

The IS-LM/AD-AS Model

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March 2025

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:

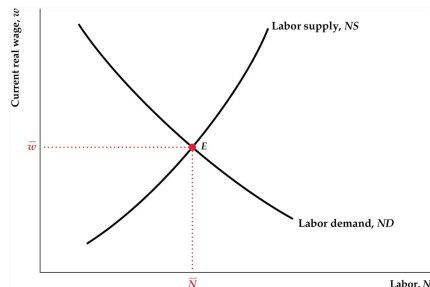
1. The FE line: equilibrium in the labor market
2. The IS curve: equilibrium in the goods market
3. The LM curve: equilibrium in the asset/money market
4. The $IS - LM - FE$ model: general equilibrium
5. Price adjustment
6. The $AD - AS$ model

1. The FE line: equilibrium in the labor market

Refresher: Labor Market Equilibrium

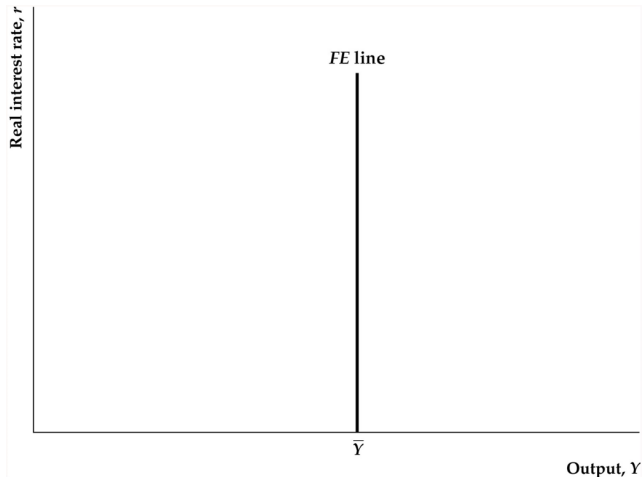
- ▶ Determines the natural level of employment \bar{N}
- ▶ ...and equilibrium wages \bar{w}
- ▶ Full-employment/natural/potential output \bar{Y} is determined by the production function

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



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

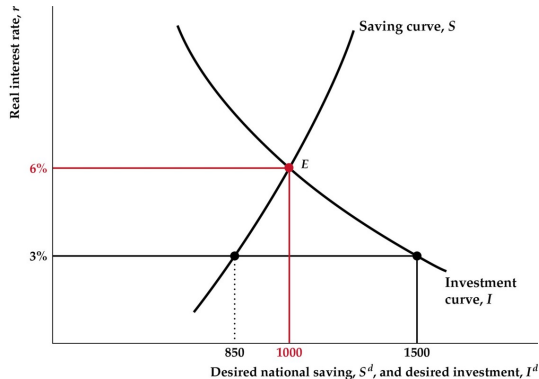
$$\bar{N} \uparrow \Rightarrow \bar{Y} \uparrow \Rightarrow FE \text{ line shifts to the right}$$

