

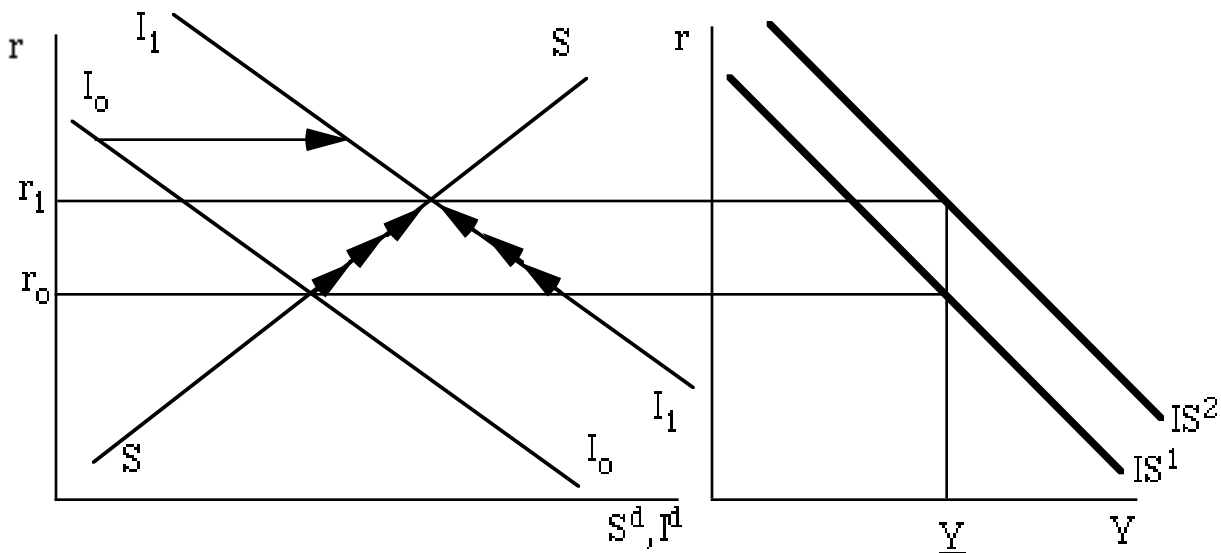
1. Use the IS-LM model to determine the effects of each of the following on the general equilibrium values of the real wage, employment, output, the real interest rate, consumption, investment, and the price level.

a. A reduction in the effective tax rate on capital that increases desired investment.

Answer:

$$I^d(r; \overline{MPK}^f, \bar{\tau})$$

If  $\downarrow \tau$ , then the investment schedule shifts to the right.



**Adjustment story:** at  $r_0$  the level of desired savings is less than the level of desired investment. That is equivalent to saying the following

$$Y < C^d + I^d + G$$

i.e., the Goods Market is not in equilibrium at  $r_0$ . Explain adjustment in the goods market in terms of **movements along** desired savings and desired investment. (Note that we are assuming that prices of the goods are not changing)

$$\text{at } r_0 : \bar{Y} < c^d + I^d + G$$

$\Rightarrow$  consumers save less and firms invest more  
when the interest rate is low

$\Rightarrow \uparrow r$  eliminates the excess demand  
 for goods over the supply by  
 $\downarrow c^d$  &  $\downarrow I^d$  until  $\bar{Y} = c^d + I^d + G$

**adjustment along the savings schedule:**

$\uparrow r \Rightarrow \uparrow S^d = Y - \downarrow C^d - G$

**adjustment along the investment schedule:**

$\uparrow r \Rightarrow (\uparrow r + d)p_k = \uparrow uc$

$\Rightarrow \downarrow I_t = \downarrow K^* - K_t + dK_t$

Now we can write out the IS function explicitly

$$IS(r, Y; \bar{y}_f^e, \bar{W}, \bar{G}, \bar{T}, \overline{MPK}^f, \bar{\tau})$$

If  $\downarrow \tau$  then the IS curve shifts up, i.e., to the right.

Note that when we consider changes in  $r$  and  $Y$ , then we are contemplating movements **along** the IS curve!

When an exogenous variable changes, we are considering what happens to the equilibrium interest rate for a **given level of output,  $\bar{Y}$** .

**Asset Market Equilibrium:**

Recall our money demand function

$$M^d = PL(Y, r + \pi^e)$$

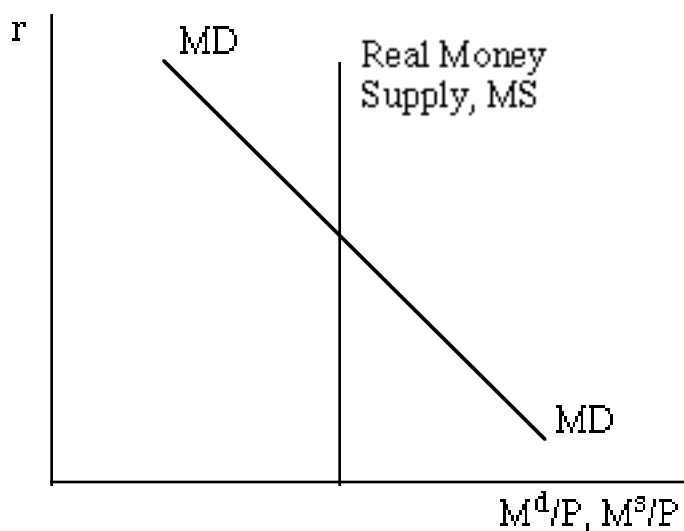
In equilibrium

$$M^s = M^d$$

$$\Rightarrow M^s = PL(Y, r + \pi^e)$$

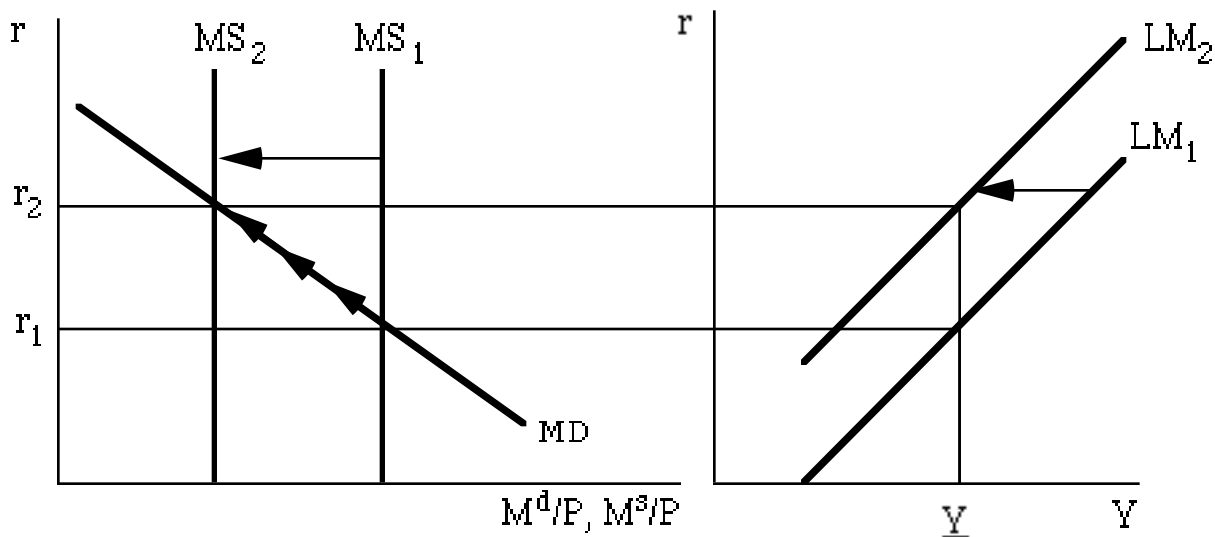
$$\Rightarrow \frac{M^s}{P} = L(Y, r + \pi^e)$$

