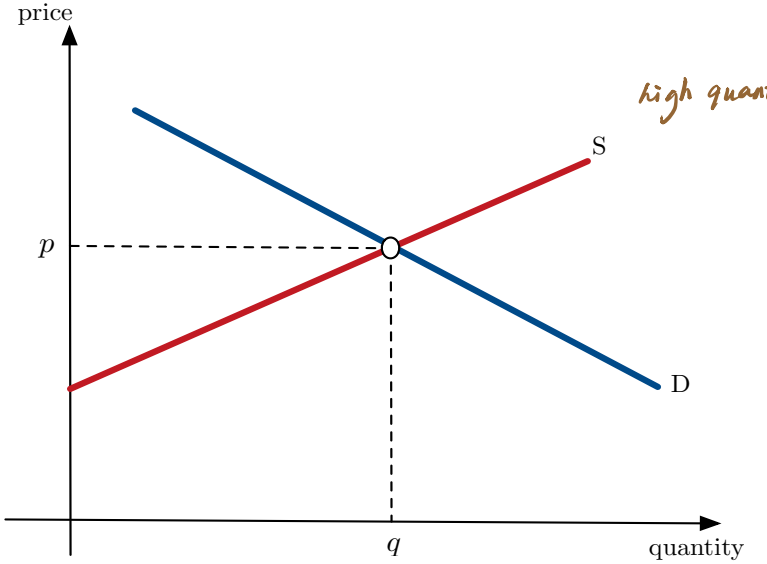
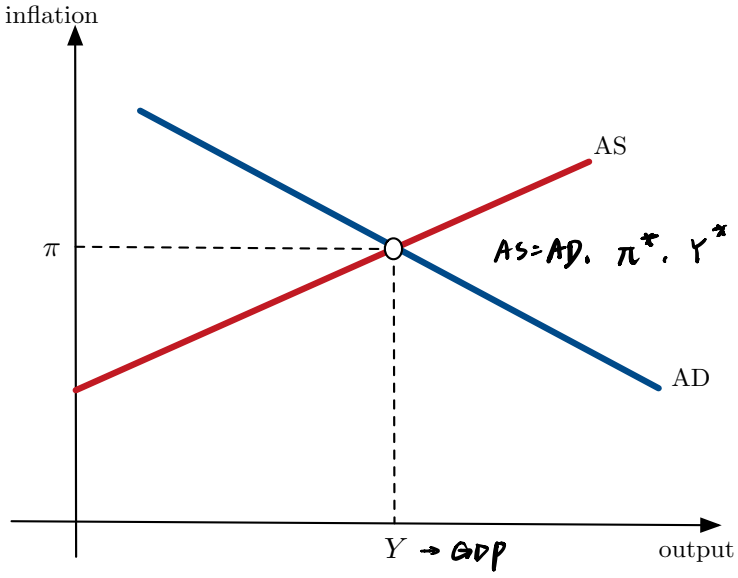
1st Semester 2021

A particular good



high quantity → high cost
↓
high price


inflation
AS
π
AS=AD. π^*. Y^*
AD
Y → GDP
output

This Lecture

- Building blocks of AD-AS model
  - **Aggregate Demand**
    - interest rates and aggregate output
    - monetary policy reaction function
  - **Aggregate Supply**
    - Phillips Curve and Okun's Law
    - inflation expectations
- BOFAH chapter 11

Overview of AD-AS Model

AD-AS Model

- Two endogenous variables, inflation π and real output Y

① • **AD curve:** *downward sloping* relationship between π and Y

  – position determined by monetary and fiscal policy, demand shocks

exogenous composition

② • **AS curve:** *upward sloping* relationship between π and Y

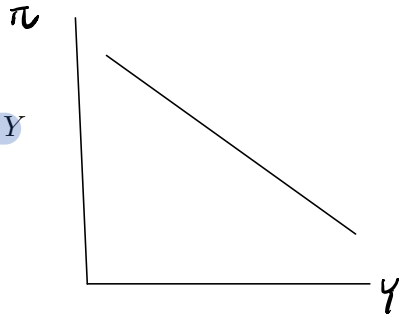
  – position determined by inflation expectation, supply shocks

- Intersection of two curves detemines equilibrium π and Y

① + ② = $\{\pi, r\}$

Aggregate Demand

Aggregate Demand



- **AD curve:** *downward sloping* relationship between π and Y
- Two components
  - **(i)** relationship between output Y and real interest rates r (from extended version of Keynesian model)
  - **(ii)** relationship between inflation π and real interest rates r (from *monetary policy reaction function*)
- Short version