- ▶ 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

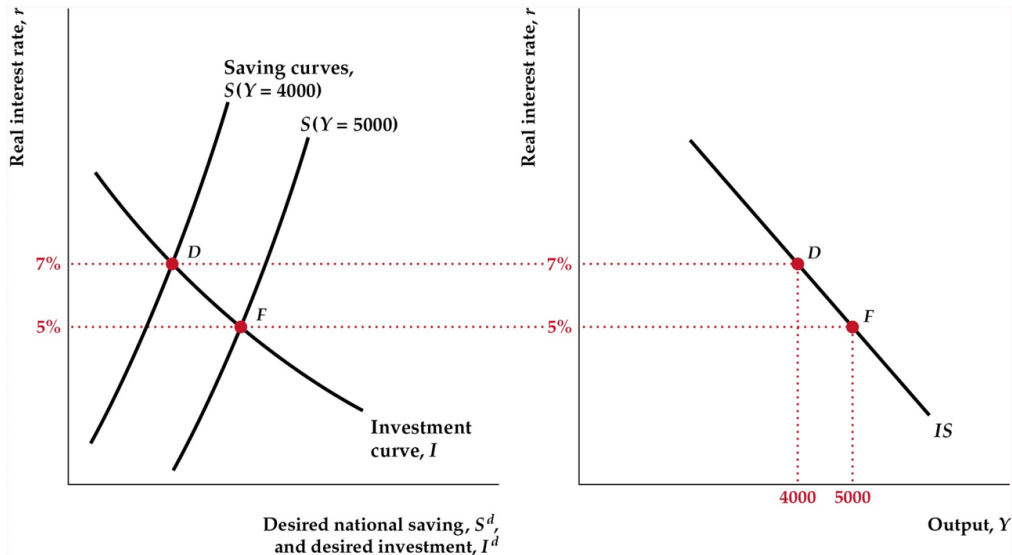
Refresher: Goods Market Equilibrium

- ▶ 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

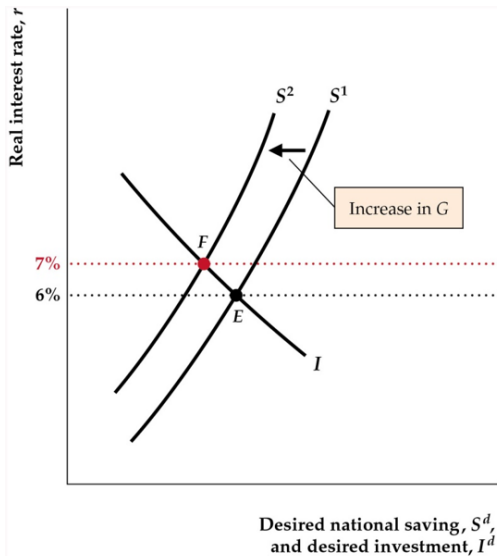
Shifts in the IS curve

- ▶ 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

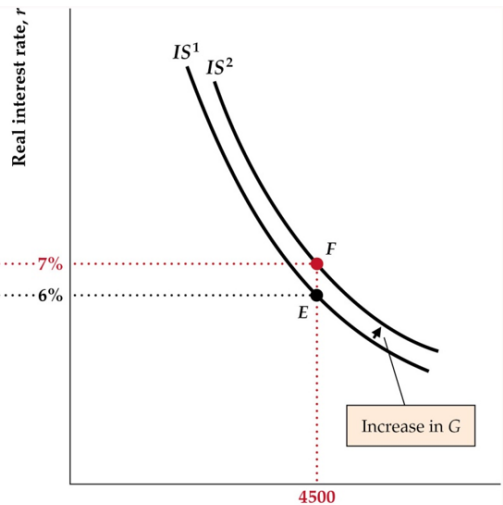
$$S^d = Y - C^d - G$$

- ▶ 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



(a)



(b)

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 π^e there is an inverse relationship between asset prices and the real interest rate