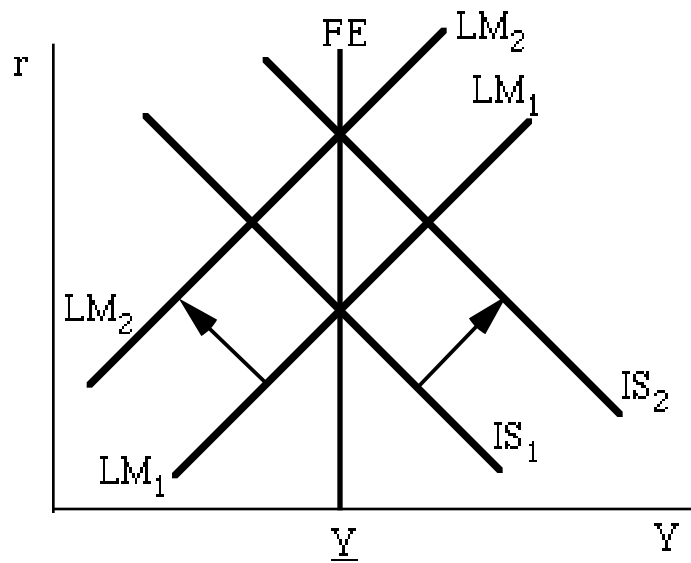
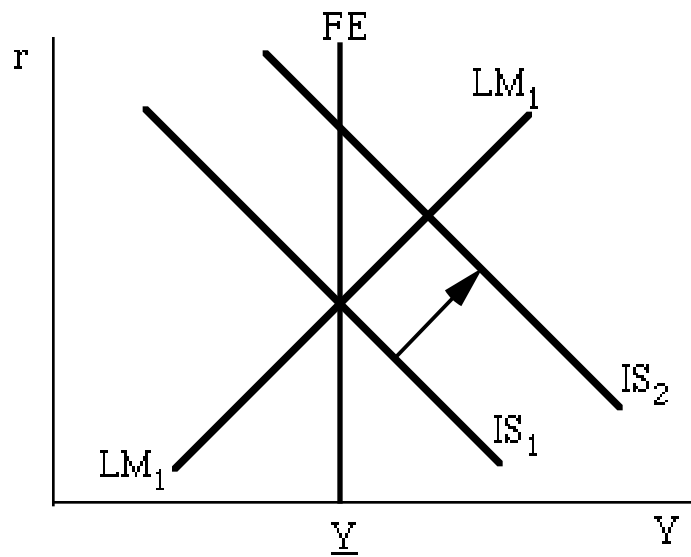
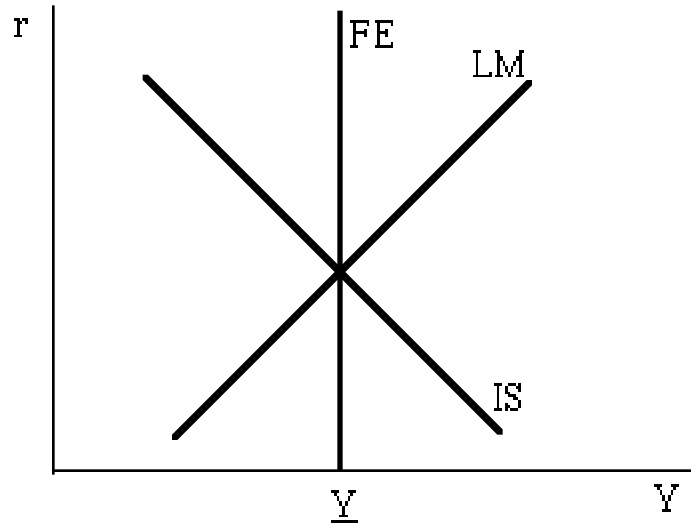
Now we can graph this relationship



Money supply changes:  $\uparrow P$  shifts the money supply curve to the left

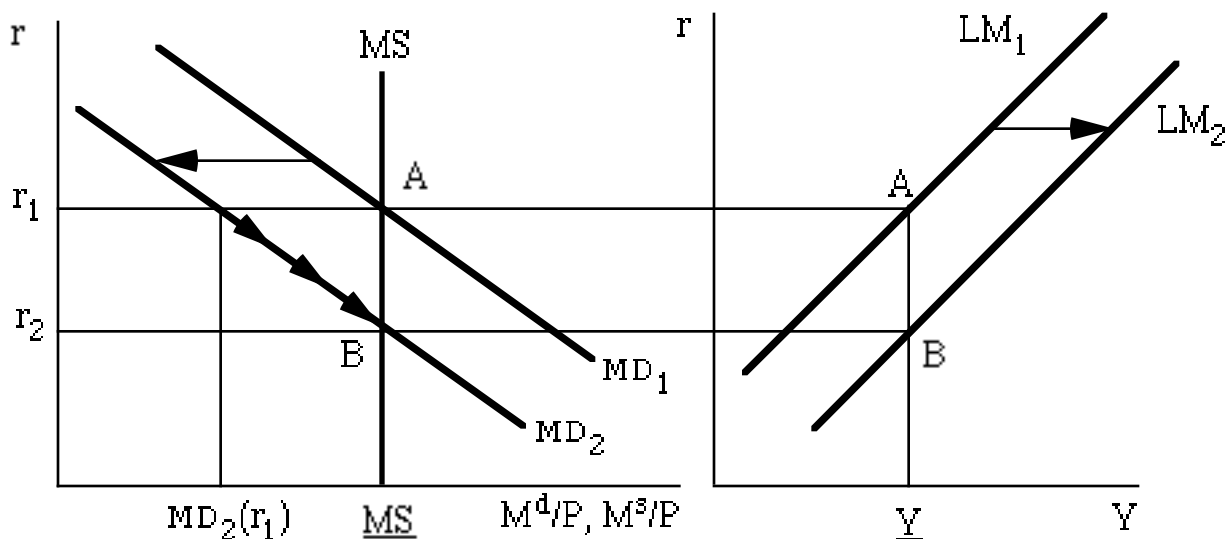
**Adjustment Story:** at  $r_1$ , the quantity of money demanded exceeds the quantity of money supplied. As money holders sell some of their nonmonetary assets so they can hold more money in their portfolios, the price of nonmonetary assets is driven down. This raises the real interest rate on nonmonetary assets. As  $r$  rises the quantity of money demanded falls (movement along a negatively sloped money demand curve), until equilibrium is reached. **Show with the money demand equation.**





b. The expected rate of inflation rises.

Answer: If  $\uparrow \pi^e$  then real money demand falls, i.e., shifts back.



**Adjustment Story:** at the old interest rate, the supply of money exceeds the quantity of money demanded. Agents purchase nonmonetary assets, driving their prices up and their real returns (the real interest rate paid on the asset) down. As the real interest rate falls, individuals find the nonmonetary asset less and less attractive relative to money. Eventually the interest rate will fall so low that the excess supply of money and the excess demand for nonmonetary assets are zero.