(ii)

$\uparrow \pi \rightarrow \uparrow r \rightarrow \downarrow Y$

(i)

(i) + (ii) ⇒ AD

Reminder

- Recall Keynesian Model

$$Y = C + I + G \qquad \text{(AE=PAE)}$$

with

$$\begin{aligned} C &= \bar{C} + c(Y - \bar{T}) \\ I &= \bar{I} \\ G &= \bar{G} \end{aligned}$$

- Gives short-run equilibrium output

$$Y = \frac{1}{1-c}\left(\bar{C} - c\bar{T} + \bar{I} + \bar{G}\right)$$

- But *no role for interest rates at all*! Will now consider an extended Keynesian model that does have a role for interest rates.

Consumption and Real Interest Rate

- Extend consumption function to include real interest rate r

$$C = \underbrace{\bar{C} + c(Y - \bar{T})}_{\text{simple model}} \underbrace{- \gamma_C r}_{\text{"extended model"}}, \qquad \gamma_C > 0$$

- Higher real interest rate r reduces consumption and increase saving

- Parameter $\gamma_C > 0$ measures *interest-sensitivity* of consumption

Investment and Real Interest Rate

- Extend investment to include real interest rate r

$$I = \bar{I} - \gamma_I r, \qquad \gamma_I > 0$$

"extended"

- Higher real interest rate r reduces investment demand
- At higher interest rates, fewer investment projects are profitable
- Parameter $\gamma_I > 0$ measures *interest-sensitivity* of investment

Output and Real Interest Rate

- Putting this together gives first building block of aggregate demand

$$Y = A - \gamma r$$

where A denotes the exogenous components

$$A = \frac{1}{1-c}\left(\bar{C} - c\bar{T} + \bar{I} + \bar{G}\right) \Rightarrow \text{exogenous term}$$

and where γ is the interest sensitivity of output

$$\gamma = \frac{1}{1-c}(\gamma_C + \gamma_I)$$

- Output Y is *decreasing* in real interest rate r

Output and Real Interest Rate

- Write natural output Y^* in terms of natural real rate r^*

(1)
$$Y^* = A^* - \gamma r^*$$

$\bar{G}, \bar{I}, \bar{C}, \bar{T} \Rightarrow$ normal level

(2) $Y = A - \gamma r^*$ γ ↑ consistent with the normal level

- Can then write output gap

subtract (1) from (2)

$$Y - Y^* = -\gamma(r - r^*) + \varepsilon_D \tag{1}$$

where $\varepsilon_D = A - A^*$ represents *shocks to aggregate demand*

- Shocks to aggregate demand include fiscal policy shocks, investment demand shocks, consumer sentiment, etc

$\bar{T}, \bar{G}$. $\bar{I}$ $\bar{C}$

- Anything that shifts components of A away from long run levels A^*

Monetary Policy Reaction Function

- Stylized depiction of monetary policy

$$i = r^* + \pi + \alpha(\pi - \pi^*)$$

where

$$\begin{aligned} i &= \text{policy interest rate (nominal)} \\ r^* &= \text{natural real rate} \\ \pi^* &= \text{central bank inflation target} \end{aligned}$$

- Central bank increases interest rates in response to inflation
- Write this in terms of real rate $r = i - \pi$