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

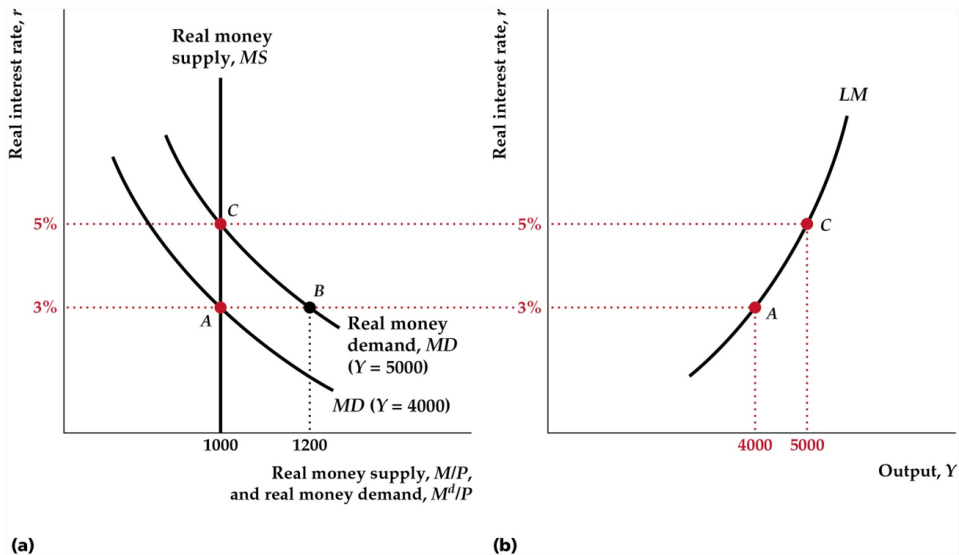
Refresher: Asset Market Equilibrium

- ▶ 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 (right-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



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?

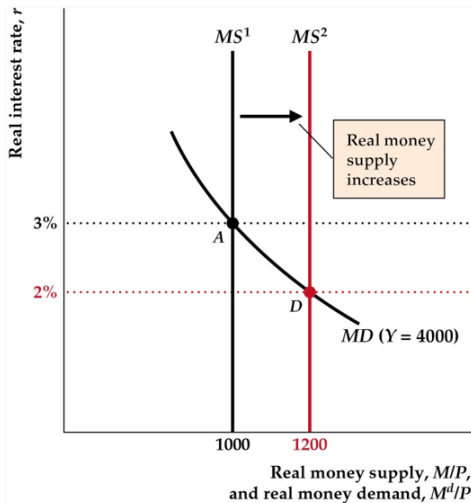
- ▶ At point *B*, people want to hold more money
- ▶ Thus they rebalance their portfolios: they sell NM assets to acquire money
- ▶ As people sell NM assets, the price of these assets falls
- ▶ This is equivalent to their real rates of return, or real interest rates, increasing

Shifts in the LM Curve

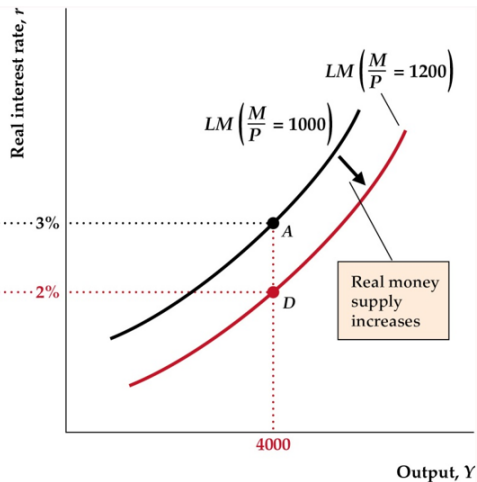
- ▶ Any factor that shifts money supply or demand, for a fixed level of output Y , will cause a shift in the LM curve
- ▶ Any factor that increases the amount of money that is supplied relative to the amount of money that is demanded causes the LM curve to shift down/to the right
 - ▶ i.e, anything that 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



(a)

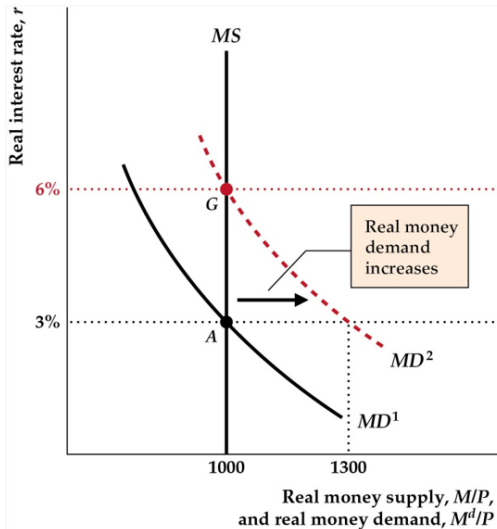


(b)