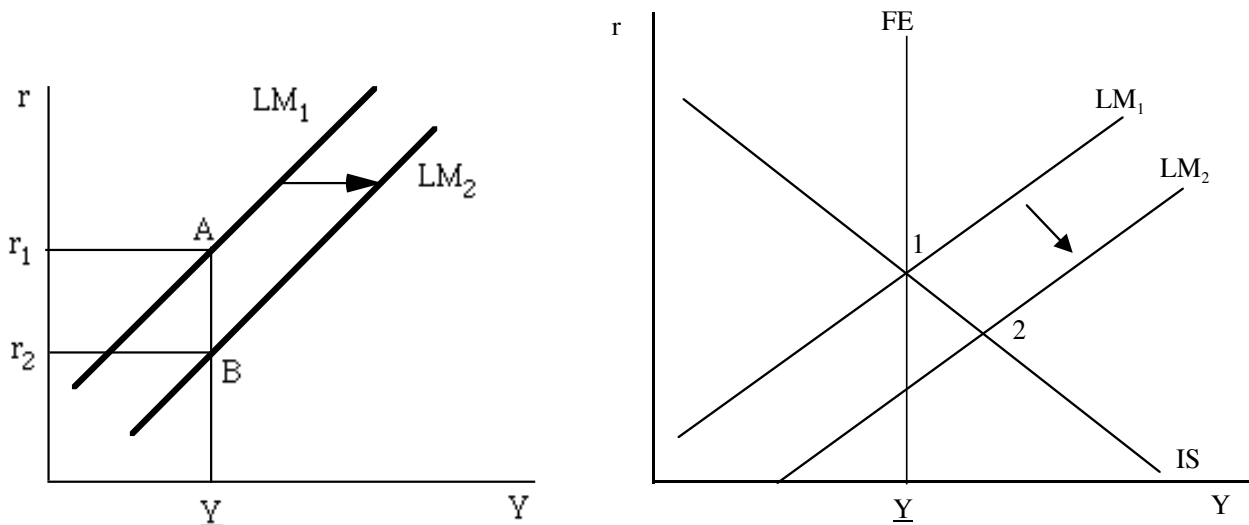
$$\begin{aligned} \downarrow r &\Rightarrow \downarrow M^d = P \downarrow L(Y, \downarrow r + \pi^e) \\ &\Rightarrow \text{movement along new money demand schedule.} \end{aligned}$$

We can write the LM function<sup>1</sup> as follows

$$LM \left( r, Y; \overline{\pi}^e, \overline{P}, \overline{M}^s, \overline{i}^m, \overline{W}, \overline{\text{risk of nonmonetary assets}}, \overline{\text{risk of money}}, \overline{\text{efficiency of payments technologies}}, \overline{\text{liquidity of alternative assets}} \right)$$

<sup>1</sup> This is by no means an exhaustive listing. Note again that when we write the LM function we usually suppress a number of the variables.

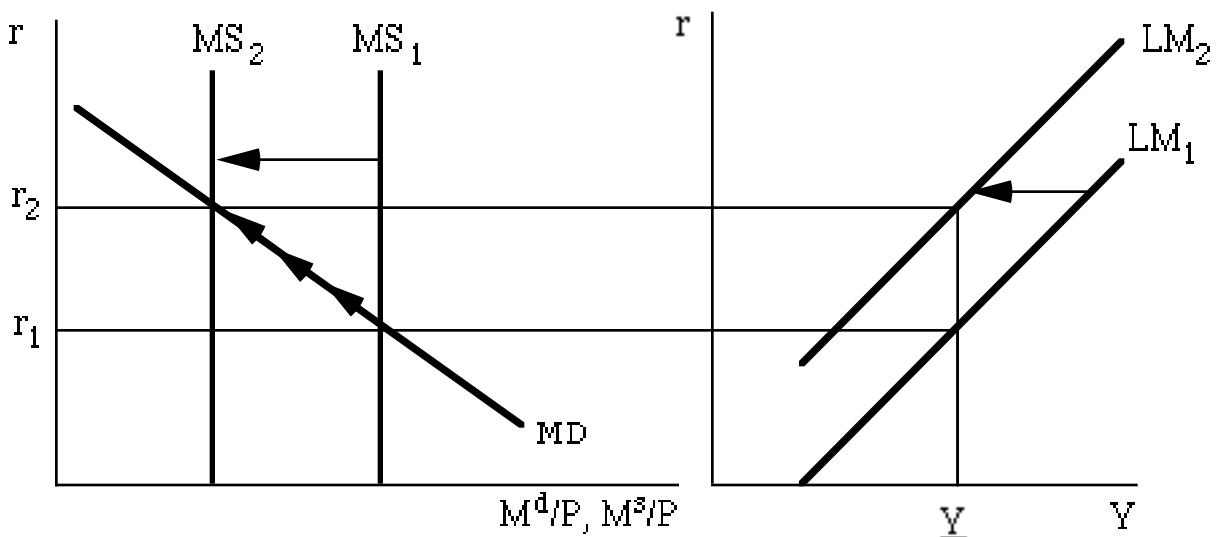
If  $\uparrow \pi^e$ , then the LM curve shifts out, i.e., shifts to the right  
**But is that the end of the story? Are we in long run equilibrium at point 2?**



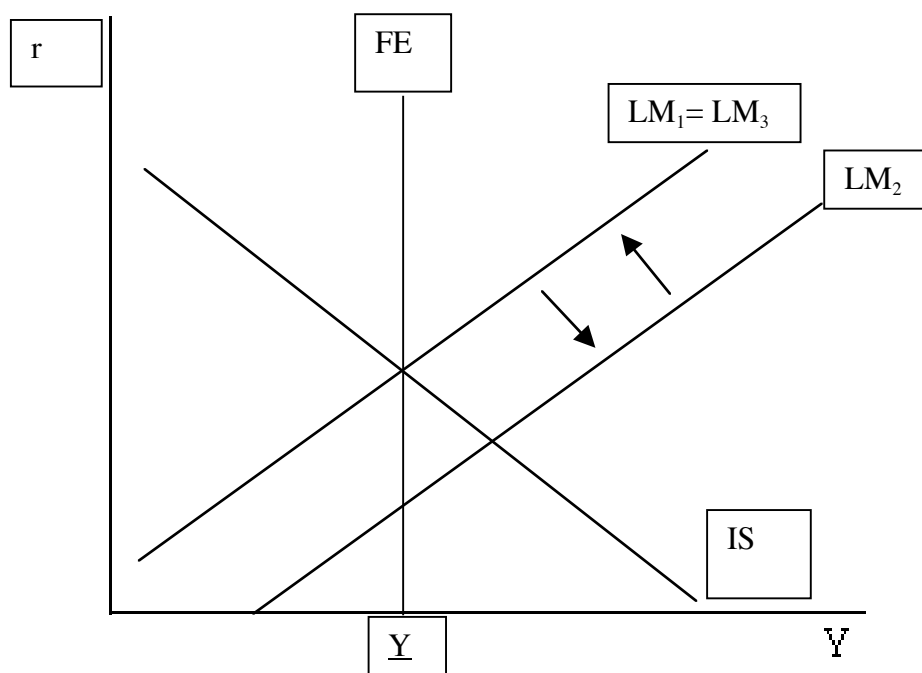
**Point 2 is not a long run equilibrium. What will bring our economy into long run equilibrium?**

**Money supply changes:**  $\uparrow P$  shifts the money supply curve to the left

**Adjustment Story:** at  $r_1$  the quantity of money demanded exceeds the quantity of money supplied. As money holders sell some of their nonmonetary assets so they can hold more money in their portfolios, the price of nonmonetary assets is driven down. This raises the real interest rate on nonmonetary assets. As  $r$  rises the quantity of money demanded falls (movement along a negatively sloped money demand curve), until equilibrium is reached. Show with the money demand equation.