$$r = r^* + \alpha(\pi - \pi^*) \tag{2}$$

$\alpha > 0$ sensitivity interest rate adjustment to movement in inflation

- When inflation at target, $\pi = \pi^*$, real rate $r = r^*$

$r > r^*$ when $\pi > \pi^*$
$r < r^*$ when $\pi < \pi^*$

AD Curve

monetary policy ↑ Keynesian model ↗

- Plug (2) into (1) to get AD curve

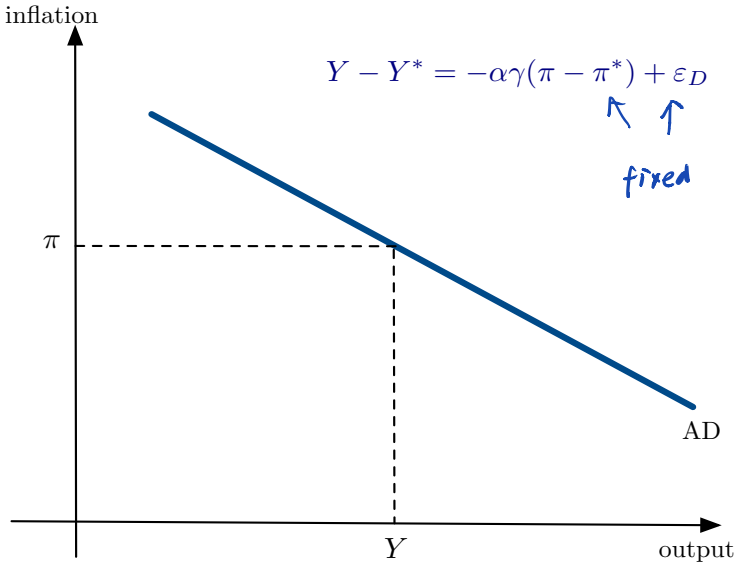
$$Y - Y^* = -\alpha\gamma(\pi - \pi^*) + \varepsilon_D \qquad \text{(AD)}$$

policy ↑

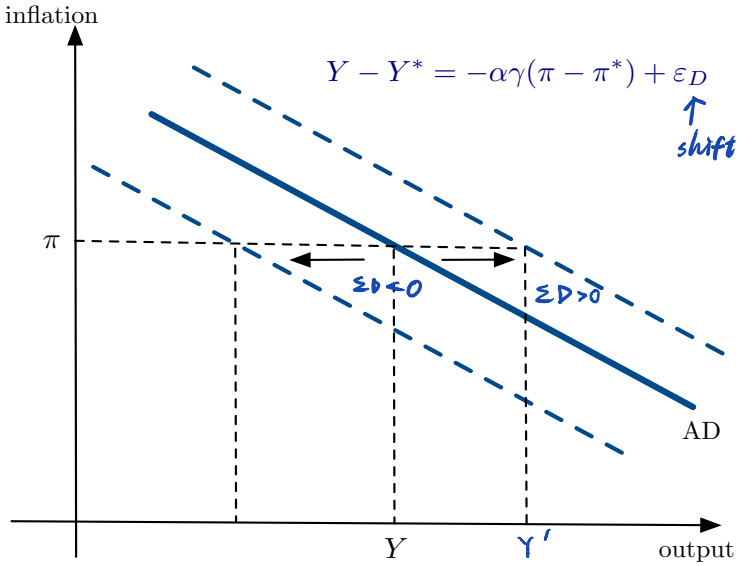
- Downward sloping relationship between π and Y, slope $\alpha\gamma$ ↑ interest sensitivity of demand; $\frac{\partial Y}{\partial \pi} = -\partial\gamma\alpha$

- Absent shocks, $\varepsilon_D = 0$, output at natural level $Y = Y^*$ when inflation at target $\pi = \pi^*$

AD Curve


inflation
$Y - Y^* = -\alpha\gamma(\pi - \pi^*) + \varepsilon_D$
fixed
π
AD
Y
output

Shocks to AD Curve



Aggregate Supply

Aggregate Supply

- **AS curve:** *upward sloping* relationship between π and Y holding inflation expectations fixed

- Two components

  (i) relationship between unemployment u and inflation π (from Phillips Curve, natural rate hypothesis) $u \to \pi$

  (ii) relationship between unemployment u and real output Y (from Okun's Law) $Y \to u$

- **Short run version**, holding inflation expectations fixed

$$\uparrow \; Y \quad \to \quad \downarrow \; u \quad \to \quad \uparrow \; \pi$$

