# The IS-LM/AD-AS Model

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# Introduction

- We have studied partial equilibrium in several markets:
  1. Labor
  2. Goods
  3. Assets/money
- We have studied these markets in isolation, but they all depend on each other
  - Ex: equilibrium in the money market depends on the real interest rate $r$ that is determined in the goods market, and output $Y$ that is determined in the labor market via the production function
- We now put everything together in a consistent framework that allows us to think of how the macroeconomy as a whole responds to shocks

# Introduction

- We start by building a version of the IS-LM model developed by John Hicks in 1937
- We then show how the IS-LM model gives rise to the AD-AS model we covered last lecture
- We can use this framework to study business cycles under Classical or Keynesian perspectives

# Introduction

This series of lectures:

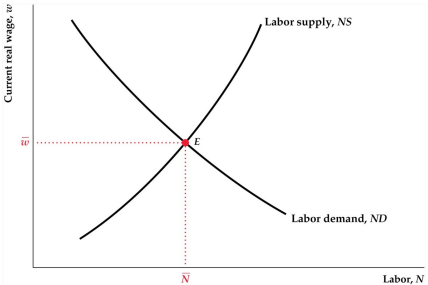
1. The $FE$ line: equilibrium in the labor market
2. The $IS$ curve: equilibrium in the goods market
3. The $LM$ curve: equilibrium in the asset/money market
4. The $IS - LM - FE$ model: general equilibrium
5. Price adjustment
6. The $AD - AS$ model

1. The *FE* line: equilibrium in the labor market

# Refresher: Labor Market Equilibrium

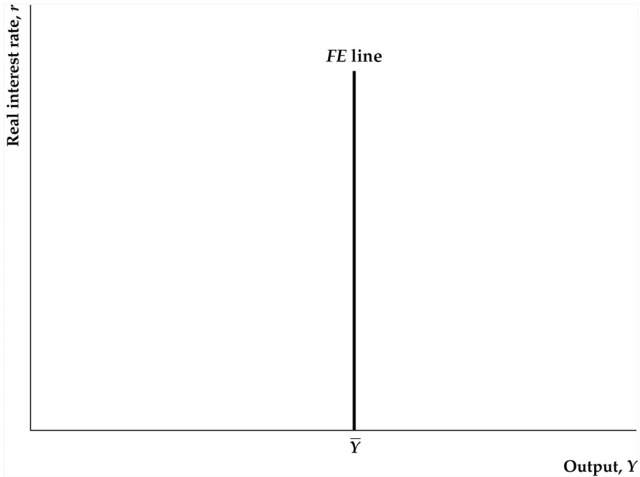
- Determines the natural level of employment $\bar{N}$
- ...and equilibrium wages $\bar{w}$
- Full-employment/natural/potential output $\bar{Y}$ is determined by the production function

$$\bar{Y} = AF(K, \bar{N})$$



# The *FE* Line

- The *FE* line represents equilibrium in the labor market in the $(Y, r)$ space
- Since the real interest rate does not directly affect the labor market equilibrium, it is a vertical line



# Factors that shift the *FE* line

Anything that affects the labor market equilibrium shifts the *FE* line

- Positive productivity shocks shift labor demand to the right

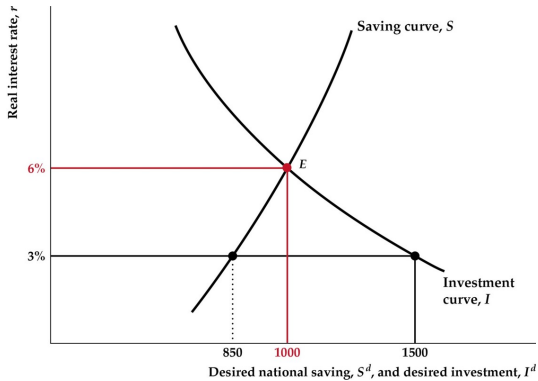
$$\bar{N} \uparrow \Rightarrow \bar{Y} \uparrow \Rightarrow FE \text{ line shifts to the right}$$

- An increase in the capital stock has the same effect
- An expansion of labor supply has the same effect
- Opposite movements cause the *FE* line to shift to the left