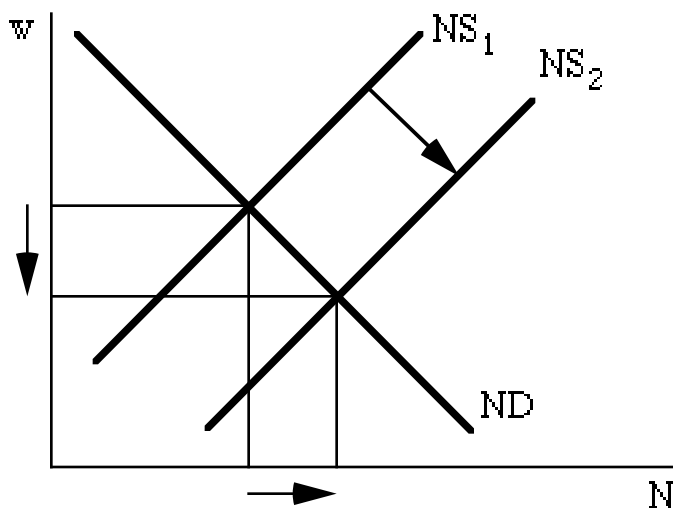
Putting it together we have the following



**Summary of Changes:** The **rise in expected inflation** shifts the LM curve down. The price level rises, shifting the LM curve up to restore equilibrium. Since the real interest rate is unchanged, consumption and investment are unchanged. Thus, there is no change in the real wage, employment, output, the real interest rate, consumption, or investment; and there is a rise in the price level.

c. An **influx of working-age immigrants** increases labor supply (ignore any other possible effects of increased population).

Answer:

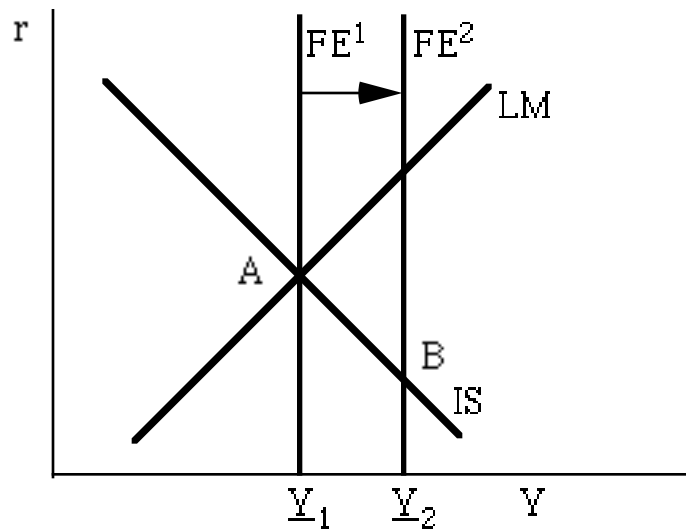


The increase in labor supply is shown above. The real wage declines and the level of employment rises

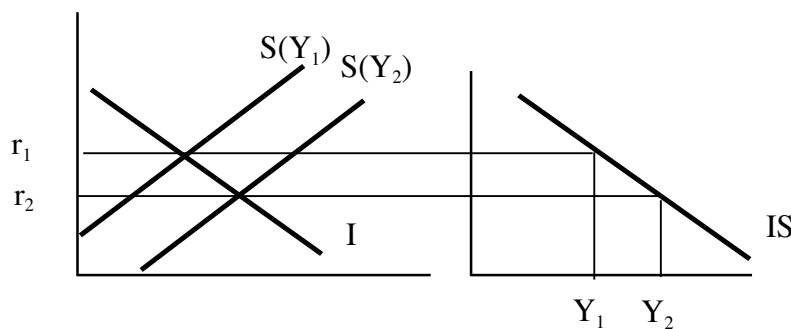
**Increase in labor supply:**

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

**Full Employment Output Changes:**  $\uparrow Y$  is precisely how we derived the IS schedule. Thus IS does not change and the shift in the FE line is along a stable IS curve.



An increase in labor supply, increases the full employment level of output. Does the IS curve shift? NO. This is a movement along the IS curve. What happens to national savings when  $Y$  changes?



**ANS:**

$$\uparrow Y \Rightarrow \uparrow S^d = \uparrow Y - \uparrow C_d - G$$

How do we explain the movement along the IS curve?

**At point A:** Initial general equilibrium point. After the influx of working-age immigrants, this is the short run equilibrium, where IS and LM intersect. Here the goods market is in equilibrium since aggregate quantities of goods supplied equal the quantities demanded. Recall that firms always produce more output as aggregate quantities of goods demanded rises. But notice that the firms, though, they are meeting this demand, they are producing less output than the new full-employment level of output. The full employment level of output rose when FE shifted to the right. The full-employment level of output is determined by firms' labor and capital hiring decisions. But, at point A, firms' are producing less than their profit maximizing levels of output. So at point A

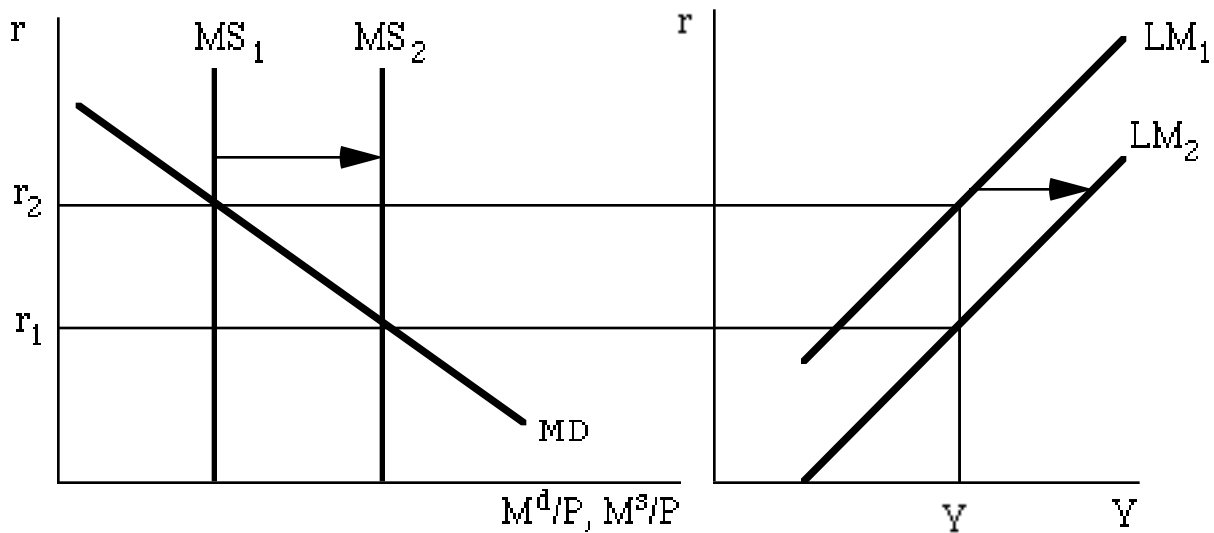
$$\bar{Y} > C^d + I^d + G$$

Thus point A cannot be a long run equilibrium. But how will this adjust? Recall, that we have taken prices to be fixed. But now that will no longer be the case. Firms will lower their prices since they want to produce more.