Phillips Curve

Okun's Law

(i)+(ii) $\pi \to Y$

Phillips Curve

- Short run tradeoff between inflation and unemployment

$$\pi = \pi^e - \phi(u - u^*) + \varepsilon_S \qquad \text{(PC)}$$

where

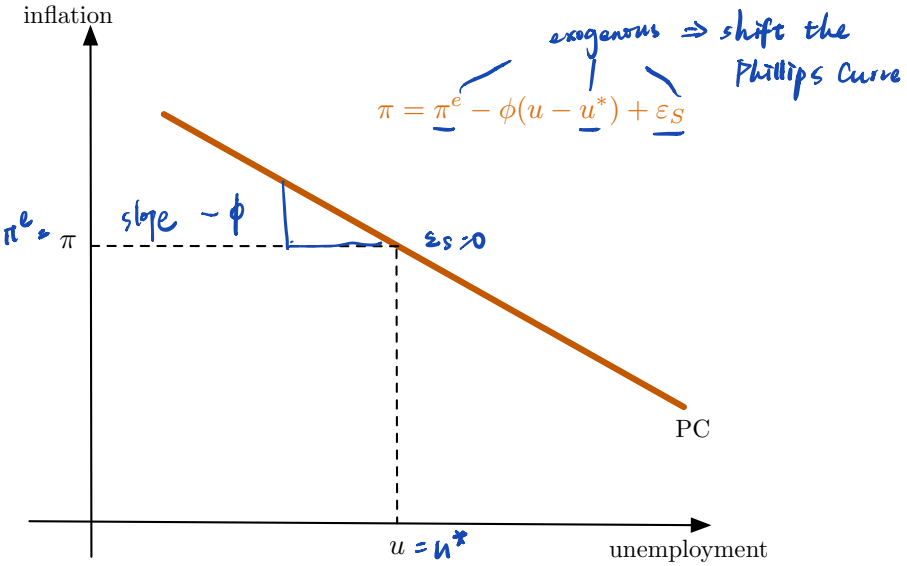
π^e = inflation expectations (taken as exogenous for now)

ε_S = supply shocks

- Holding inflation expectations fixed, a decrease in unemployment u increases inflation π

- As labour market gets tighter, wages rise, business costs rise, and hence prices rise

Phillips Curve



Natural Rate Hypothesis

- In long run $\pi^e = \pi$ and $\varepsilon_S = 0$

- Long run Phillips' Curve is then

$$\pi = \pi - \phi(u - u^*) \qquad \varepsilon_S = 0$$

$\uparrow$

$\pi^e = \pi$

- Long run unemployment $u = u^*$

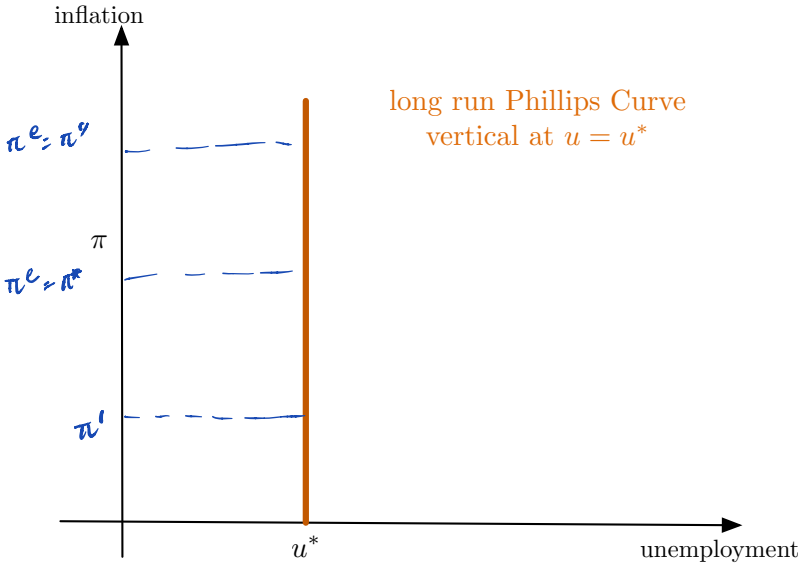
- Long run inflation indeterminate

don't know which π obtain $u = u^*$

we can have any π

- No long run tradeoff between inflation and unemployment

Natural Rate Hypothesis



Okun's Law

- Inverse relationship between *output gap* and *cyclical unemployment*
- Write this