# 2. The *IS* curve: equilibrium in the goods market

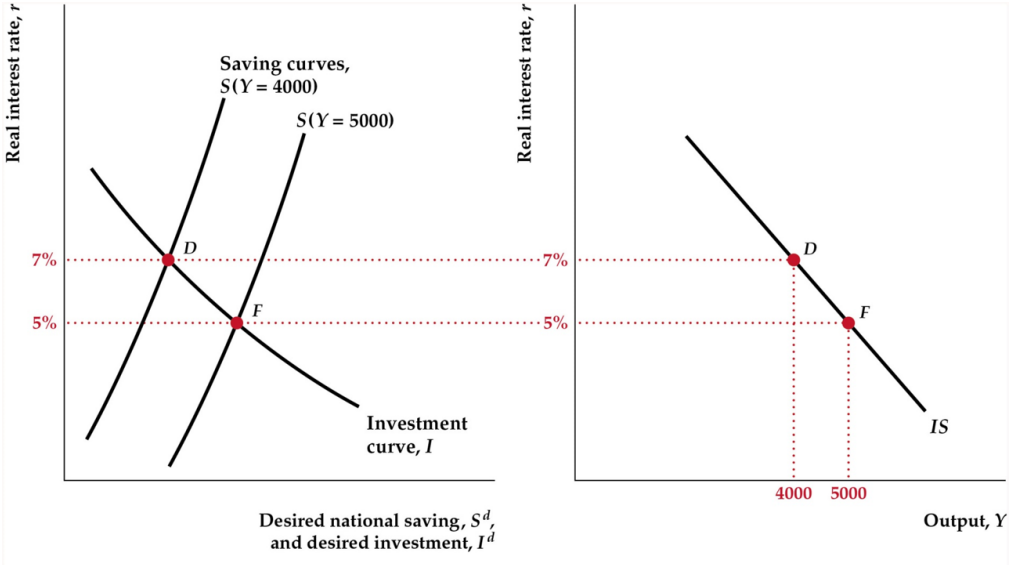
# Refresher: Goods Market Equilibrium

- Recall that equilibrium in goods market was equivalent to equilibrium in the savings/investment market
- Determines national savings/investment $S^d = I^d$
- ...as well as the real interest rate $r$



# The *IS* curve

The *IS* curve represents goods market equilibrium in the $(Y, r)$ space



# Deriving the *IS* curve

The *IS* curve represents goods market equilibrium in the $(Y, r)$ space

- When $Y \uparrow$, desired savings increase for a given $r$
  - Recall the model of intertemporal consumption we studied
  - An increase in current income causes an increase in consumption today **and** tomorrow, so savings increase
- This is an expansion of the saving curve
- The goods market equilibrium then implies that the real interest rate must fall $r \downarrow$
- This generates a downward-sloping relationship in the $(Y, r)$ space that represents goods market equilibrium

# Deriving the *IS* curve

An alternative derivation of the *IS* curve starts with $r \uparrow$

- Recall that this leads to a decrease in consumption today $C \downarrow$
- Also, firms invest less as this raises the user cost of capital $I \downarrow$
- Since both consumption and investment decline, the quantity that is demanded of goods declines
- Since the demand of goods declines, supply must also decline in an equilibrium $Y \downarrow$
- This again generates a negative relationship between $Y$ and $r$ that represents goods market equilibrium

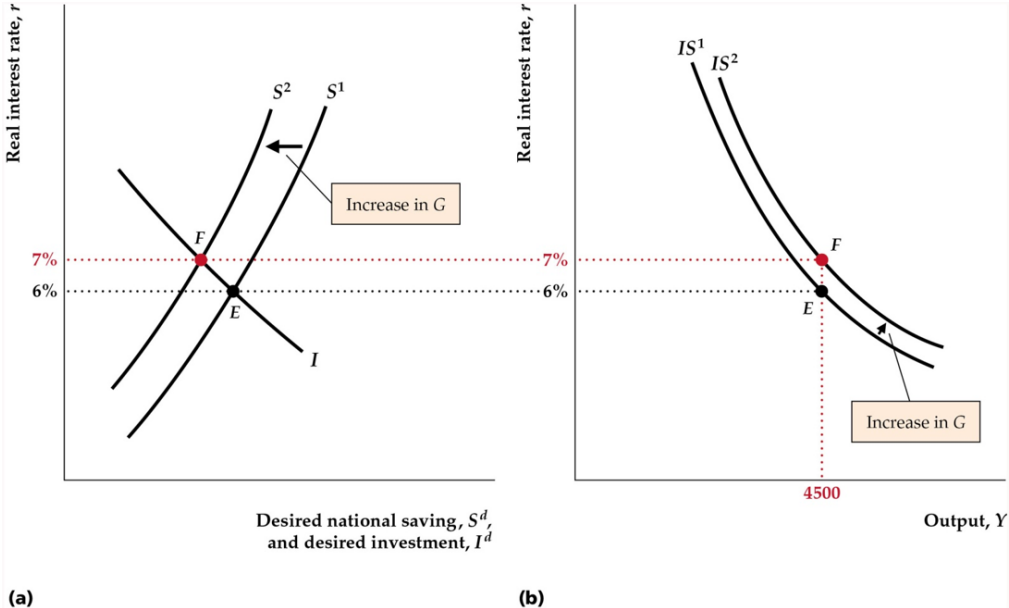
# Shifts in the *IS* curve

- Anything that affects desired saving or investment for a given $Y$ shifts the *IS* curve
- Any factor that reduces saving relative to investment raises the $r$ that clears the goods market and shifts the *IS* curve up/to the right
- Examples include (i) expected future output $\uparrow$, (ii) wealth $\uparrow$, (iii) government purchases $\uparrow$, (iv) $MPK^f \uparrow$
- Generally, any factor that expands the aggregate demand for goods and services shifts the *IS* curve to the right
  - Why? Recall desired savings

$$S^d = Y - C^d - G$$

  - For a constant level of output $Y$, any increase in $C^d$ or $G$ reduce desired saving
  - This shifts the saving curve to the left, see next example

