



# Business Cycles Econ 402 Professor Yamin Ahmad

## Lecture 4: The AD/AS Model

- Aggregate Demand
- Labor Market
- Short Run Aggregate Supply



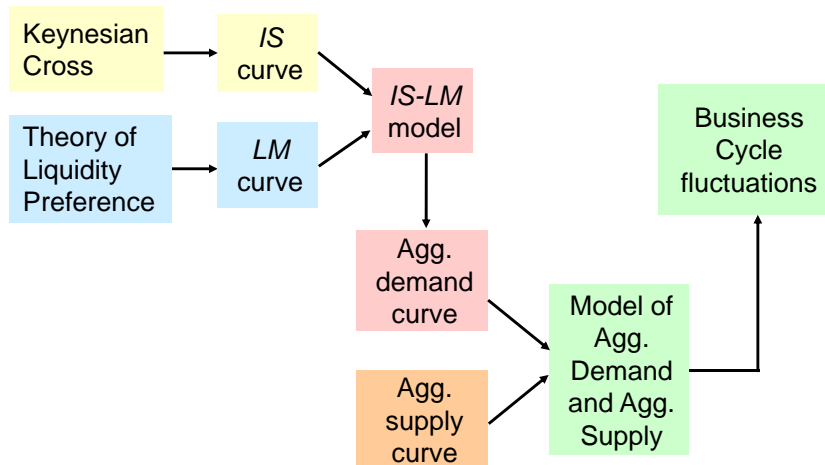
## Big Concepts in this lecture...

- Deriving the AD curve
- The Labor Market
- Models of supply in the short run
  - Sticky Wage model
  - Workers Misperceptions model
  - Imperfect Information model
  - Sticky Price model

Note: These lecture notes are incomplete without having attended lectures



## The Big Picture



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## IS-LM and Aggregate Demand

- So far, we've been using the *IS-LM* model to analyze the short run, when the price level is assumed fixed.
- However, a change in  $P$  would shift *LM* and therefore affect  $Y$ .
- The **Aggregate Demand curve** (introduced in *Lecture 1*) captures this relationship between  $P$  and  $Y$ .

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## Aggregate Demand

- The Keynesian Transmission Mechanism links prices to output and can be described as follows:
- $P \uparrow \Rightarrow M/P \downarrow \Rightarrow LM \uparrow \Rightarrow r \uparrow \Rightarrow I \downarrow \Rightarrow Y \downarrow$   
(Keynes Effect)
- The factors that shift the IS and LM curves (with the exception of prices) leads to a shift of the AD curve, and can be calculated via the usual multiplier approach.
- A change in the price level leads to a change in output via the mechanism described above.

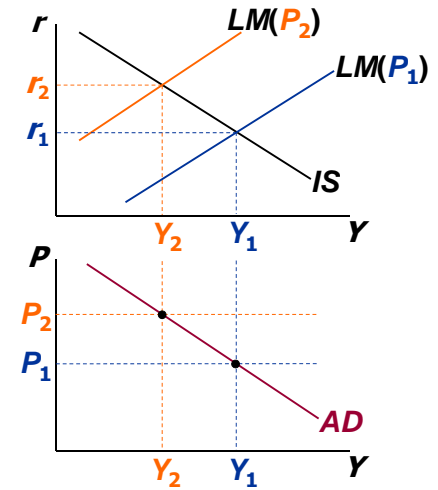
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## Deriving the AD curve

Intuition for slope of AD curve:

- $\uparrow P \Rightarrow \downarrow (M/P)$
- $\Rightarrow LM$  shifts left
- $\Rightarrow \uparrow r$
- $\Rightarrow \downarrow I$
- $\Rightarrow \downarrow Y$



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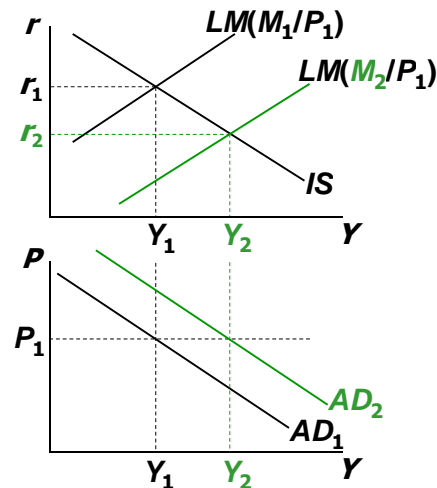


## Monetary policy and the AD curve

The Fed can increase aggregate demand:

$\uparrow M \Rightarrow LM$  shifts right

- $\Rightarrow \downarrow r$
- $\Rightarrow \uparrow I$
- $\Rightarrow \uparrow Y$  at each value of  $P$



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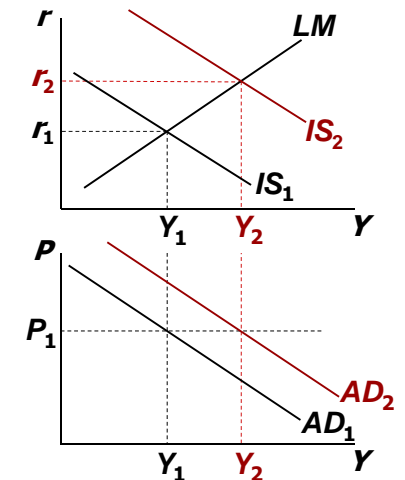


