

# 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
- ▶ We now start putting 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:

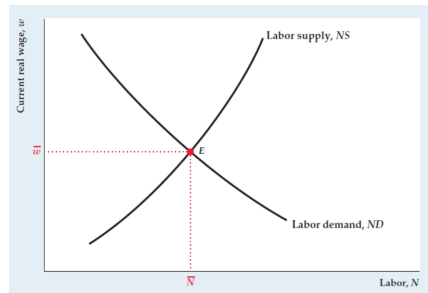
1. The  $FE$  line: equilibrium in the labor market
2. The  $IS$  curve: equilibrium in the goods market
3. The  $LM$  curve: equilibrium in the asset/money market
4. The  $IS - LM - FE$  model: general equilibrium
5. Price adjustment
6. The  $AD - AS$  model

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

# Refresher: Labor Market Equilibrium

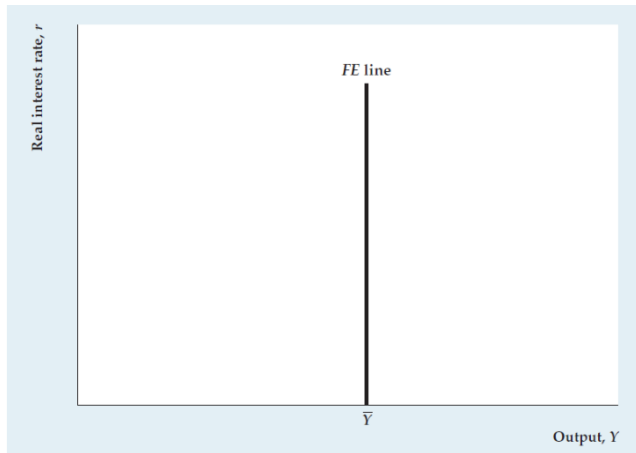
- ▶ Determines the natural level of employment  $\bar{N}$
- ▶ ...and equilibrium wages  $\bar{w}$
- ▶ Full-employment/natural/potential output  $\bar{Y}$  is determined by the production function

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



## The *FE* Line

- ▶ The *FE* line represents equilibrium in the labor market in the  $(Y, r)$  space
- ▶ Since the real interest rate does not depend directly on 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

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

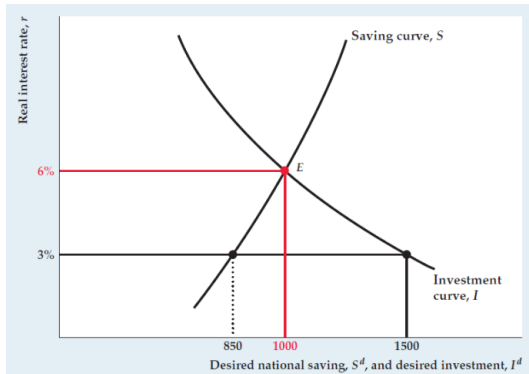
- ▶ An increase in the capital stock has the same effect
- ▶ An expansion of labor supply has the same effect
- ▶ Opposite movements cause the  $FE$  line to shift to the left