# Increase in Government Purchases



# Increase in Government Purchases

- Consider a temporary increase in government purchases
- Recall that this leads to a decrease in desired national saving for a given level of output $Y$ and interest rate $r$

$$S^d = Y - C^d - G$$

- Thus the saving curve shifts to the left
- This leads to an increase in the real interest rate that is consistent with the same level of output $Y$
- This in turn leads to an expansion of the IS curve
- The goods market equilibrium shifts from $E$ to $F$

# 3. The *LM* curve: equilibrium in the asset market

# Asset Prices vs. Interest Rates

- The price of an asset is inversely related to its interest rate or yield
- Example: bond pays \$10,000 in one year and its current price is \$9,615. Then its yield/implied return/interest rate is

$$r = \frac{\$10,000 - \$9,615}{\$9,615} = 0.04 = 4\%$$

- Imagine now that its price falls to \$9,524. Then its return becomes

$$r = \frac{\$10,000 - \$9,524}{\$9,524} = 0.05 = 5\%$$

- Investors earn high returns when "buying cheap"
- For a given level of expected inflation $\pi^e$ there is an inverse relationship between asset prices and the real interest rate

$$i = r + \pi^e$$

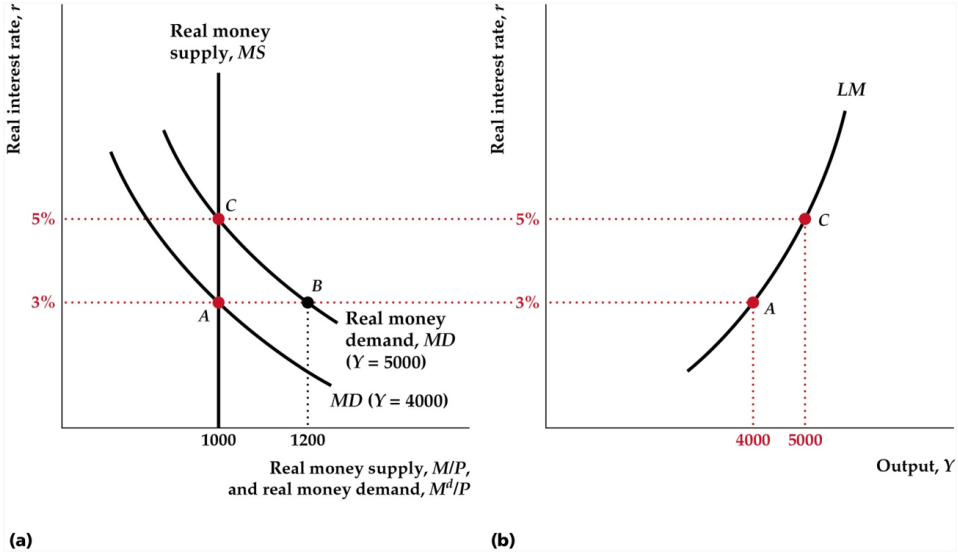
# Refresher: Asset Market Equilibrium

- Recall that equilibrium in the market for nonmonetary assets implied equilibrium in the market for monetary assets, and vice-versa
- Equilibrium in the market for monetary assets was given by the condition

$$\frac{M^s}{P} = L(Y, r + \pi^e)$$

- The left-hand side does not depend on $r$, i.e. the supply of money is determined by the central bank and independent of real interest rates
- Real money demand (righ-hand side) is decreasing in $r$, i.e. the real interest represents the opportunity cost of holding (real) money balances
- Real money demand is increasing in $Y$: when output is higher, people want to hold more money

# The *LM* Curve


Real interest rate, r
Real money supply, MS
C
5%
B
3%
A
Real money demand, MD (Y = 5000)
MD (Y = 4000)
1000
1200
Real money supply, M/P, and real money demand, M^d/P
(a)
Real interest rate, r
LM
5%
C
3%
A
4000
5000
Output, Y
(b)

# The *LM* Curve

- The *LM* curve represents asset market equilibrium in the $(Y, r)$ space
- Consider an increase in output $Y \uparrow$, then people want to hold more money
- Money demand expands, and at a fixed real interest rate $r$, demand moves from $A$ to $B$
- At point $B$, people are demanding too much money, in excess of what the central bank is supplying
- Thus the real interest rate must rise $r \uparrow$ to restore equilibrium in the asset market, to point $C$
- This induces a positive relationship between $Y$ and $r$ that represents asset market equilibrium: the *LM* curve

# The *LM* Curve

Why does an increase in the real interest rate restore asset market equilibrium?