## Fiscal policy and the AD curve

Expansionary fiscal policy ( $\uparrow G$  and/or  $\downarrow T$ ) increases Agg. demand:

$\downarrow T \Rightarrow \uparrow C$

- $\Rightarrow IS$  shifts right
- $\Rightarrow \uparrow Y$  at each value of  $P$



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## IS-LM and AD-AS in the short run & long run

Recall from Lecture 1: The force that moves the economy from the short run to the long run is the gradual adjustment of prices.

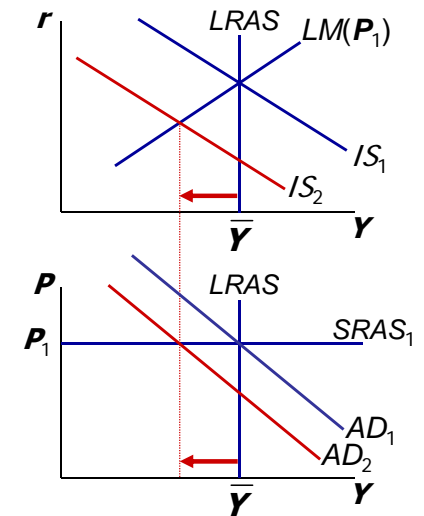
In the short-run equilibrium, if	then over time, the price level will
$Y > \bar{Y}$	rise
$Y < \bar{Y}$	fall
$Y = \bar{Y}$	remain constant

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## The SR and LR effects of an IS shock

A negative IS shock shifts IS and AD left, causing  $Y$  to fall.

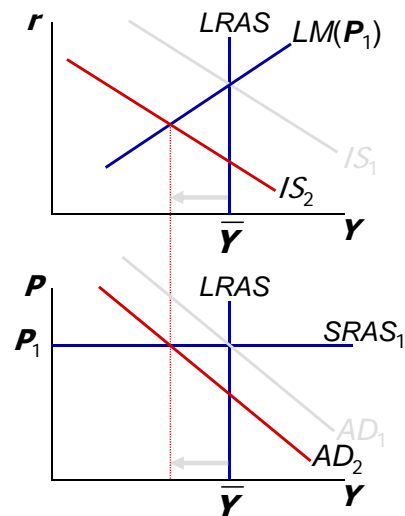


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## The SR and LR effects of an IS shock

In the new short-run equilibrium,  $Y < \bar{Y}$



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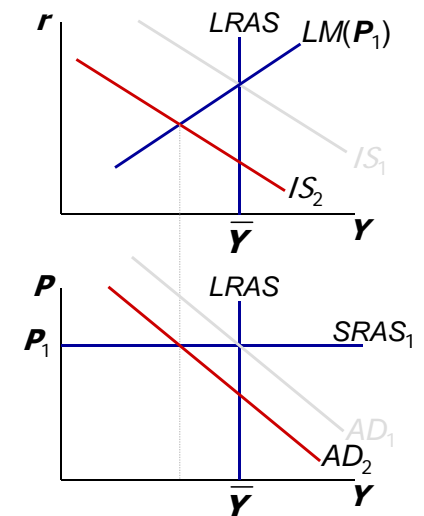


## The SR and LR effects of an IS shock

In the new short-run equilibrium,  $Y < \bar{Y}$

Over time,  $P$  gradually falls, which causes

- SRAS to move down.
- $M/P$  to increase, which causes LM to move down.



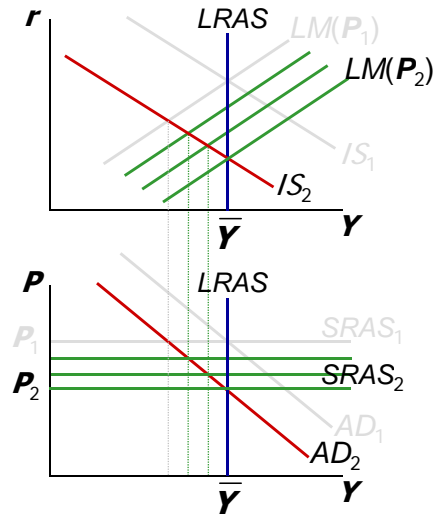
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### The SR and LR effects of an IS shock

Over time,  $P$  gradually falls, which causes

- $SRAS$  to move down.
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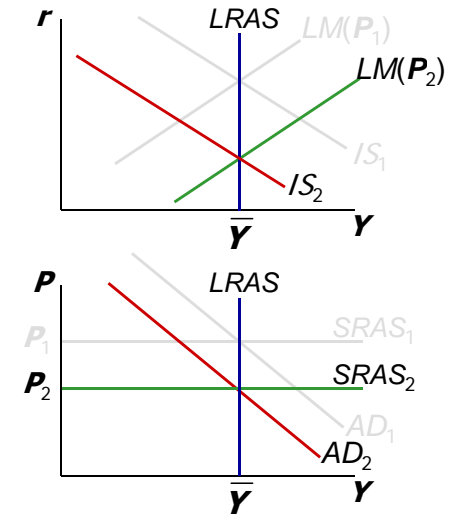