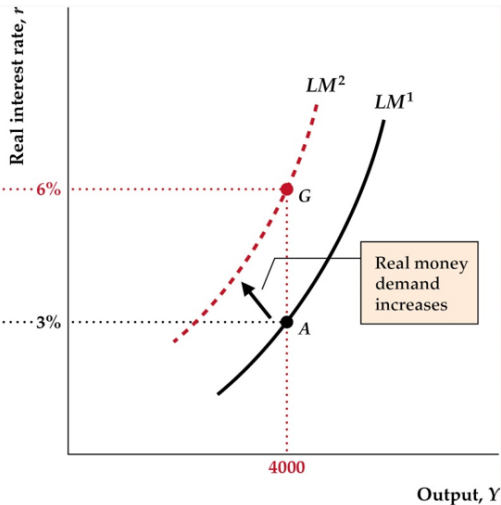
Shifts in the LM Curve

- ▶ 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



(a)



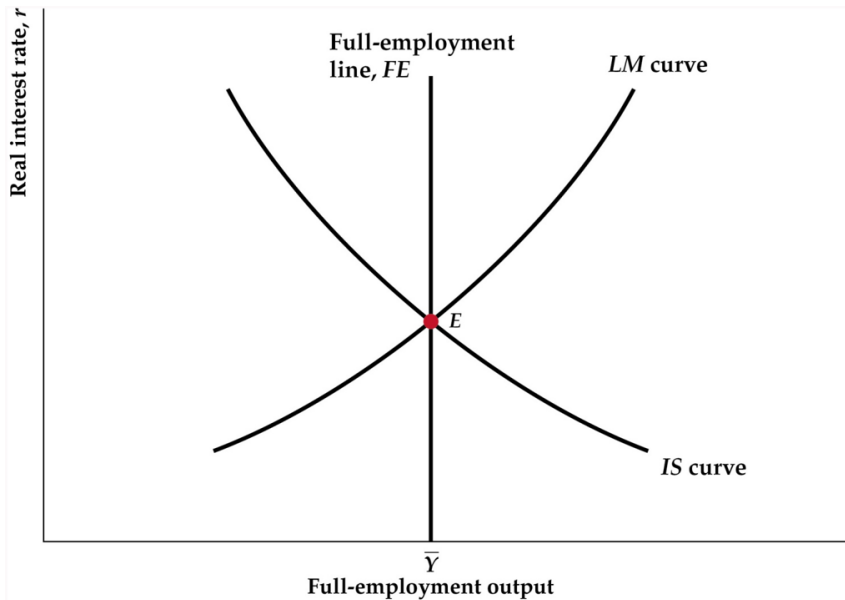
(b)