$$u - u^* \;=\; -\beta(Y - Y^*) \qquad \text{(OL)}$$

- Unemployment $u = u^*$ when output $Y = Y^*$

AS Curve

- Plugging OL into PC gives

$$\pi = \pi^e + \phi\beta(Y - Y^*) + \varepsilon_S \qquad \text{(AS)}$$

short-run AS curve SRAS

- Upward sloping relationship between Y and π, slope $\phi\beta$

ϕ: from PC

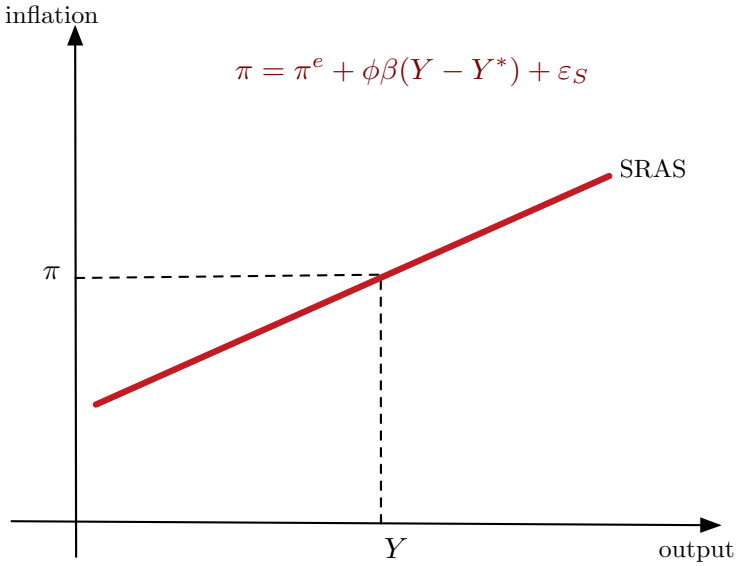
β: from OL

- More properly, this is the Short Run AS (SRAS) curve, takes inflation expectations as exogenous

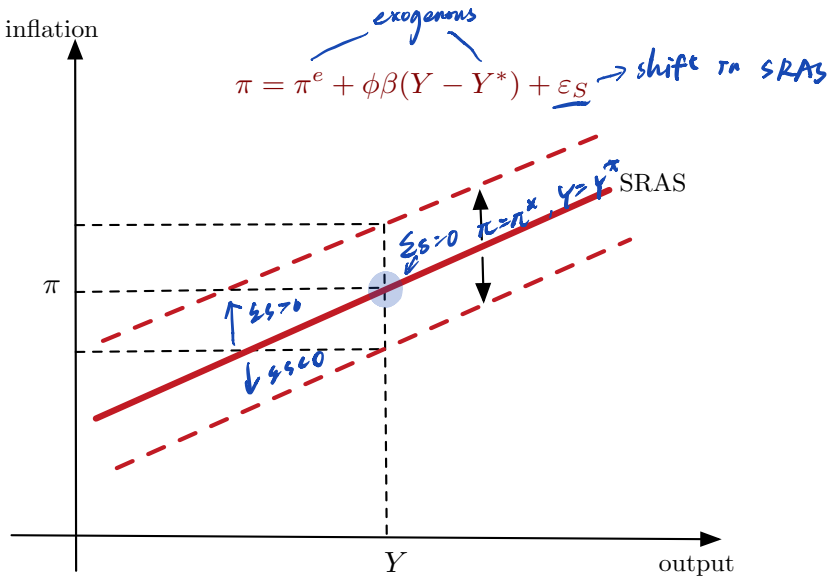
- Long Run AS (LRAS) curve when $\pi = \pi^e$ and $\varepsilon_S = 0$

- LRAS curve is vertical at $Y = Y^*$

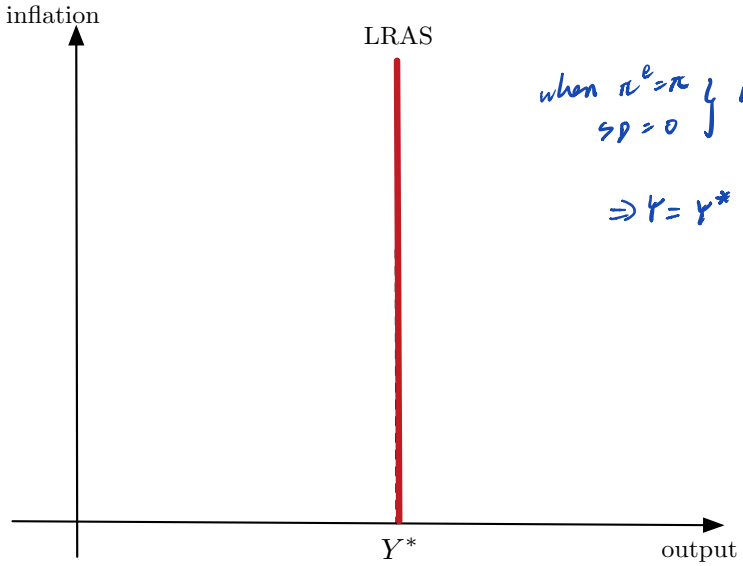
SRAS Curve



SRAS Curve


inflation
exogenous
$\pi = \pi^e + \phi\beta(Y - Y^*) + \varepsilon_S$
→ shift in SRAS
SRAS
$\varepsilon_S = 0$
$\pi = \pi^e$, $Y = Y^*$
π
$\varepsilon_S > 0$
$\varepsilon_S < 0$
Y
output