Price level falls:

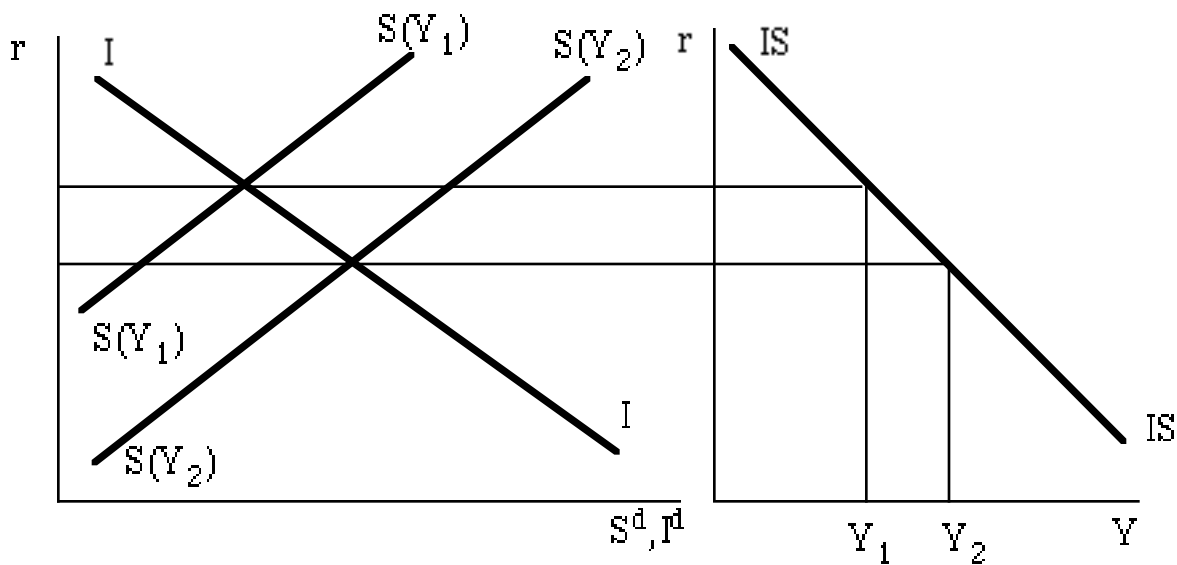
$$\Rightarrow \uparrow \left( \frac{M^s}{\downarrow P} \right) = \uparrow L(Y, \downarrow r + \pi^e)$$

$\Rightarrow$  real money supply shifts to the right  
along a stable money demand function

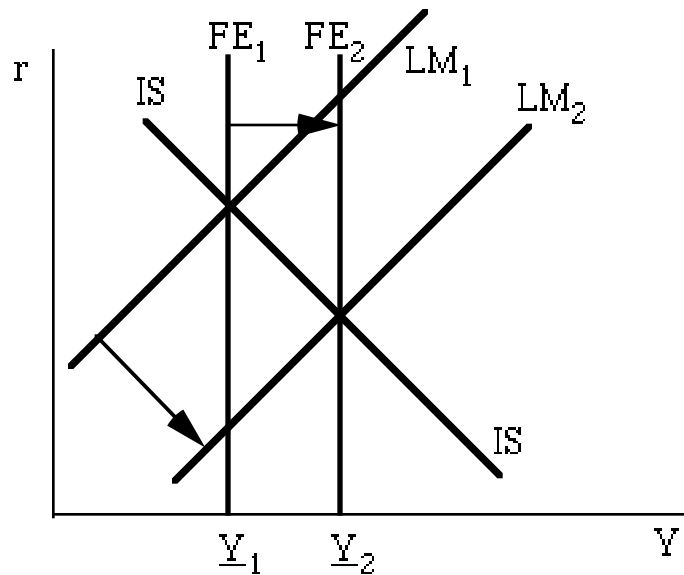


$$\uparrow Y \Rightarrow \uparrow C^d \Rightarrow \uparrow S^d = \uparrow Y - \uparrow C^d - \bar{G}$$

$\Rightarrow$  savings shifts rightward



After the adjustment



The rise in employment causes an increase in output, shifting the FE line to the right. To restore equilibrium, the price level must decline, shifting the LM curve down. Since **output increases** and the **real interest rate declines**, **consumption and investment increase**. In summary, **real wage, the real interest rate, and the price level decline; and employment, output, consumption, and investment rise**.

d. The introduction of automatic teller machines reduces the demand for money.

Answer: The reduction in the demand for money gives results identical to those in part (b).

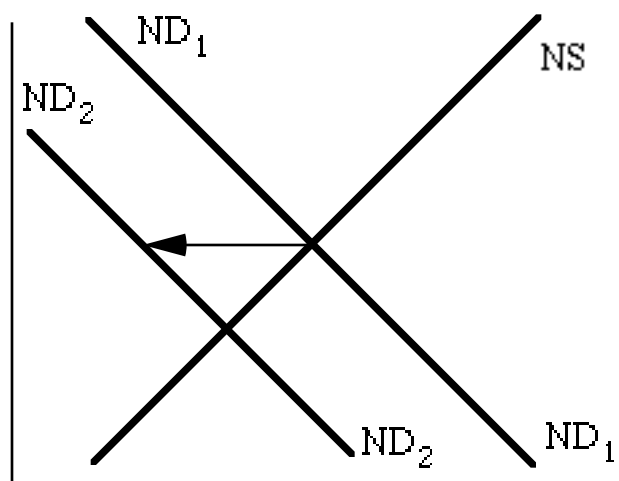
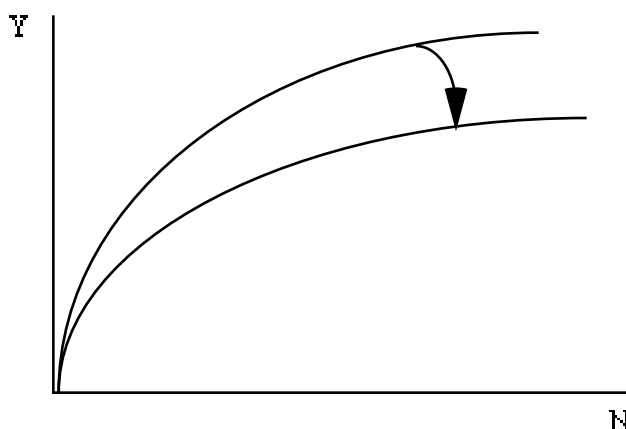
2. Use the IS-LM model to analyze the general equilibrium effects of a permanent increase in the price of oil (a permanent adverse supply shock) on current output, employment, real wage, national saving, consumption, investment, the real interest rate, and the price level. Assume that, besides reducing the current productivity of capital and labor, the permanent supply shock lowers both the expected future MPK and households' expected future incomes. Show that, if real interest rate rises at all, it will rise less than in the case of a temporary supply shock that has an equal effect on current output.