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### The SR and LR effects of an IS shock

This process continues until economy reaches a long-run equilibrium with  $Y = \bar{Y}$

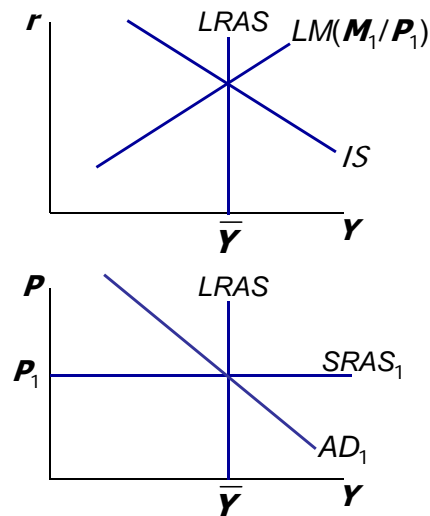


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### EXERCISE: Analyze SR & LR effects of $\Delta M$

- Draw the  $IS-LM$  and  $AD-AS$  diagrams as shown here.
- Suppose Fed increases  $M$ . Show the short-run effects on your graphs.
- Show what happens in the transition from the short run to the long run.
- How do the new long-run equilibrium values of the endogenous variables compare to their initial values?



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### Next Step... Thinking About Supply

- Production Decisions
  - Long Run
  - Short Run
- Understanding the Labor Market

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## Production Decisions

- Regardless of the long run or the short run, firms want to maximize profits
  - Profits: Revenue – Costs
  - Chooses labor and capital
  
- Short Run:
  - Certain factors of production are fixed, e.g.  $\bar{K}, \bar{Z}$
  - Wages and/or prices may be fixed
  
- Long Run:
  - All factors of production are flexible
  - Wages and prices are flexible

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## Focus: The Labor Market

### Labor Demand

- Competitive Firms maximize profits
 
$$= PF(L; \bar{K}) - WL$$

$$\Rightarrow PF_L(L^d; \bar{K}) = W$$

$$\Rightarrow L^d = L^d\left(\frac{W}{P}; \bar{K}\right)$$

(-) (+)

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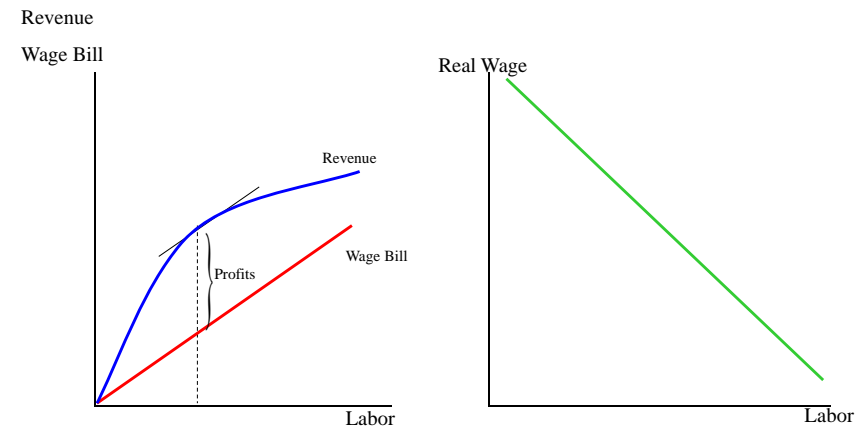
## Example: Deriving labor demand

- Suppose that  $Y = F(\bar{K}, L, \bar{Z}) = ZK^{\frac{1}{3}}L^{\frac{2}{3}}$  where  $Z=1$
  
- Profit maximization involves:  $\max_L PF(\bar{K}, L) - WL$
  
- First order condition (FOC) is:

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## Labor Demand



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## Labor Supply

### Household Problem

- Choice for households is to allocate time between labor and leisure:  $\max_{C,L} U(C, L)$
- Worker derives utility from leisure
- However, disutility of labor yields a wage that the worker can use to purchase goods and services
  - Thus labor supply is positively related to the real wage:

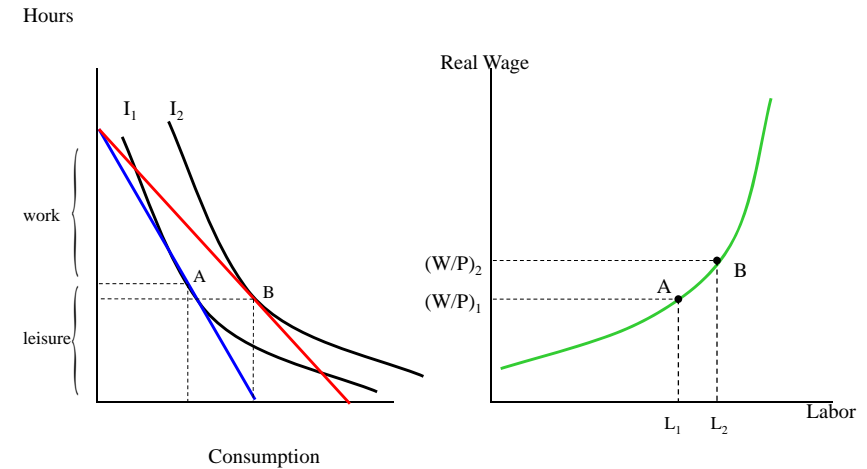
$$L^S = L \left( \frac{W}{P} \right)^{(+)}$$