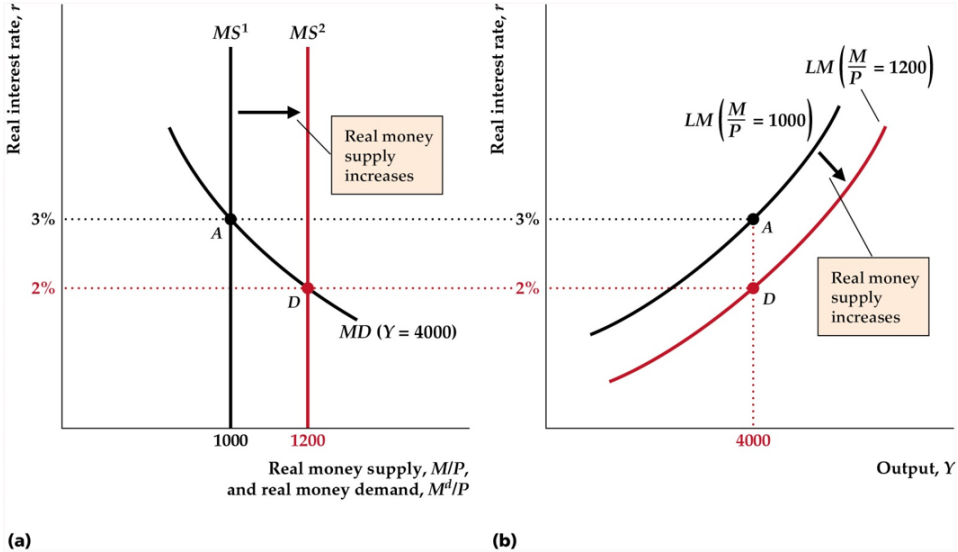
- At point $B$, people want to hold more money
- Thus they rebalance their portfolios: they sell NM assets to acquire money
- As people sell NM assets, the price of these assets falls
- This is equivalent to their real rates of return, or real interest rates, increasing

# Shifts in the *LM* Curve

- Any factor that shifts money supply or demand, for a fixed level of output $Y$, will cause a shift in the *LM* curve
- Any factor that increases the amount of money that is supplied relative to the amount of money that is demanded causes the *LM* curve to shift down/to the right
  - i.e, anything that expands money supply or contracts money demand
- Things that make the *LM* curve shift to the right: (i) an expansion of real money supply $M^s \uparrow$, (ii) a decrease in the price level $P \downarrow$, (iii) an increase in expected inflation $\pi^e \uparrow$, (iv) a decrease in the interest rate on money $i^m \downarrow$, (v) any factor that makes people prefer non-monetary assets over money

# Shifts in the *LM* Curve

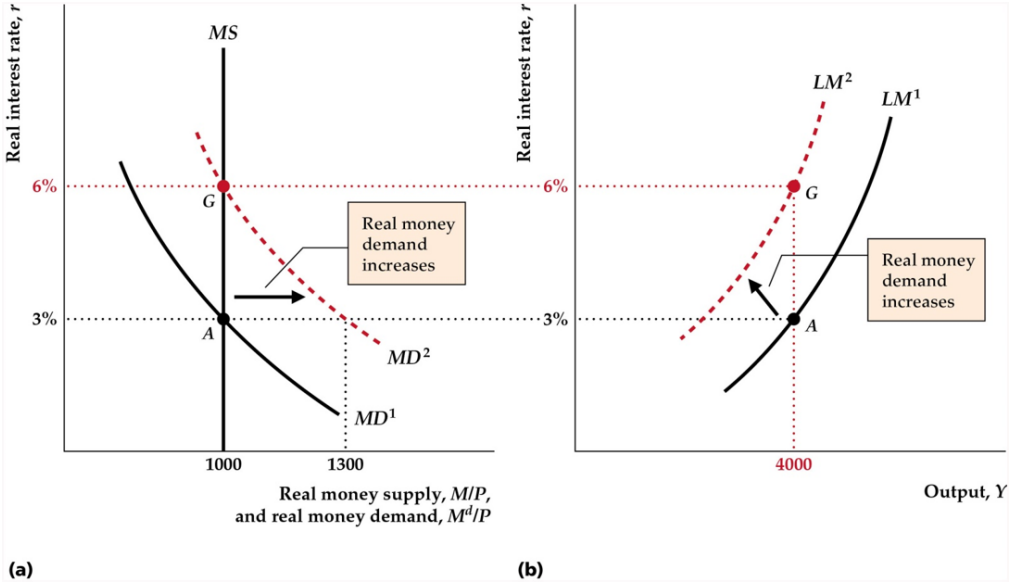
Consider an expansion in the real supply of money



# Shifts in the *LM* Curve

- When money supply increases and output is constant, equilibrium in the market for monetary assets shifts from $A$ to $D$
- At the new equilibrium, the real interest rate must be lower $r \downarrow$. Why?
  - Output has not changed, so people want to purchase the same amount of things they did before
  - Similarly, prices have not changed, so those things are not more expensive
  - So what do people do with this extra money they need to hold? They purchase NM assets
  - This raises their price, which lowers the real interest rate
- Since output has not changed, but the real interest rate has fallen, the *LM* curve has to shift down