**Answer:** The increase in the price of oil reduces the marginal product of labor, causing the labor demand curve to shift to the left. Consider the following Cobb-Douglas Production function.

$$Y = AK^\gamma N^{(1-\gamma)} \quad \text{where } \gamma \in [0, 1]$$

$$\frac{\partial Y}{\partial N} = (1-\gamma)A \left(\frac{K}{N}\right)^\gamma$$

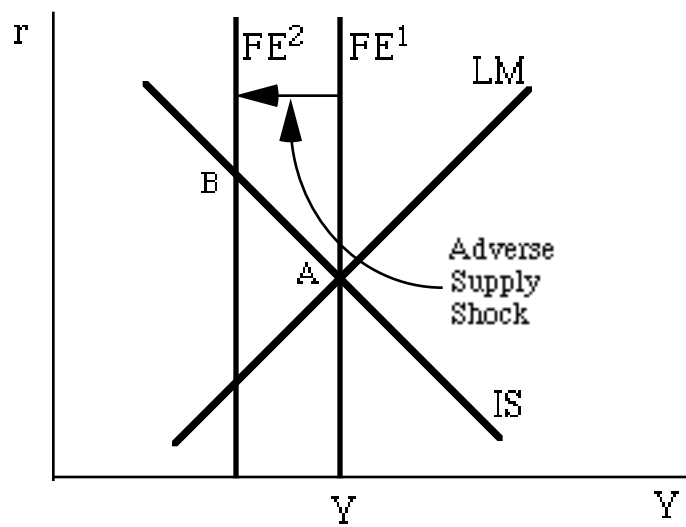
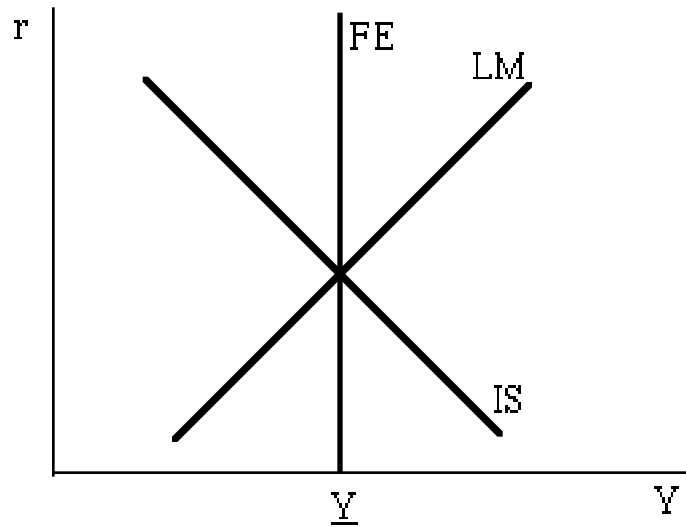
$$\text{If } \downarrow A \Rightarrow \downarrow \frac{\partial Y}{\partial N} = (1-\gamma) \downarrow A \left(\frac{K}{N}\right)^\gamma$$



**Decrease in the quantity of labor supplied:**

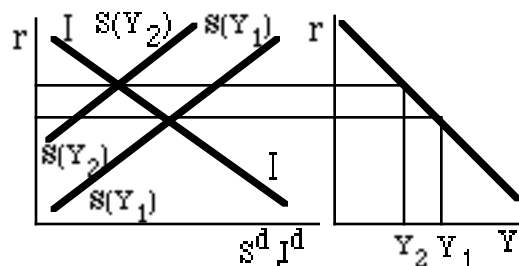
$$\downarrow \bar{N} \Rightarrow \downarrow \bar{Y} = AF(\bar{K}, \downarrow \bar{N})$$

**Full Employment Output Changes:** Consider a temporary adverse supply shock first



A temporary adverse supply shock, reduces the full employment level of output. Does the IS curve shift? **NO**. This is a movement along the IS curve. What happens to national savings when Y changes? **ANS:**

$$\downarrow Y \Rightarrow \downarrow S^d = \downarrow Y - \downarrow C^d - \bar{G}$$



$\downarrow Y$  is precisely how we derived the IS schedule. Thus IS does not change and the shift in the FE line is along a stable IS curve.

At point A: Initial general equilibrium point. After the adverse supply shock, this is the short run equilibrium, where IS and LM intersect. Here the goods market is in equilibrium since aggregate quantities of goods supplied equal the quantities demanded. Recall that firms always produce more output as aggregate quantities of goods demanded rises. But notice that the firms, though, they are meeting this demand, they are producing more output than the new full-employment level of output. The full employment level of output fell when  $\bar{Y}$  shifted to the left. The full-employment level of output is determined by firms' labor and capital hiring decisions. But, at point A, firms' are producing more than their profit maximizing levels of output. So at point A

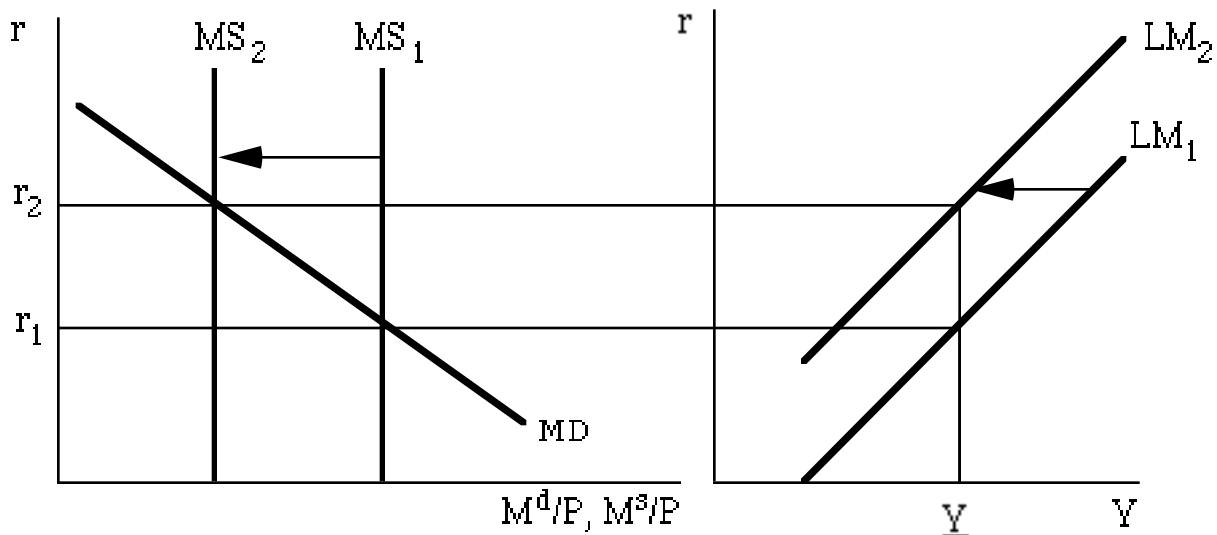
$$\bar{Y} < C^d + I^d + G$$

Thus point A cannot be a long run equilibrium. But how will this adjust? **Recall, that we have taken prices to be fixed. But now that will no longer be the case.** Firms will raise their prices since the aggregate quantity of goods demanded exceeds what firms want to produce.