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

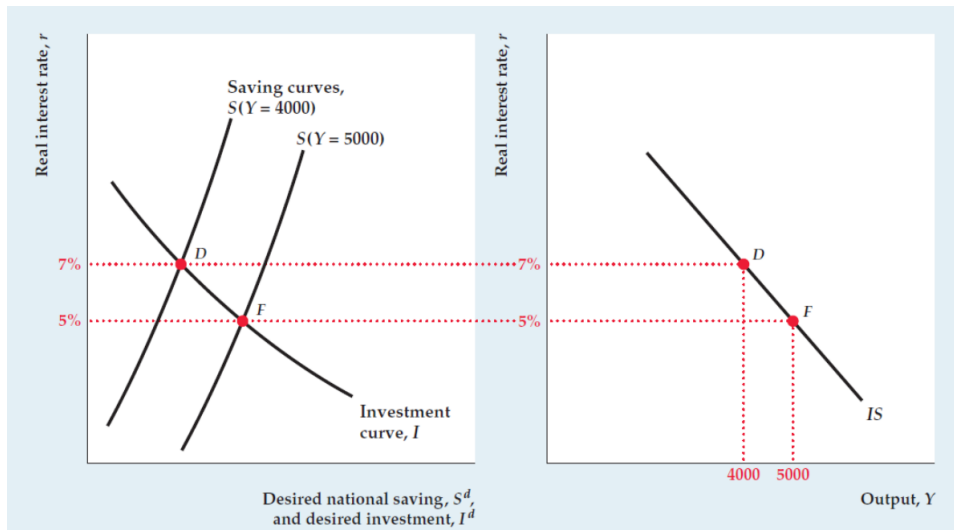
# Refresher: Goods Market Equilibrium

- ▶ 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
- ▶ 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

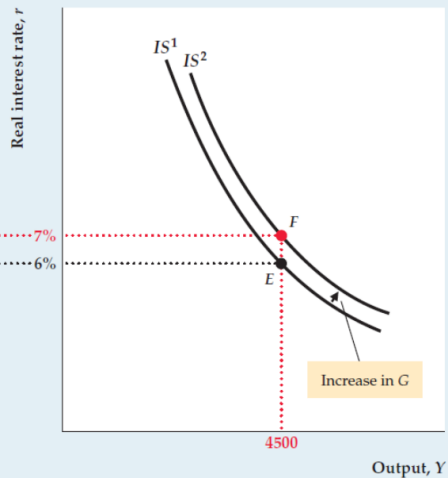
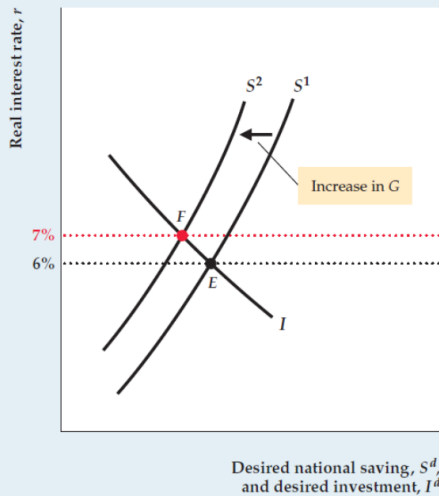
## Shifts in the $IS$ curve

- ▶ 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

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

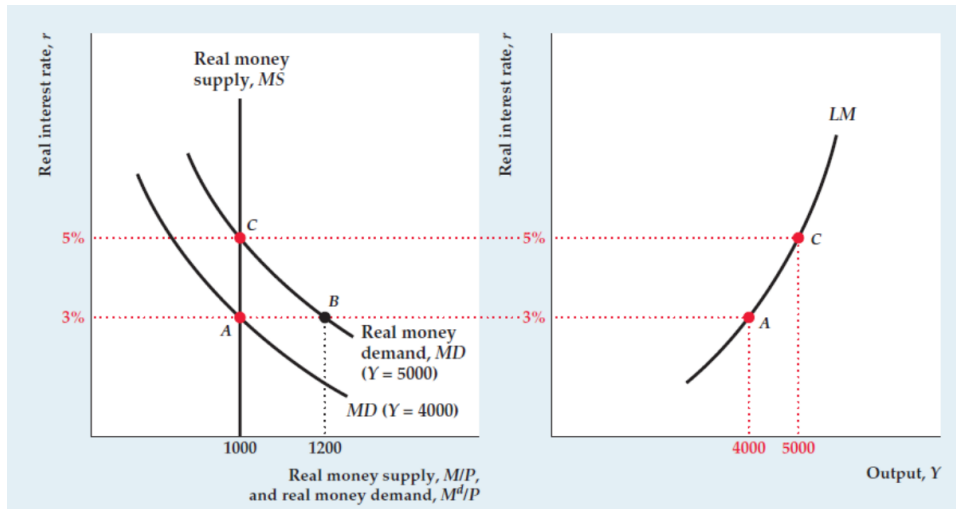
## Refresher: Asset Market Equilibrium

- ▶ Recall that equilibrium in the market for nonmonetary assets implied equilibrium in the market for monetary assets, and vice-vers
- ▶ 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
- ▶ The right-hand side is decreasing in  $r$ , i.e. the real interest represents the opportunity cost of holding (real) money balances
- ▶ Additionally, the right-hand side is increasing in  $Y$ : when output is higher, people want to hold more money