# Expansion of Real Money Demand

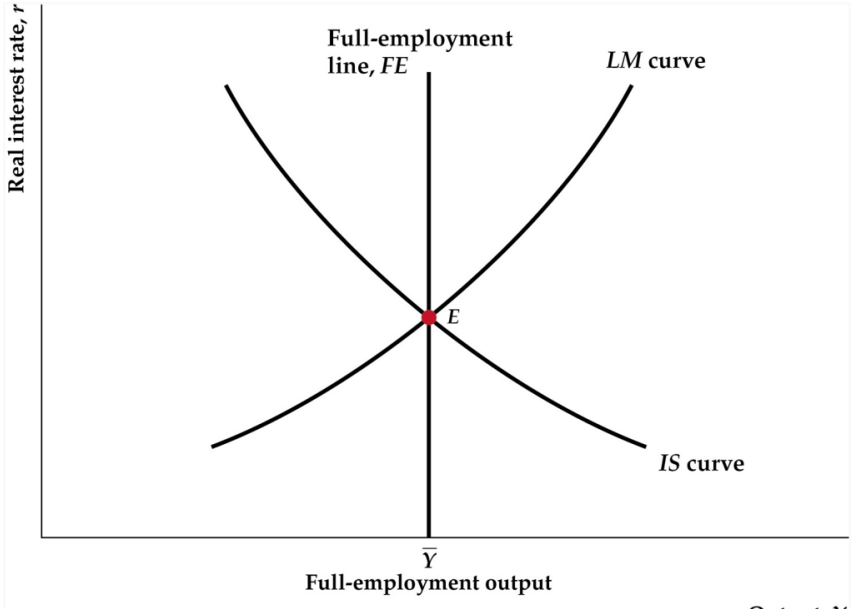


# 4. The $IS - LM - FE$ model: general equilibrium

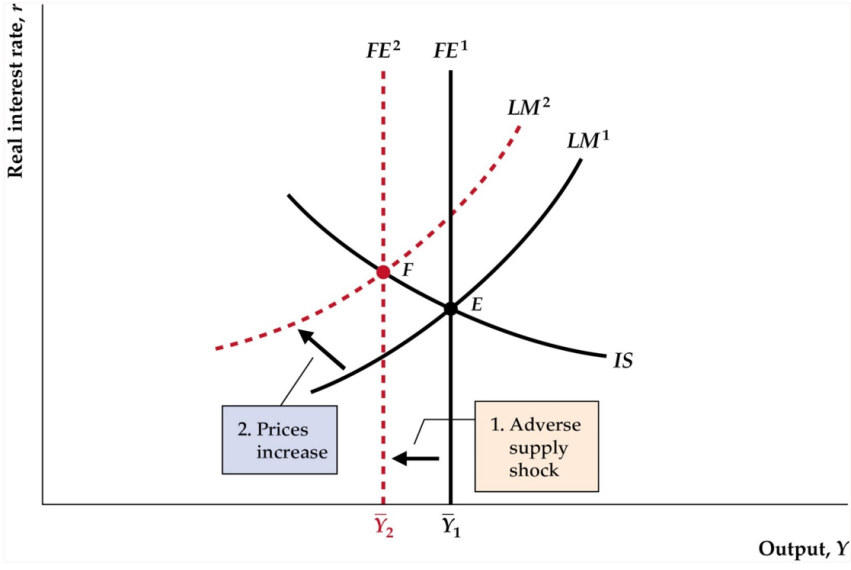
# General Equilibrium

- So far, we have seen how to represent in the $(Y, r)$ space equilibrium in three separate markets:
  - The labor market, via the $FE$ curve
  - The goods market, via the $IS$ curve
  - The asset market, via the $LM$ curve
- We now combine all three and study the **general equilibrium** of the economy: when all of its markets are simultaneously in equilibrium
- This is done via the $IS - LM$ model

# The $IS - LM$ Model



# Temporary Negative Supply Shock in the $IS - LM$ Model



# Temporary Negative Supply Shock in the $IS - LM$ Model

- Consider a negative productivity shock to the economy
- This shifts the labor demand curve to the left, reducing the natural level of employment $\bar{N} \downarrow$
- Consequently, full-employment output falls $\bar{Y} = AF(K, \bar{N}) \downarrow$ and the $FE$ curve shifts to the left
- Note that only output is changing, and nothing else that affects saving or investment (i.e. wealth, future output, etc.)
- Then, this is a movement **along** the IS curve (not a shift of the curve)
- For general equilibrium to be restored, the LM curve must contract so that it intersects the IS and FE curves at point $F$
- This is achieved by a rise in the price level $P \uparrow$
- Recall that for a constant supply of nominal money, a rise in the price level is equivalent to a contraction in the real supply of money

# Temporary Negative Supply Shock in the $IS - LM$ Model

What are the effects of this shock?