Price level rises:

$$\Rightarrow \downarrow \left( \frac{M^s}{\uparrow P} \right) = \downarrow L(Y, \uparrow r + \pi^e)$$

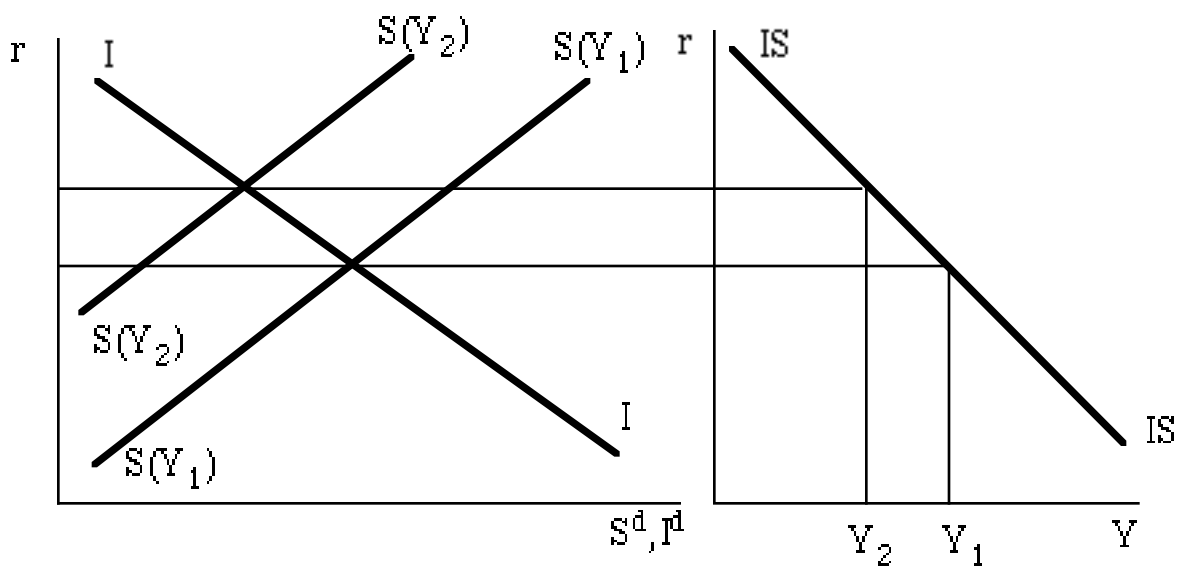
$\Rightarrow$  real money supply shifts to the left  
along a stable money demand function



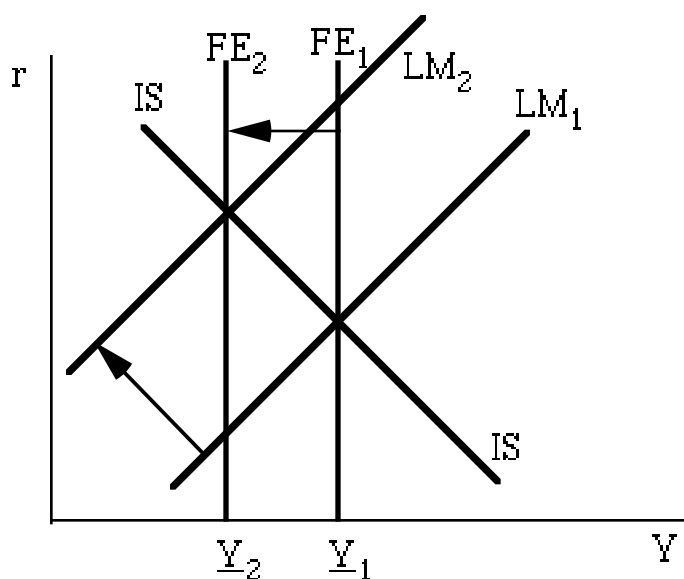
How do we explain the movement along the IS curve?

$$\downarrow Y \Rightarrow \downarrow C^d \Rightarrow \downarrow S^d = \downarrow Y - \downarrow C^d - \bar{G}$$

$\Rightarrow$  savings shifts leftward



After the adjustment



When the **shock is temporary** there is no impact on **future output** or the **future marginal product of capital**, so the **IS curve does not shift**. In that case the price level increases to restore equilibrium. In that case, **the real interest rate unambiguously increases**.

**KEY POINT:** Under a **permanent shock**, the IS curve shifts down, so the rise in the real interest rate is less than in the case of a temporary shock, and the real interest rate can even decline.

We have provided the answer to the case of a temporary supply shock.

Now consider the case of a **permanent supply shock**.

The **adverse supply shock** results in a shift to the left of the full-employment line, as both employment and productivity decline.

Because the **shock is permanent**, it **reduces future output** and **reduces the future marginal product of capital**, both of which result in a **downward shift of the IS curve**.

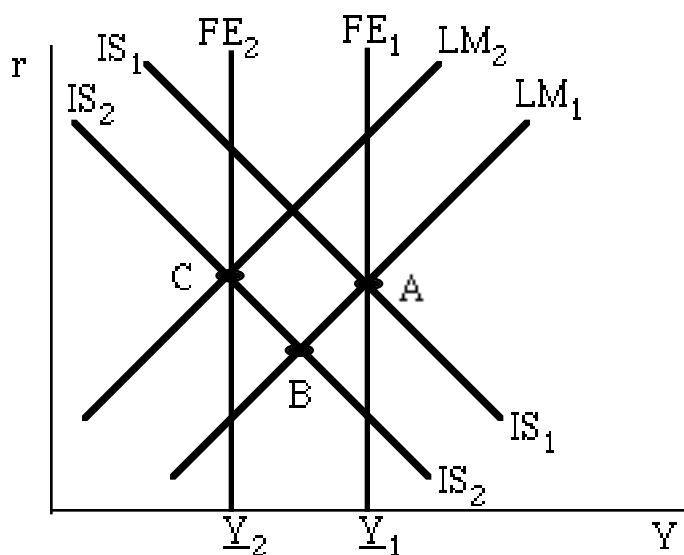
The new equilibrium is located at the intersection of the new IS curve and the new FE line.

If, as we have drawn the figure, this intersection lies above and to the left of the original LM curve, the price level will increase and shift the LM curve upward to pass through the new equilibrium point.

The **result** is an **increase in the price level**, but an **ambiguous effect on the real interest rate**.