# The $LM$ Curve



## 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?

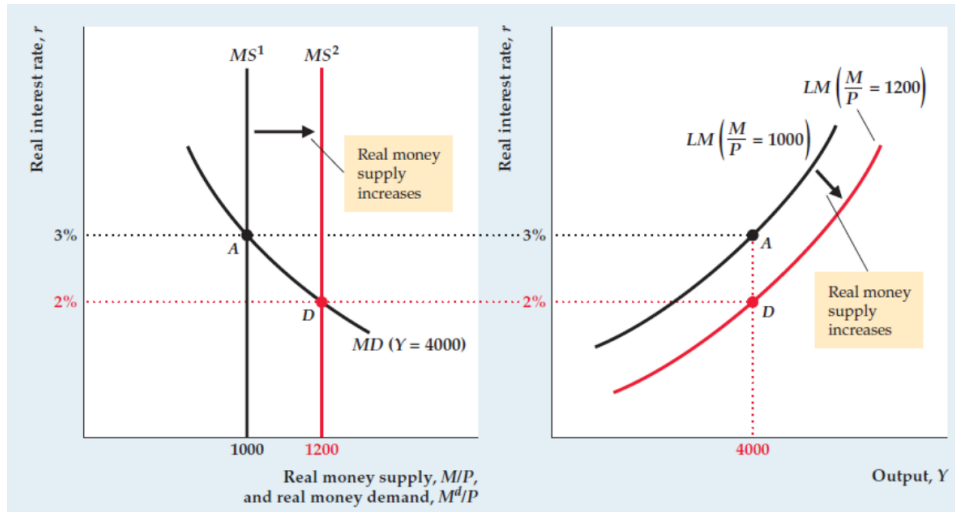
- ▶ At point *B*, people want to hold more money
- ▶ Thus they rebalance their portfolios: they sell NM assets to acquire money
- ▶ As people sell NM assets, the price of these assets falls
- ▶ This is equivalent to their real rates of return, or real interest rates, increasing

## 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
- ▶ Examples include: (i) an expansion of real money supply  $M^s \uparrow$ , (ii) a decrease in the price level  $P \downarrow$ , (iii) a decrease in expected inflation  $\pi^e \downarrow$ , (iv) a decrease in the interest rate on money  $i^m \downarrow$