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

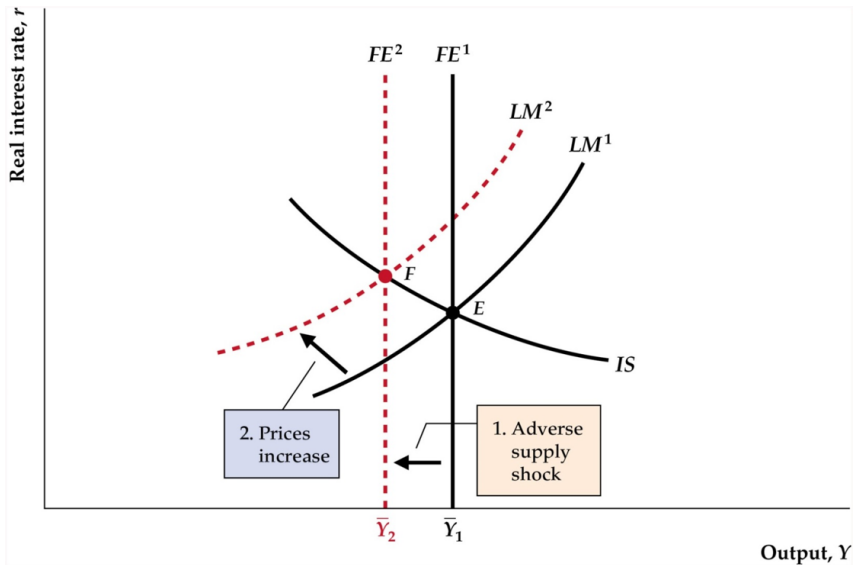
General Equilibrium

- ▶ 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

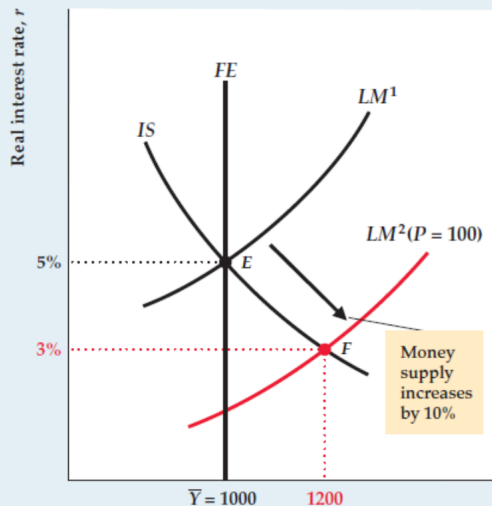
5. Price adjustment

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

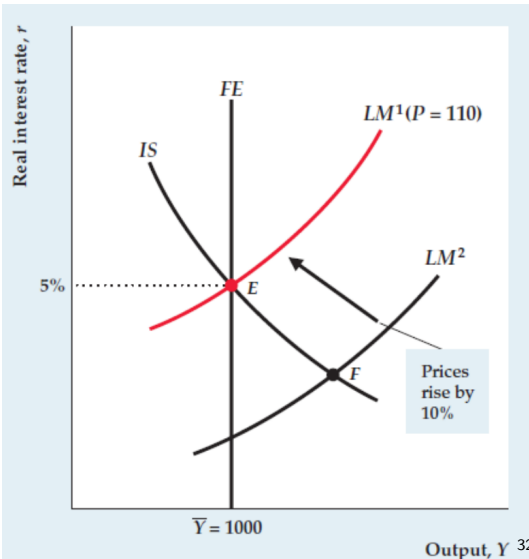


Monetary Expansion in the $IS - LM$ Model

- ▶ 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

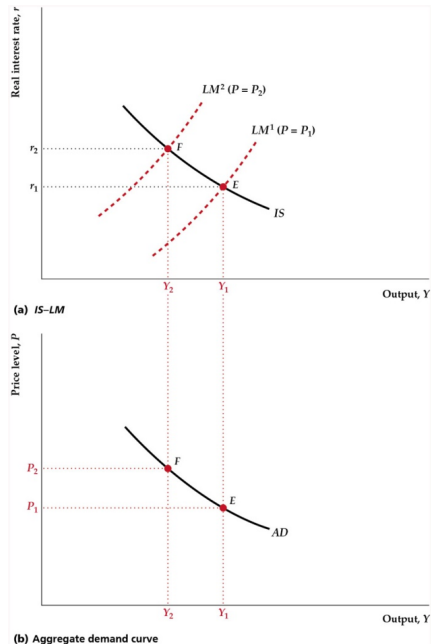
6. The $AD - AS$ model

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 $Y_1 \downarrow Y_2$



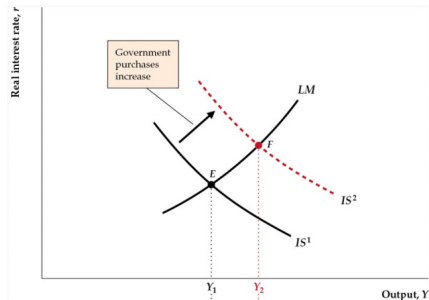
Aggregate Demand

- ▶ 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

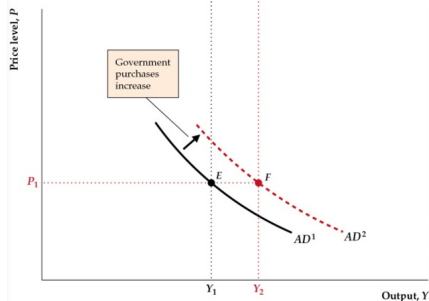
Shifts in Aggregate Demand

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



(a) IS-LM



(b) Aggregate demand curve

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.