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## Competitive Labor Supply



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## Example: Labor – Leisure Tradeoff

Suppose that households maximize:

$$\begin{aligned} \max_{C_t, L_t} U(C_t, N_t) &= C_t + N_t - \frac{1}{2} N_t^2 \\ \text{st } P_t C_t &= W_t L_t \quad (\text{Budget constraint}) \\ \text{and } N_t + L_t &= 1 \quad (\text{Time constraint}) \end{aligned}$$

where  $C_t$  is consumption,  $L_t$  is labor hours,  $N_t$  is leisure hours

- Write out the first order conditions and solve for the labor – Leisure Tradeoff.

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## Example: Labor – Leisure Tradeoff

Solution: Set the problem up as a constrained maximization problem:

- Lagrangean for the problem is:
- First order conditions are:

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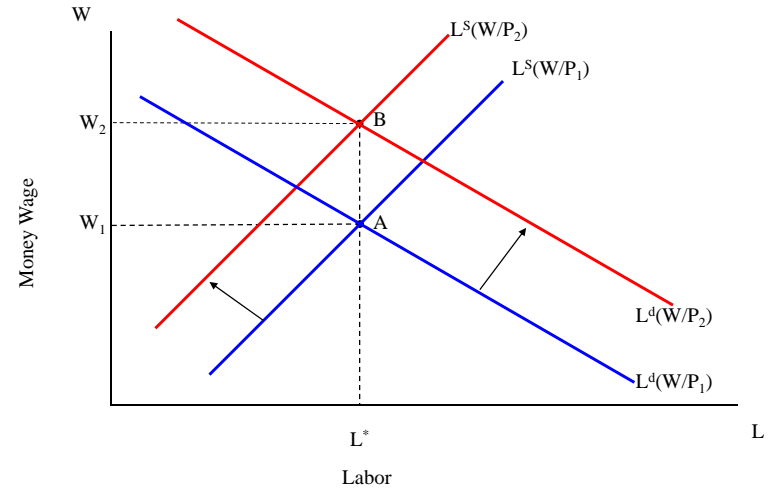
## Labor Market Clearing

- In equilibrium,  $L^s = L^d = L^*$
- Continuing our example, we can see that  $L^* = f(\bar{K})$ , i.e.  $L^* =$
- Long run (classical) output, is thus determined as:
 
$$Y = F(\bar{K}, L^*) = K^{\frac{1}{3}}L^{*\frac{2}{3}}$$
- Note that output is independent of prices in the long run.

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## Classical Supply/ Flexible Wages and Prices



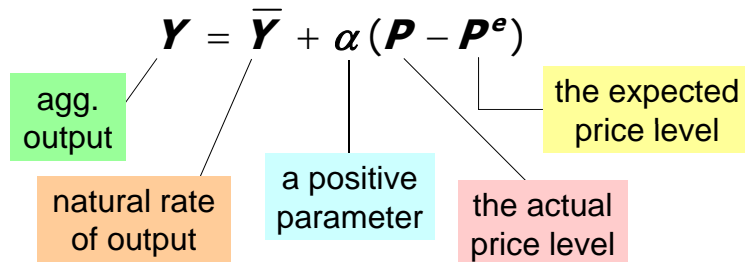
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## Models of Aggregate Supply

1. The Sticky-Wage model (Traditional Keynesian)
2. Worker Misperceptions model (Friedman, Phelps)
3. The Imperfect-Information model (Lucas)
4. The Sticky-Price model (“New Keynesian”, “New Neoclassical”)

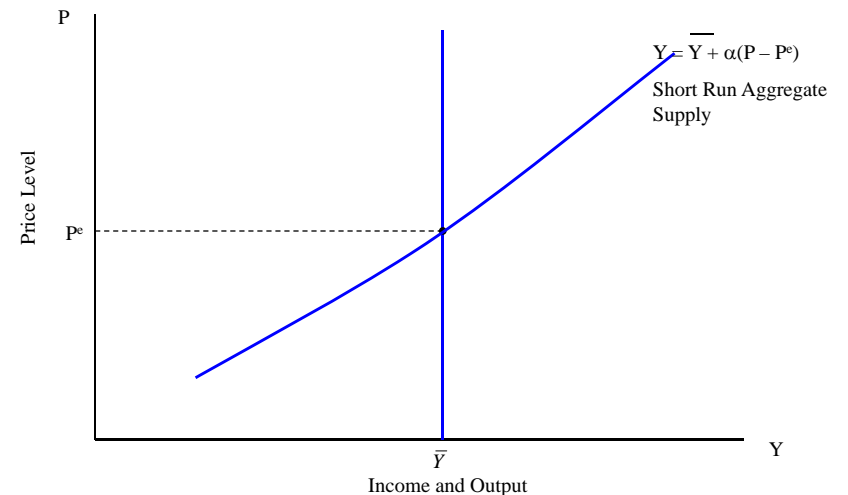
All these models imply:



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## The Short Run Aggregate Supply Curve



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## The Sticky-Wage model

- Assumes that firms and workers negotiate contracts and fix the nominal wage before they know what the price level will turn out to be.
- The nominal wage they set is the product of a target real wage and the expected price level:

$$W = \omega \times P^e$$

Target real wage

$$\Rightarrow \frac{W}{P} = \omega \times \frac{P^e}{P}$$

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## The Sticky-Wage model

$$\frac{W}{P} = \omega \times \frac{P^e}{P}$$

If it turns out that

then

$$P = P^e$$

Unemployment and output are at their natural rates.

$$P > P^e$$

Real wage is less than its target, so firms hire more workers and output rises above its natural rate.

$$P < P^e$$

Real wage exceeds its target, so firms hire fewer workers and output falls below its natural rate.

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## The Sticky-Wage model

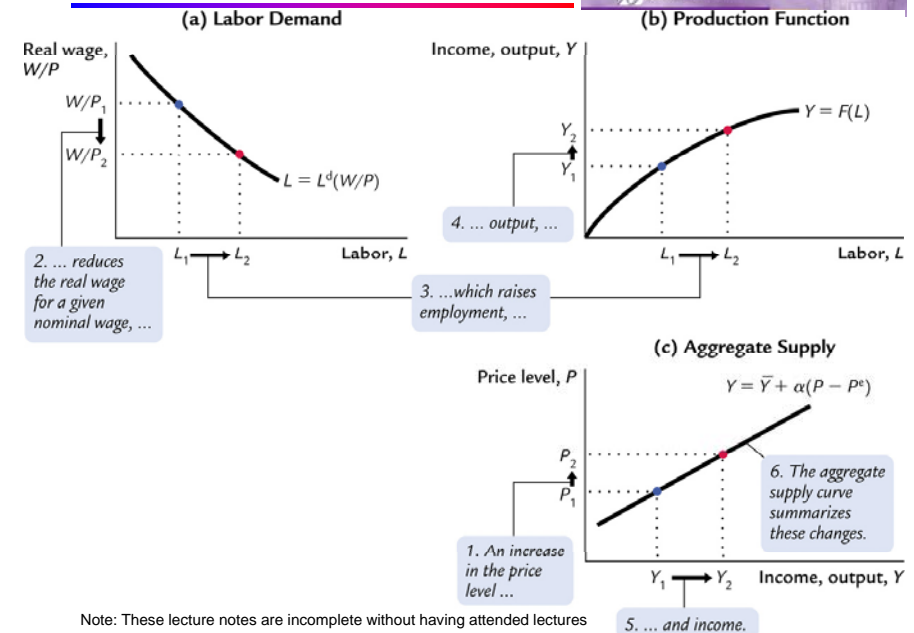
- Labor Demand:  $L^d = L^d(W/P; \bar{K})$   
(-) (+)
- Labor Supply/ Wage Setting:  $L^S = L^S(W/P)$   
(+)
- Negotiation costs  $\Rightarrow$  money wage set infrequently. Let  $\omega$  be expected equilibrium real wage. Then money (or nominal) wage set so that  $\bar{W} = \omega P^e$ .

$$L = L^d(W/P; \bar{K}) = L^d(\omega P^e/P; \bar{K})$$

$$\Rightarrow Y^S = F(L^d; \bar{K}) = Y^S(P/P^e; \bar{K})$$

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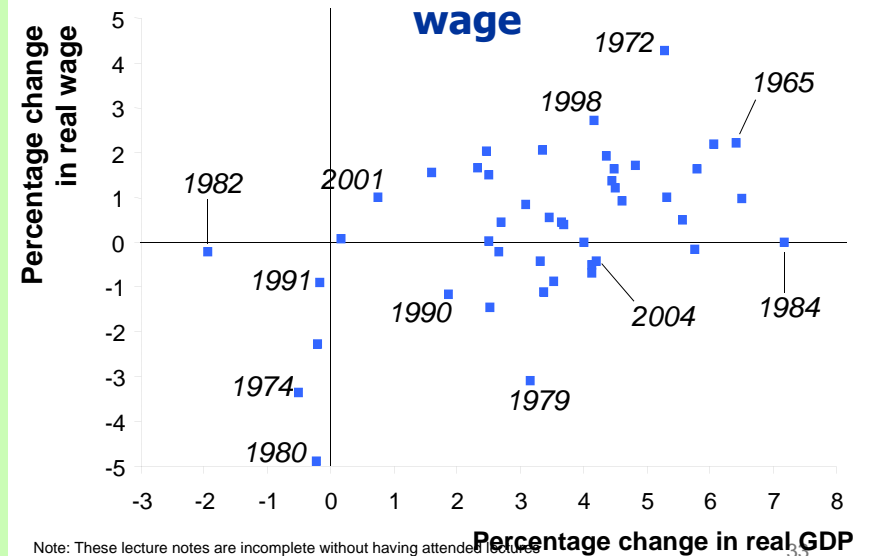
## The Sticky-Wage model