**Since output is lower, consumption is lower.**

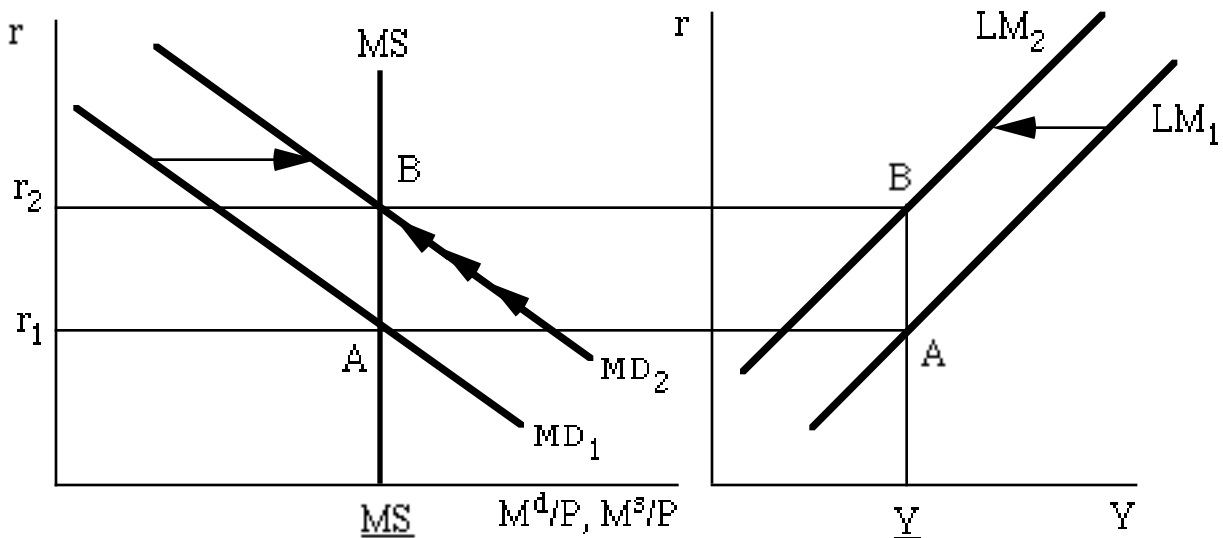
Since the effect on the real interest rate is ambiguous, **the effect on saving and investment are ambiguous** as well, though the fall in the future marginal product of capital would tend to reduce investment.



3. Suppose that the price level is fixed in the short run so that the economy doesn't reach general equilibrium immediately after a change in the economy. For each of the following changes, what are the short-run effects on the real interest rate and output? Assume that, when the economy is in disequilibrium, only the labor market is out of equilibrium; assume also that for a short period firms are willing to produce enough output to meet the aggregate demand for output.

a. A decrease in the expected rate of inflation.

Answer: If  $\downarrow \pi^e$  then real money demand rises, i.e., shifts rightward.



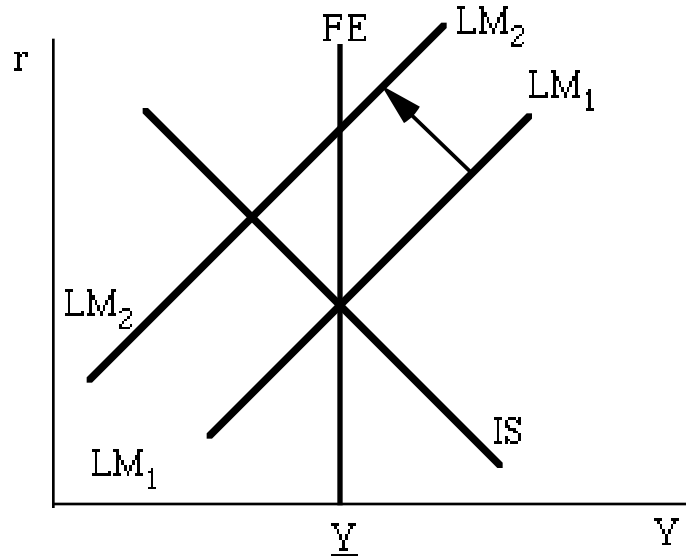
**Adjustment Story:** at the old interest rate, the quantity of money demanded exceeds the supply of money. Agents sell nonmonetary assets, driving their prices down and their real returns (the real interest rate paid on the asset) up. As the real interest rate rises, individuals find money less and less attractive relative to the nonmonetary asset. Eventually the interest rate will rise so high that the excess supply of money and the excess demand for nonmonetary assets are zero.

$$\uparrow r \Rightarrow \uparrow M^d = P \uparrow L(Y, \uparrow r + \pi^e)$$

$\Rightarrow$  movement along new money demand schedule.

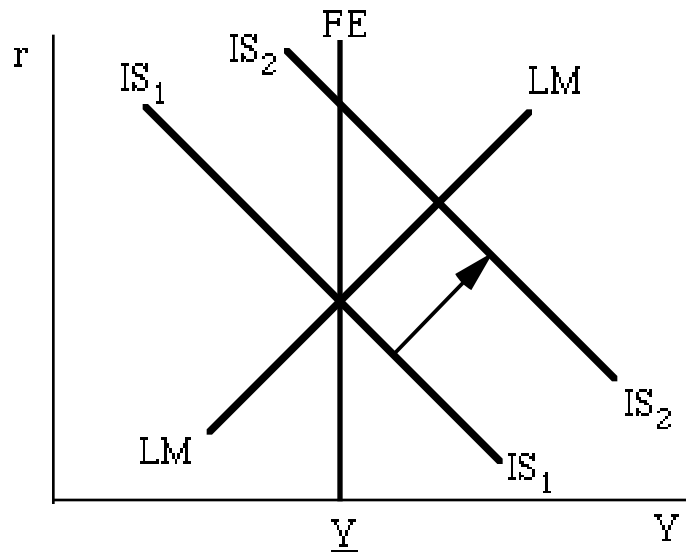
Where the LM function is

$$LM \left( r, Y; \overline{\pi}^e, \overline{P}, \overline{M}^s, \overline{i}^m, \overline{W}, \overline{\text{risk of nonmonetary assets}}, \overline{\text{risk of money}}, \overline{\text{efficiency of payments technologies}}, \overline{\text{liquidity of alternative assets}} \right)$$



b. An **increase in consumer optimism** that increases desired consumption at each level of income and the real interest rate.

**Answer:** The increase in desired consumption shifts the IS curve up, as shown below. This causes the real interest and output to rise.

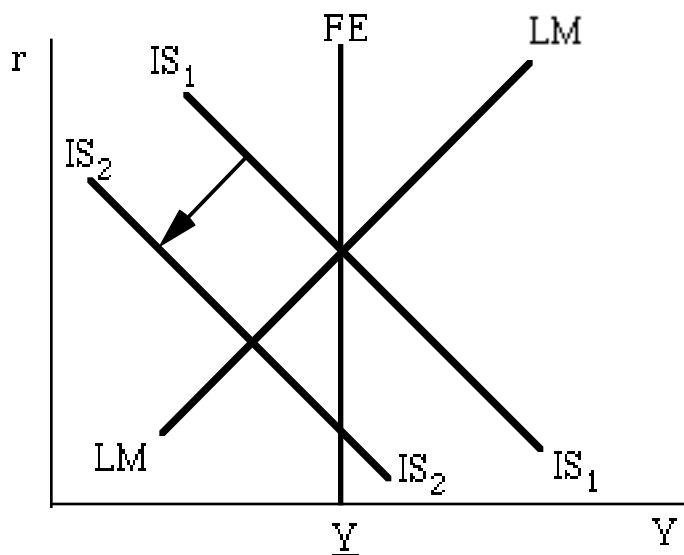


c. An **increase in government purchases**.

**Answer:** The increase in government purchases shifts the IS curve up, with the same result as in part (b).

d. An **increase in lump-sum taxes**, with no change in government purchases (consider both the case in which Ricardian equivalence holds and the case in which it doesn't).

Answer: **If Ricardian equivalence holds, the increase in taxes has no effect.** If Ricardian equivalence doesn't hold, the increase in taxes reduces consumption spending and the IS curve shifts down. Both the real interest rate and output decline.



e. A scientific breakthrough increases the expected future MPK.

Answer: An increase in the expected future marginal productivity of capital shifts the IS curve up, with the same result as in part (b).