LRAS Curve



when $\pi^e = \pi$ } long run
$\varepsilon p = 0$

$\Rightarrow Y = Y^*$

Long Run Equilibrium

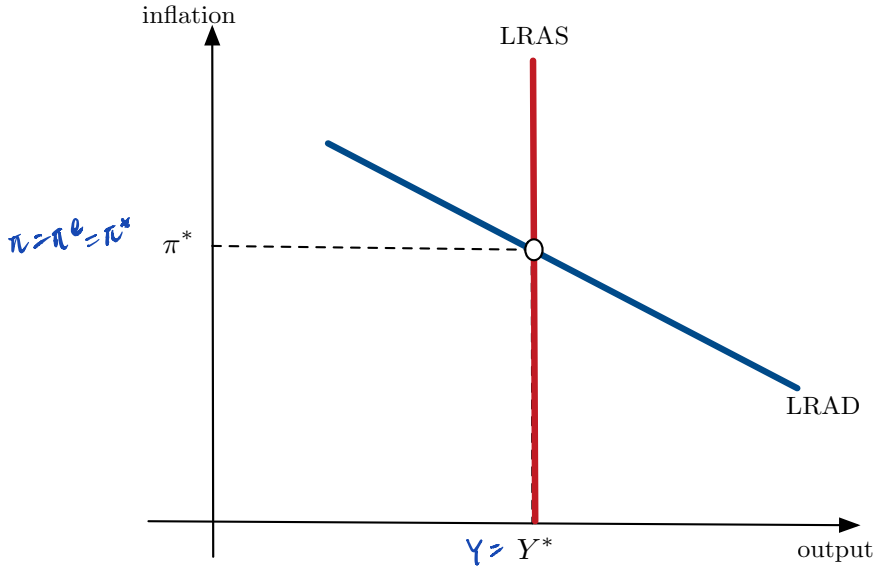
- Long run equilibrium where
  - demand and supply shocks equal zero $\varepsilon_D = \varepsilon_S = 0$
  - inflation expectations consistent $\pi^e = \pi$
- AD-AS equations in the long run

$$Y - Y^* = -\alpha\gamma(\pi - \pi^*) + 0 \qquad \text{(LRAD)}$$

$$\pi = \pi + \phi\beta(Y - Y^*) + 0 \qquad \text{(LRAS)}$$

- Solves for $Y = Y^*$ and hence $\pi = \pi^*$.

Long Run Equilibrium



Short Run Equilibrium

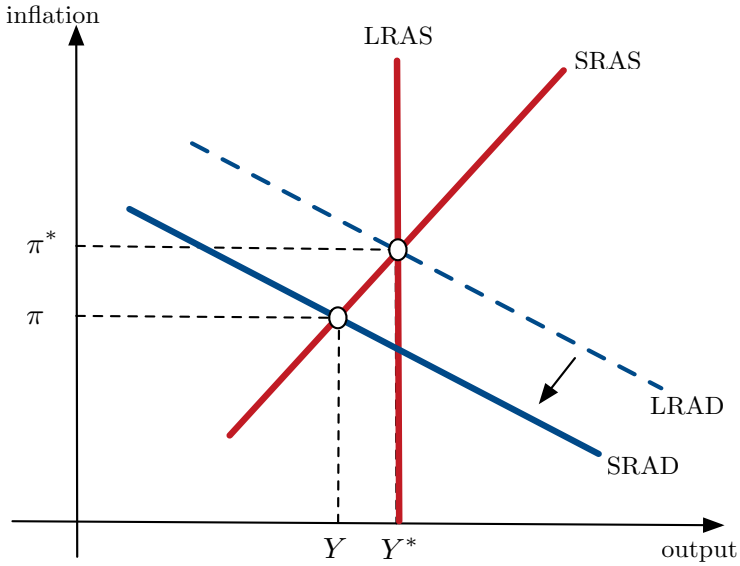
- Short run equilibrium where
  - demand and supply shocks $\varepsilon_D, \varepsilon_S$
  - inflation expectations π^e treated as exogenous
- AD-AS equations in the short run

$$Y - Y^* = -\alpha\gamma(\pi - \pi^*) + \varepsilon_D \qquad \text{(SRAD)}$$

$$\pi = \pi^e + \phi\beta(Y - Y^*) + \varepsilon_S \qquad \text{(SRAS)}$$

- Solves for Y and π in terms of exogenous $\pi^e, \varepsilon_D, \varepsilon_S$ and parameters

Example: Negative AD Shock



Next Lecture

- Working with the AD-AS model
  - shocks to AD, shocks to AS
  - LR and SR tradeoffs
- BOFAH chapter 11