- Implies that the real wage should be **counter-cyclical**, should move in the opposite direction as output during business cycles:
  - In booms, when  $P$  typically rises, real wage should fall.
  - In recessions, when  $P$  typically falls, real wage should rise.
- This prediction does not come true in the real world:

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## The cyclical behavior of the real wage



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## Sticky Wage Model

- For more details on the sticky wage model, see article by:
- Jo Anna Gray, 1976, "Wage Indexation: A Macroeconomic Approach", *Journal of Monetary Economics*, 2:2, pp. 221-235

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## Worker Misperceptions Model

- Similar to sticky wage model but:
  - money wage **flexible** (market clearing);
  - workers have incomplete information about general price level  $\Rightarrow L = L^S(W/P^e)$
- Labor Market Equilibrium  $\Rightarrow L^S = L^d = L$ , so:

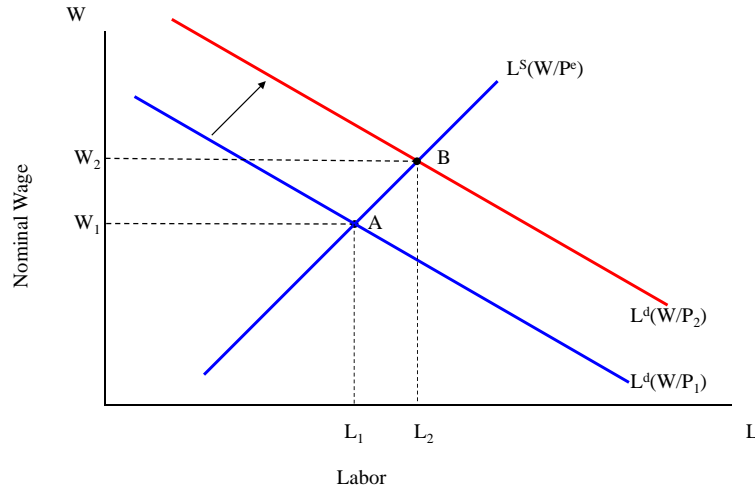
$$L = L^S[(W/P)(P/P^e)] = L^S[F_L(L,K)(P/P^e)]$$

$$\Rightarrow L = f \underset{(+)}{(P/P^e)}; \underset{(+)}{K} \Rightarrow Y^S = F(L;K) = Y^S \underset{(+)}{(P/P^e)}; \underset{(+)}{K}$$

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## Worker Misperceptions Model



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## The Imperfect-Information model

### Assumptions

- All wages and prices are perfectly flexible, all markets are clear.
- Each supplier produces one good, consumes many goods.
- Each supplier knows the nominal price of the good she produces, but does not know the overall price level.
- Supplier does not know price level at the time she makes her production decision, so uses the expected price level,  $P^e$ .

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## The Imperfect-Information model

- Similar to worker misperception model, but people use local market conditions to make inferences about aggregate prices.
- General Price Level:  $P = P^e + u$  (u random)
- Local Price Level :  $P_i = P + v_i$  ( $v_i$  random)
- Worker-firm pair :  $Y_i^S = \bar{Y}^S + \alpha(P_i - P_+^e)$   
where  $P_+^e \equiv$  best guess of P given  $P^e$  and  $P_i$ .

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## The Imperfect-Information model

- Using a result from statistics, suppose that this best guess is a weighted average of the local price level and agent's expectations of the aggregate price level:  
 $P_+^e = \theta P^e + (1 - \theta)P_i$   
where  $\theta \equiv \text{Var}(v_i) / (\text{Var}(v_i) + \text{Var}(u))$
- Hence:  $Y_i^S = Y^S + \alpha\theta(P_i - P^e)$
- In aggregate:  $Y^S = Y^S + \alpha\theta(P - P^e)$

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## The Imperfect-Information model

- Suppose  $P$  rises but  $P^e$  does not.
  - Supplier thinks her relative price has risen, so she produces more.
  - With many producers thinking this way,  $Y$  will rise whenever  $P$  rises above  $P^e$ .
  
- So slope of Aggregate Supply curve also depends on the informativeness of the price mechanism. If aggregate demand is very variable, e.g. because of erratic policy, the AS will be very steep because  $\theta$  is small.

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## The Imperfect-Information model

### Further Reading:

- Milton Friedman 1968, “The Role of Monetary Policy”, *American Economic Review*, 58, (March), pp 1 – 17
  
- Robert E Lucas Jr. 1977, “Understanding Business Cycles”, *Stabilization of the Domestic Economy*, vol. 5 of Carnegie-Rochester Conference of Public Policy (Amsterdam: North-Holland), pp. 7 – 29.