# Shifts in the $LM$ Curve

Consider an expansion in the real supply of money

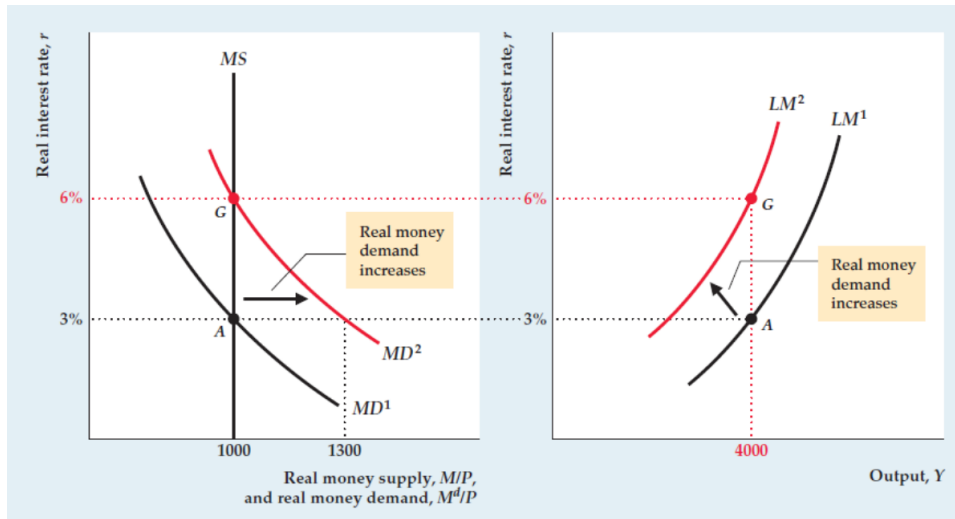




## Shifts in the $LM$ Curve

- ▶ 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

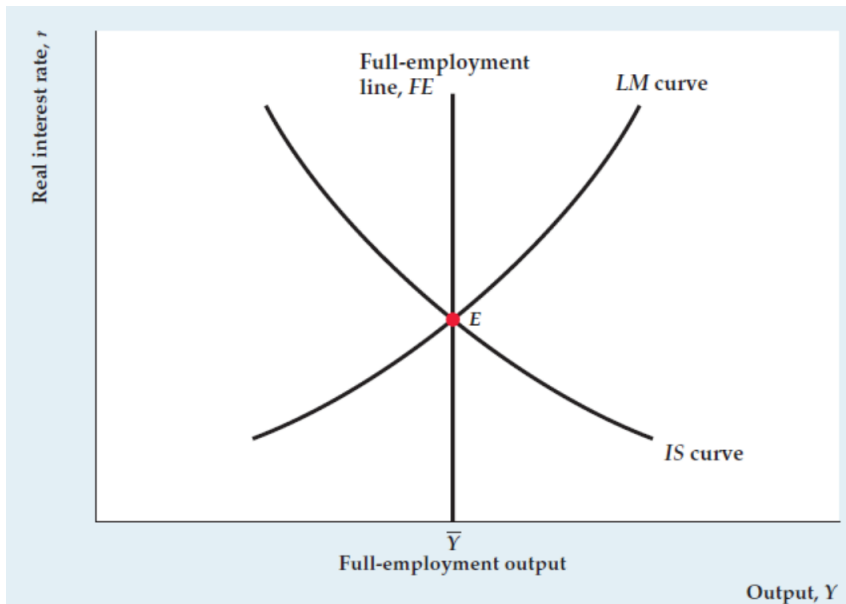


#### 4. The $IS - LM - FE$ model: general equilibrium

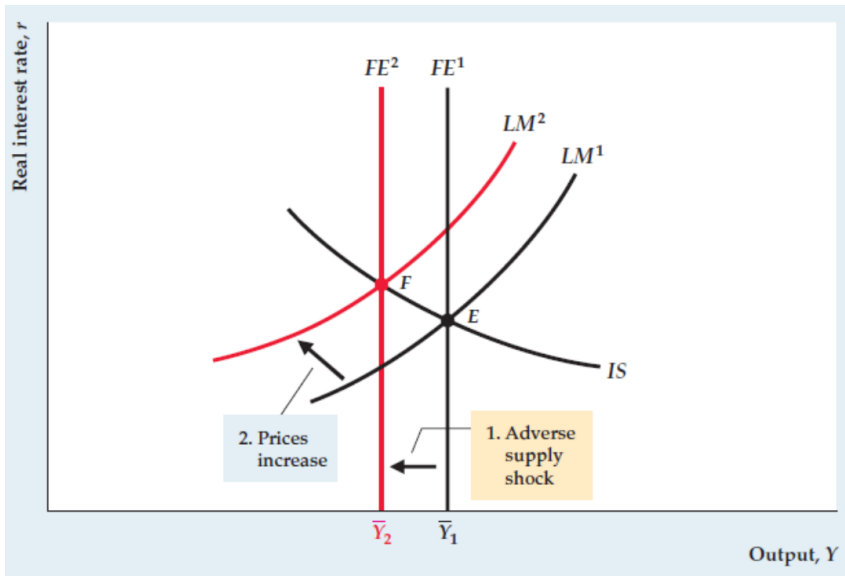
# General Equilibrium

- ▶ 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 that since the shock is temporary, the price level eventually returns to  $P_1$ , thus inflation is also temporary