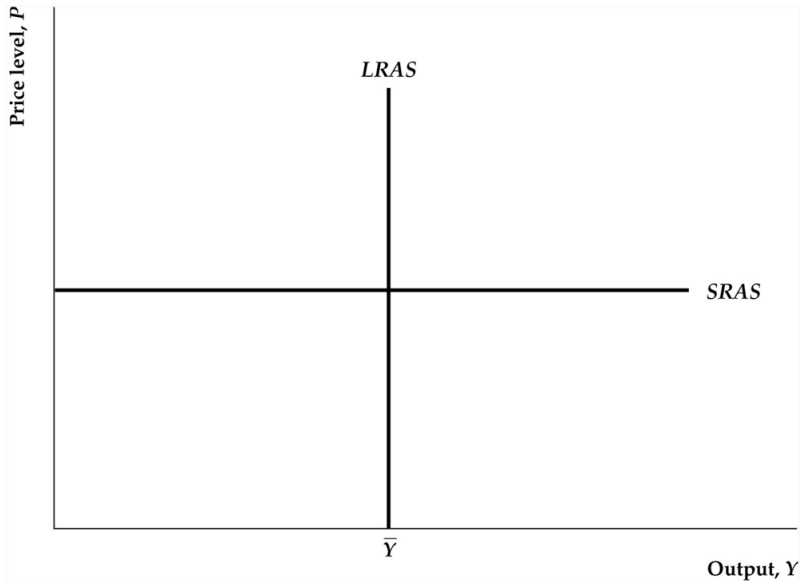
Factors that shift the LM curve down and to the right, and thus shift the AD curve up and to the right (see Summary table 13, p. 335) include

- an increase in the nominal money supply, M ;
- a rise in expected inflation, π^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

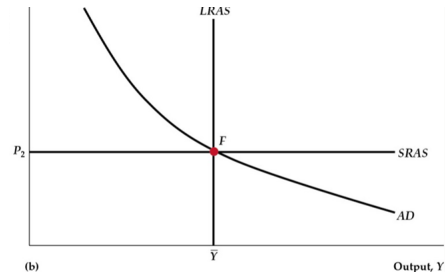
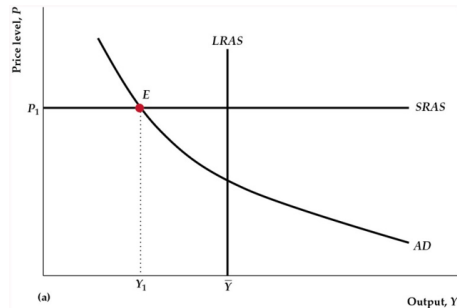


Shifts in Aggregate Supply

- ▶ 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

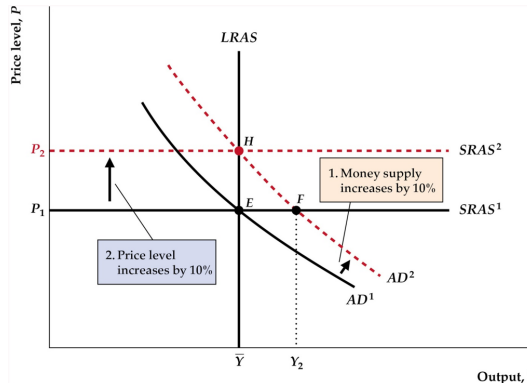
- ▶ **Short-run equilibrium** determined by AD and $SRAS$
- ▶ **Long-run equilibrium** determined by AD and $LRAS$
- ▶ At point E , output is lower than what firms want to produce
- ▶ Eventually prices fall $P \downarrow$
- ▶ $SRAS$ shifts down
- ▶ Economy converges to long-run equilibrium F



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