1. Output has fallen, $\bar{Y}_2 < \bar{Y}_1$
2. The real interest rate has increased, $r_2 > r_1$
3. The price level has increased, $P_2 > P_1$
4. (1) and (2) both imply that consumption and investment are also lower

This type of recession, where prices rise, is sometimes known as **stagflation**

- Example: oil shock of the 1970s
- Note inflation is temporary, while the price level adjusts to $P_2$

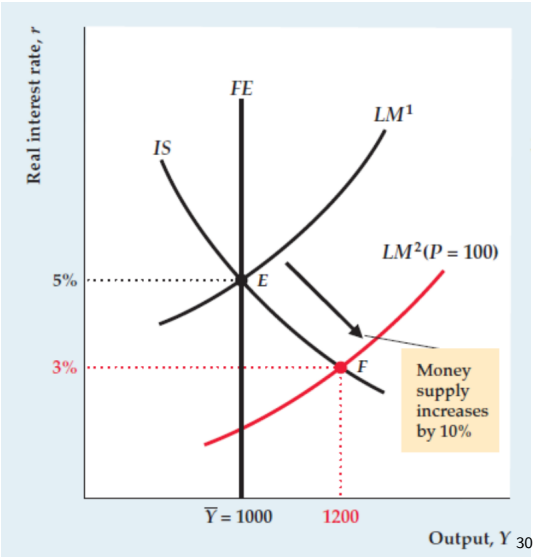
# 5. Price adjustment

# Price Adjustment

- How exactly do prices adjust to restore general equilibrium?
- Let us consider the effects of a monetary expansion
- The central bank increases the nominal supply of money $M^s \uparrow$

# Monetary Expansion in the $IS - LM$ Model

- An expansion of money supply shifts the $LM$ curve to the right
- The real interest rate required to clear the asset market is now lower
- The $IS$ curve does not shift, and we have a movement along this curve
- Note that at point $F$, the $FE$ curve does not intersect the $IS - LM$ curves

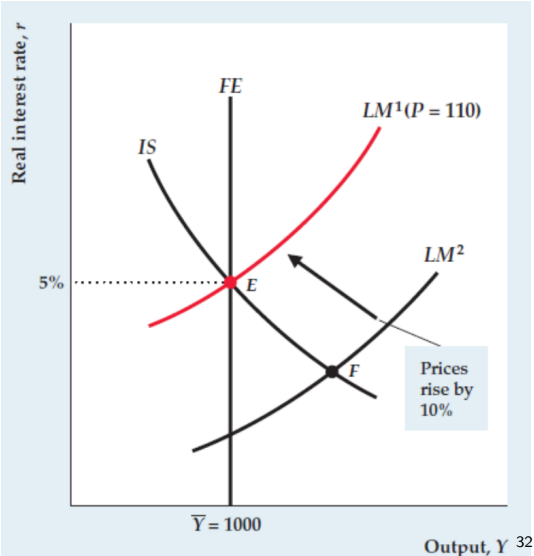


# Monetary Expansion in the $IS - LM$ Model

- We allow the labor market to be in **disequilibrium** at this point, due to slow worker-job matching and wage renegotiation
- The money supply expansion has caused a rise in output (above full-employment) and a fall in the real interest rate
- This situation where the $IS$ and $LM$ curves intersect, but the $FE$ does not is a **short-run equilibrium**
- Firms are temporarily willing to produce more than they would like at given prices

# Adjustment of the Price Level

- Firms eventually raise their prices, $P \uparrow$
- A rise in the price level is equivalent to a contraction of the real money supply $\frac{M^s}{P}$
- This shifts the LM curve back to its original point
- Prices rise until firms are back to their profit-maximizing point



# Adjustment of the Price Level

In the end, what changed?

- Output, employment, and the real interest rate are back to their original levels
- This means that most other variables, such as consumption, investment, and wages are also unchanged
- The only variables that have changed were:
  - Nominal money supply, $M^s$
  - Price level, $P$
- The price level changed in such a way to exactly offset the change in nominal money supply
- So real money supply $\frac{M^s}{P}$ has remained constant
- All real variables are unchanged

# Trend Money Growth and Inflation

- This analysis can be extended to the more realistic case where money supply and the price level grow continuously
- If money supply and prices grow at the same rate, then real money supply is constant and the economy is in general equilibrium
- If money supply starts growing faster, this will cause the $LM$ curve to shift to the right, leading to a temporary expansion
- Eventually, price growth may catch up and the $LM$ curve shifts back, ending the expansion
- When we talk about "an increase in the money supply", we have in mind an increase in the growth rate relative to the trend

# Classical vs. Keynesian Theories

The $IS - LM$ model allows to analyze the business cycle from either a Classical or Keynesian perspectives

- The key disagreement between the two refers to the speed of the adjustment of prices
- ...and hence of the speed of adjustment of the $LM$ curve back to the point of general equilibrium

# Classical vs. Keynesian Theories

- **Classical theory** presumes that prices are flexible, and price adjustment is rapid
  - This means that the economy never leaves its general equilibrium
  - An expansion of money supply is immediately offset by a proportional increase in the price level
  - For this reason, the central bank cannot affect the economy via changes in the money supply
- **Keynesian theory** presumes that prices are **sticky**, and price adjustment is slow
  - The economy can deviate from its general equilibrium for years
  - This implies that the central bank can actively influence the business cycle