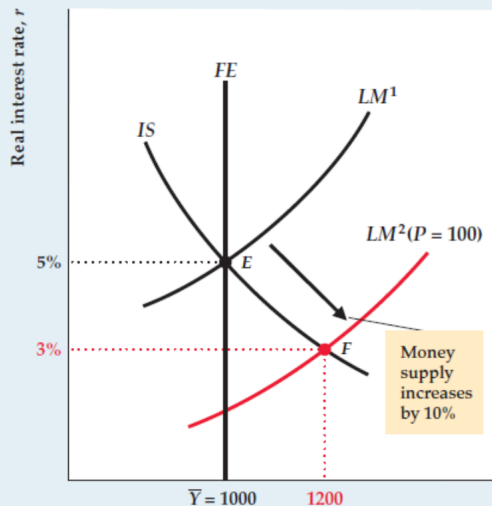
## 5. Price adjustment

# 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

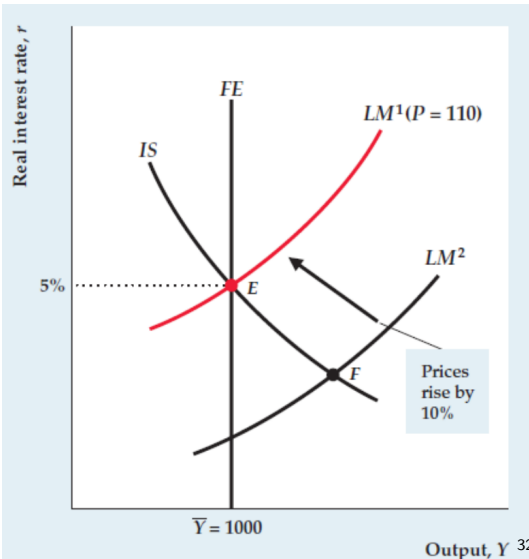


## Monetary Expansion in the $IS - LM$ Model

- ▶ We allow the labor market to be in **desequilibrium** 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 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

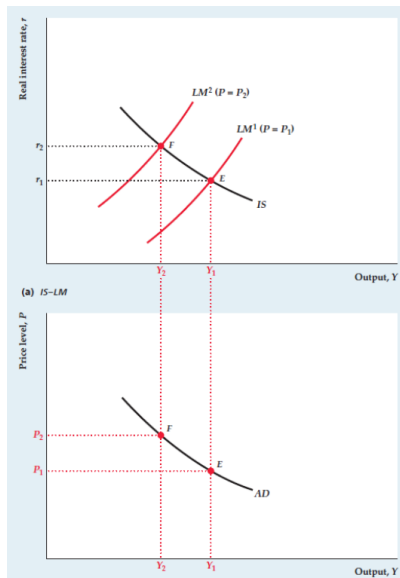
## 6. The $AD - AS$ model

## 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
- ▶  $AD - AS$  more useful to study the effects of shocks on the price level and inflation
- ▶  $IS - LM$  more 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
- ▶ Consider 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  $Y_1 \downarrow Y_2$



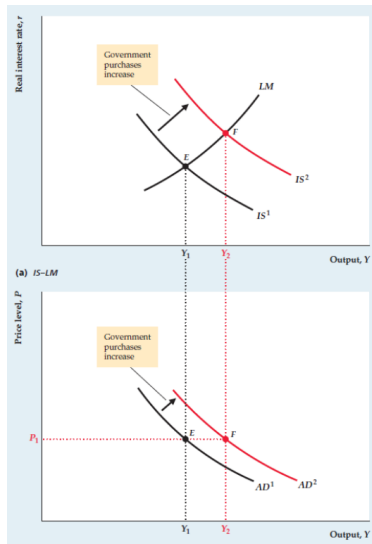
# Aggregate Demand

- ▶ 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

## Factors That Shift the *AD* Curve

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. 319) 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. 325) include