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## The Sticky-Price model

- Like the Sticky Wage Model, but now **prices** are pre-set.
  
- Firm side:-
  - Monopolistic Competition: produce differentiated products
  - Fraction of firms can reset their prices (Calvo, Taylor)
  - Firms set price as a markup over marginal cost
  - All goods ‘bundled’ into one product through an ‘Aggregator’
  
- Consumer side:-
  - Consumers purchase units of ‘bundled’ goods
  - Maximize utility

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## The Sticky-Price model

- **Reasons for sticky prices:**
  - long-term contracts between firms and customers
  - menu costs
  - firms not wishing to annoy customers with frequent price changes
  
- **Key Assumptions:**
  - Firms set their own prices as a markup over marginal costs (e.g., as with monopolies).
  - Only a fraction of firms can reoptimize their price

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## The Sticky-Price model

- An individual firm's desired price is

$$p = P + a(Y - \bar{Y})$$

where  $a > 0$ .

Suppose two types of firms:

- firms with flexible prices, set prices as above
- firms with sticky prices, must set their price before they know how  $P$  and  $Y$  will turn out:

$$p = P^e + a(Y^e - \bar{Y}^e)$$

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## The Sticky-Price model

$$p = P^e + a(Y^e - \bar{Y}^e)$$

- Assume sticky price firms expect that output will equal its natural rate. Then,

$$p = P^e$$

- To derive the aggregate supply curve, we first find an expression for the overall price level.
- Let  $s$  denote the fraction of firms with sticky prices. Then, we can write the overall price level as...

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## The Sticky-Price model

$$P = sP^e + (1-s)[P + a(Y - \bar{Y})]$$

price set by sticky price firms

price set by flexible price firms

- Subtract  $(1-s)P$  from both sides:

$$sP = sP^e + (1-s)[a(Y - \bar{Y})]$$

- Divide both sides by  $s$ :

$$P = P^e + \left[ \frac{(1-s)a}{s} \right] (Y - \bar{Y})$$

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## The Sticky-Price model

$$P = P^e + \left[ \frac{(1-s)a}{s} \right] (Y - \bar{Y})$$

- High  $P^e \Rightarrow$  High  $P$   
If firms expect high prices, then firms that must set prices in advance will set them high. Other firms respond by setting high prices.
- High  $Y \Rightarrow$  High  $P$   
When income is high, the demand for goods is high. Firms with flexible prices set high prices. The greater the fraction of flexible price firms, the smaller is  $s$  and the bigger is the effect of  $\Delta Y$  on  $P$ .

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## The Sticky-Price model

$$P = P^e + \left[ \frac{(1-s)a}{s} \right] (Y - \bar{Y})$$

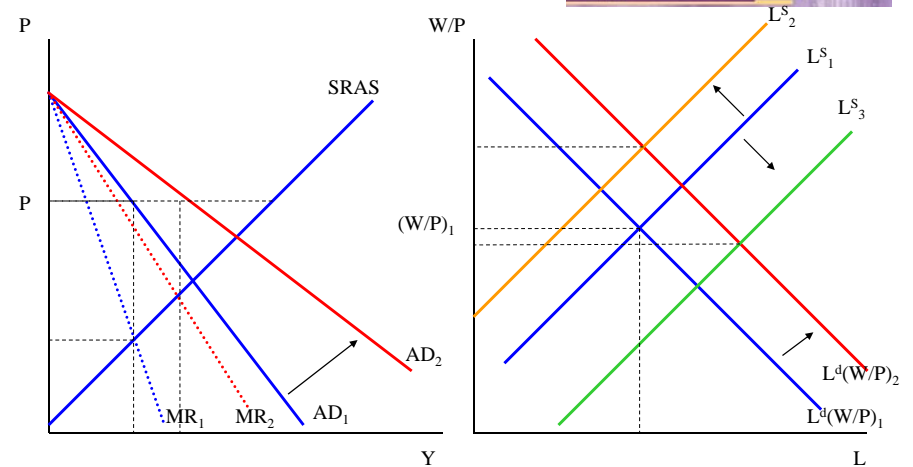
- Finally, derive AS equation by solving for  $Y$ :

$$Y = \bar{Y} + \alpha (P - P^e),$$

where  $\alpha = \frac{s}{(1-s)a}$

- Note: Slope of Aggregate Supply curve now depends on fraction of firms with pre-set prices.