# Monetary Neutrality

- Economists say that **money is neutral** if a change in the nominal money supply has a proportional effect in the price level without affecting any real variables
- Classicals argue that money is always neutral
- Keynesians argue that money is neutral in the long-run, but not in the short-run

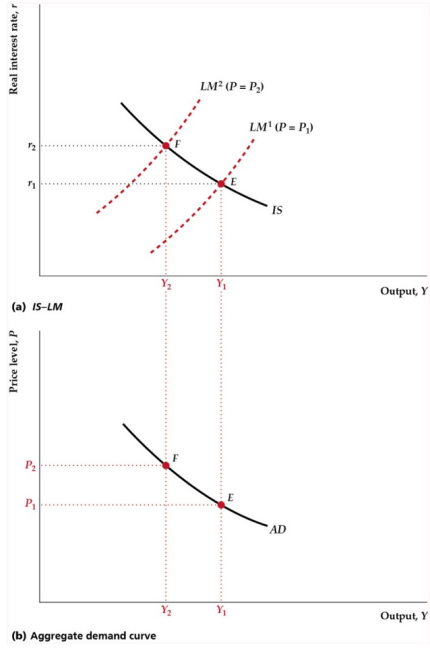
# 6. The $AD - AS$ model

# The $AD - AS$ model

- The $AD - AS$ model is equivalent to the $IS - LM$ model
- One or the other may be more useful depending on the issue
  - $AD - AS$ is set on the $(Y, P)$ space
  - $IS - LM$ is set on the $(Y, r)$ space
- $AD - AS$ is useful to study the effects of shocks on the price level and inflation
- $IS - LM$ is useful to study the effects of shocks on the real interest rate

# Aggregate Demand

- The $AD$ curve relates the quantity of goods demanded $C^d + I^d + G$ and the price level $P$
- The $AD$ represents equilibrium in the goods market and in the asset market
- Assume that $P_1 \uparrow P_2$
- This reduces real money supply $\frac{M^s}{P} \downarrow$
- Thus the $LM$ curve shifts to the left
- Equilibrium in the asset market requires the real rate to increase $r \uparrow$
- This shift along the $IS$ curve implies lower demanded output $Y_1 \downarrow Y_2$



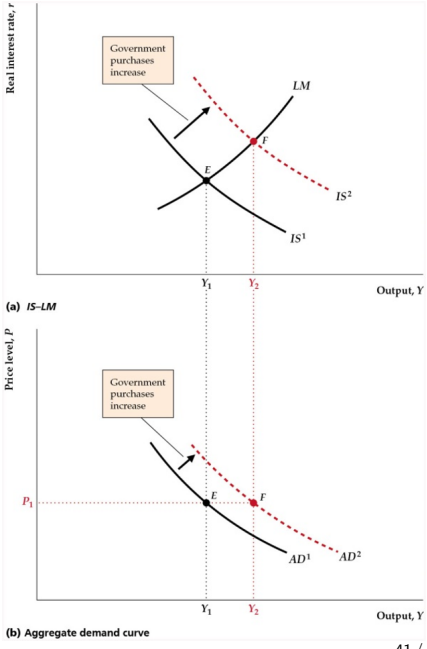
# Aggregate Demand

- Aggregate Demand thus represents a negative relationship between demanded output and the price level
- Note that this negative relationship arises through the real interest rate $r$
- For a constant price level, any factor that shifts the $IS - LM$ equilibrium shifts the $AD$ curve
- One example that we already considered is a temporary increase in government purchases

# Shifts in Aggregate Demand

Consider an increase in govt purchases, $G \uparrow$

- $G \uparrow$ shifts the $IS$ curve to the right
- More output is demanded at the same $r$
- This expansion in $Y$ requires a higher $r$ to clear the asset market
- This is a shift along the $LM$ curve
- $P$ has not changed, but demanded output increased
- So the $AD$ curve must shift to the right



# Shifts in Aggregate Demand

For a constant price level, any factor that shifts the intersection of the *IS* and *LM* curves to the right increases aggregate output demanded and shifts the *AD* curve up and to the right.

Factors that shift the *IS* curve up and to the right, and thus shift the *AD* curve up and to the right (see Summary table 12, p. 329) include

- an increase in expected future output;
- an increase in wealth;
- an increase in government purchases, *G;*
- a reduction in taxes, *T* (assuming no Ricardian equivalence so that consumers respond by raising desired consumption);
- an increase in the expected future *MPK;* and
- a reduction in the effective tax rate on capital.