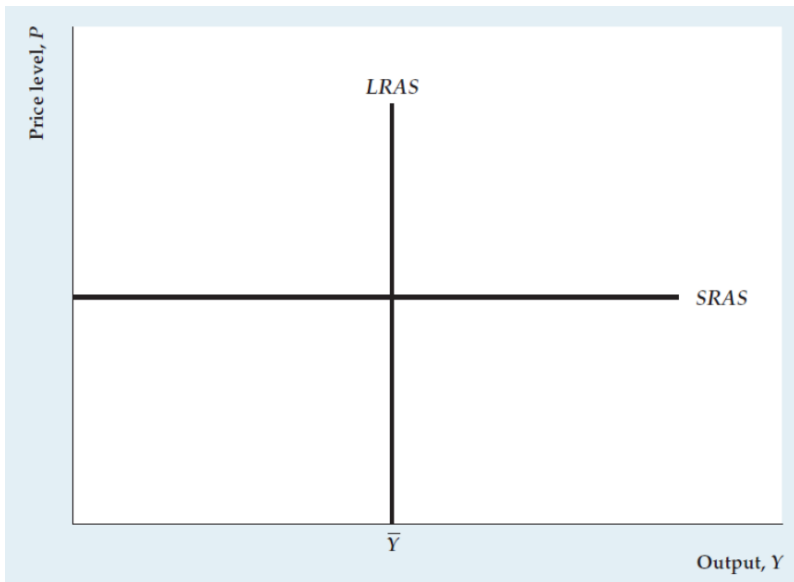
- an increase in the nominal money supply,  $M$ ;
- a rise in expected inflation,  $\pi^e$ ;
- a decrease in the nominal interest rate on money,  $i^m$ ; and
- any other change that reduces the real demand for money.



# Aggregate Supply

- ▶ The *AS* curve is the relationship between the price level and the amount of production that firms undertake
- ▶ Recall that we assume 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

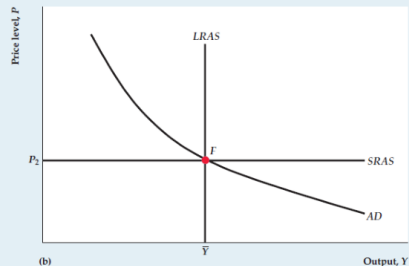
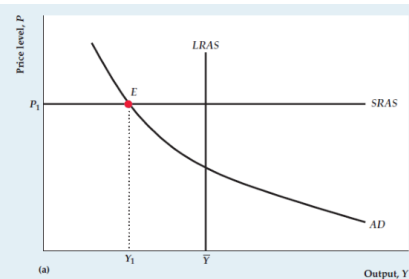


# Shifts in Aggregate Supply

- ▶ Any factor that changes the full-employment level of output  $\bar{Y}$  shifts  $LRAS$  accordingly
- ▶ Any factor that affects the way firms change their prices shifts the  $SRAS$  curve up or down

# AD – AS Equilibrium

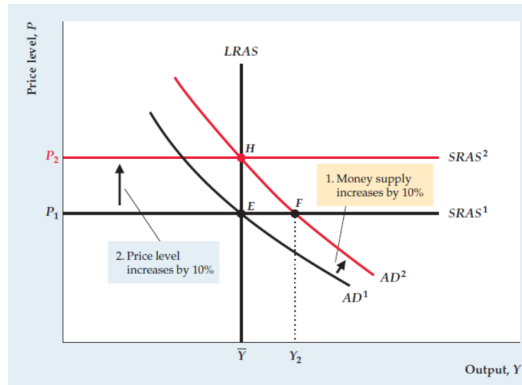
- ▶ **Short-run equilibrium** determined by  $AD$  and  $SRAS$
- ▶ **Long-run equilibrium** determined by  $AD$  and  $LRAS$
- ▶ At point  $E$ , output is lower than what firms want to produce
- ▶ Eventually prices fall  $P \downarrow$
- ▶  $SRAS$  shifts down
- ▶ Economy converges to long-run equilibrium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



# 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