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- If **substitution effect dominates**, labor supply shifts  $L^{S_1}$  to  $L^{S_2}$
- If **income effect dominates**, labor supply shifts  $L^{S_1}$  to  $L^{S_3}$

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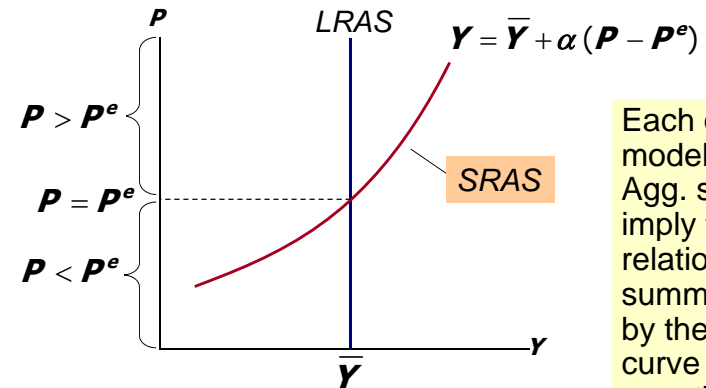
## The Sticky-Price model

Further Reading:

- Blanchard, Olivier J., and Nobuhiro Kiyotaki (1983): "Monopolistic Competition and the Effects of Aggregate Demand," *American Economic Review* 77: 647-666.
- Julio Rotemberg, 1982, "Monopolistic Price Adjustment and Aggregate Output", *Review of Economic Studies*, 49:4, pp. 517 - 531
- Laurence Ball, N. Gregory Mankiw, and David Romer (1988), "The New-Keynesian Economics and the Output-Inflation Tradeoff", *Brookings Papers on Economic Activity*, 1, pp. 1 – 65.
- David Romer (1993), 'The New Keynesian Synthesis,' *Journal of Economic Perspectives*, 7:1, 5-22.

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## Summary & Implications



Each of the models of Agg. supply imply the relationship summarized by the SRAS curve & equation.

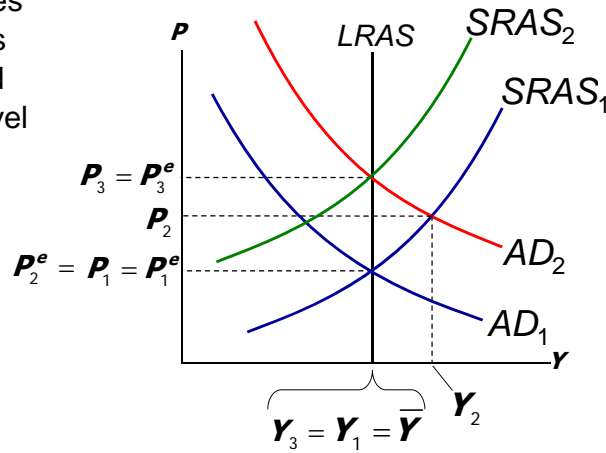
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## Summary & Implications

Suppose a positive AD shock moves output above its natural rate and  $P$  above the level people had expected.

SRAS equation:  $Y = \bar{Y} + \alpha(P - P^e)$



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## Summary of Model Implications For Real Wage

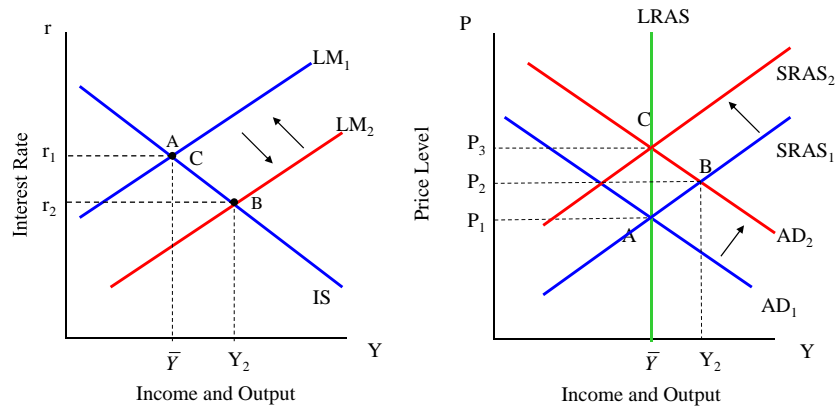
Model	Market Clearing?	Effect of AD on Real Wage?
Sticky Wage	No	Countercyclical
Worker Misperception	Yes	Countercyclical
Imperfect Information	Yes	Countercyclical
Sticky Price	No	Pro- or Countercyclical

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## Putting it all together...

### Monetary Expansion

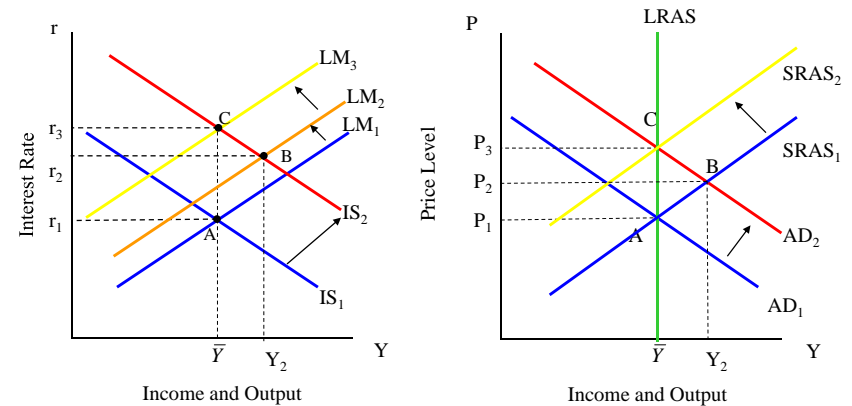


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## Putting it all together...

### Fiscal Expansion



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