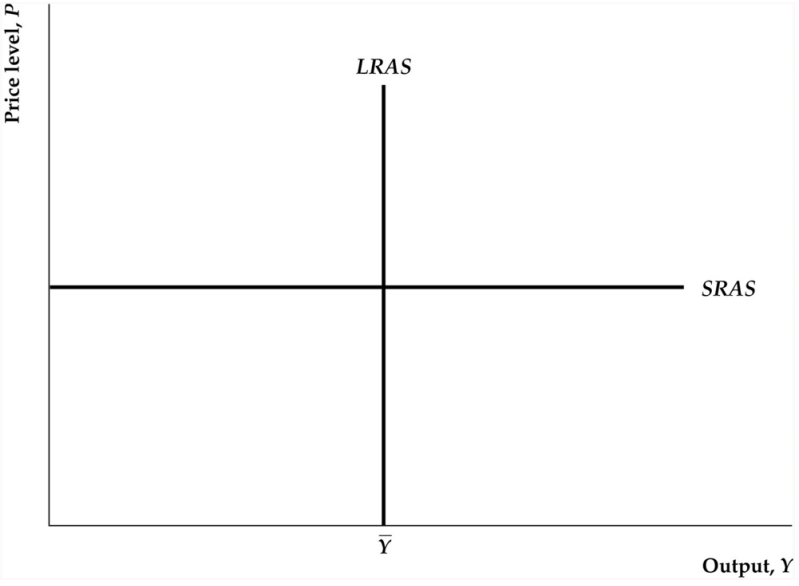
Factors that shift the *LM* curve down and to the right, and thus shift the *AD* curve up and to the right (see Summary table 13, p. 335) include

- an increase in the nominal money supply, *M;*
- a rise in expected inflation, $\pi^e$;
- a decrease in the nominal interest rate on money, $i^m$; and
- any other change that reduces the real demand for money.

# Aggregate Supply

- The $AS$ curve is the relationship between the price level and the amount of production that firms undertake
- We assume that firms behave differently in the short- and long-run
  - In the **short-run**, prices are fixed and firms are willing to supply any amount of demanded output
  - In the **long-run**, prices adjust and the labor market clears at the full-employment level that maximizes firms' profits, $\bar{N}$
- This gives rise to a short-run supply curve $SRAS$ that is flat in the $(Y, P)$ space
- And a long-run supply curve $LRAS$ that is vertical in the $(Y, P)$ space

# Aggregate Supply

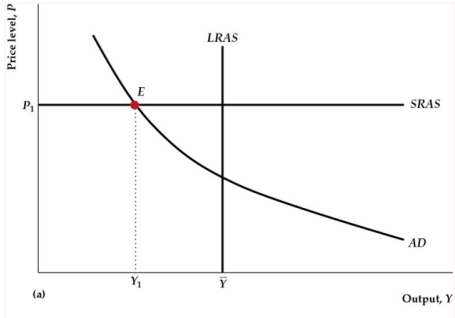


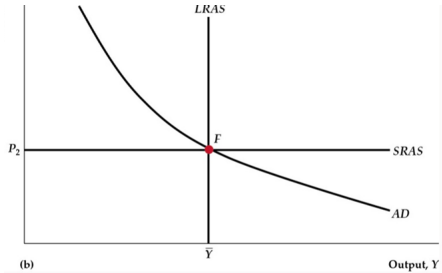
# Shifts in Aggregate Supply

- Any factor that changes the full-employment level of output $\bar{Y}$ shifts *LRAS* accordingly
  - Ex: equilibrium in the labor market
- Any factor that affects the way firms change their prices shifts the *SRAS* curve up or down
  - Ex: increased costs of producing goods

# $AD - AS$ Equilibrium

- **Short-run equilibrium** determined by $AD$ and $SRAS$
- **Long-run equilibrium** determined by $AD$ and $LRAS$
- At point $E$, output is lower than what firms want to produce
- Eventually prices fall $P \downarrow$
- $SRAS$ shifts down
- Economy converges to long-run equilibrium $F$

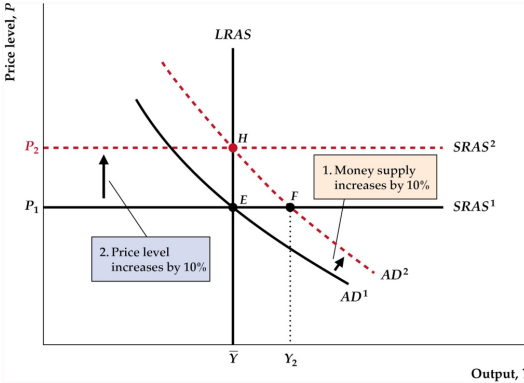


# Monetary Neutrality in the $AD - AS$ Model

Consider an expansion of the nominal money supply, $M^s \uparrow$

- $LM$ curve shifts to the right
- This leads to a shift $AD^1 \rightarrow AD^2$
- The new SR equilibrium is $F$
- Eventually firms start raising prices, $P \uparrow$
- This shifts up $SRAS$
- The $LM$ curve contracts $\Rightarrow$ movement along $AD^2$
- Economy returns to $LRAS$ at $H$




All real variables are unchanged from $E$ to $H$, but nominal variables have increased proportionally.

# Monetary Neutrality in the $AD - AS$ Model

Again, the key question is how long does it take to get from the short- to the long-run?

- Classicals argue the adjustment is quick, only $AD$ and $LRAS$ matter
- Keynesians argue the adjustment is slower, and the short-run can last for some time