# The IS-LM model

## Learning objectives

On completion of this chapter and having completed the essential reading and activities you should be able to:

- explain the determination and economic interpretation of the IS-LM model
- illustrate the simultaneous equilibrium in the goods and the money market
- describe how any change in the variables and the parameters of the IS-LM model alters the equilibrium levels of output and interest rate
- clarify the Keynesian view of short-run fluctuations in economic activity
- show how fiscal and monetary policies contribute to the determination of output and interest rate in the short run, and their use as tools for macroeconomic stabilisation

## The goods market

The goods market is the trade market of all goods and services produced in an economy. The Keynesian cross model, which you have already encountered in the Introduction to Economics, which describes the goods market equilibrium under the following assumptions:

1. all firms produce the same goods, which are then used by consumers for consumption and residential investment, by firms for fixed assets investment, or by the government
2. firms are willing to supply any amount of goods at the existing price level
3. the economy is closed
4. investment is exogenous or fixed, i.e. it is not affected by income and the interest rate

***The aggregate demand*** $(G)$ ***is equal to the sum of private consumption*** $(C)$, ***investments*** $(I)$ ***and government spending*** $(G)$:

$$Z=C+I+G. \qquad (2.1)$$

Consumption is defined as the value of goods and services purchased by households. Investment refers to fixed business investment carried out by firms, i.e. purchases of real assets, such as plant and machinery; and to residential investment carried out by households, i.e. purchases of real estate properties such as houses. Government spending refers to the demand for goods and services of the public sector.

In general, consumption depends positively on income and negatively on taxes:

$$C = C\underset{+}{(}Y,\underset{-}{T}).$$

Many textbooks assume the function $C(.)$ to be linear, so that consumption can be written as:

$$C= c_0+c_1(Y-T), \qquad (2.2)$$

where $T$ measures lump sum taxes on consumption, and the term $Y$-$T$ indicates disposable income.[3] The parameter $c_0$ indicates the level of consumption affected by factors other than disposable income, such as borrowing, sale of real and financial assets, etc. The value of $c_0$ depends also upon consumers' spending habits and ***consumer confidence*** about current and future spending opportunities. The parameter $c_1$ is the ***marginal propensity to consume***, namely the increase in consumption resulting from one unit increase in disposable income. Since $0< c_1<1$, an increase in disposable income cannot be either entirely saved, $c_1=0$, or entirely consumed, $c_1=1$. In turn, the value $1$-$c_1$ measures the ***marginal propensity to save***, i.e. the increase in saving resulting from an extra unit of disposable income.

In the basic version of the model investment, taxes and government spending are exogenous and indicated by using a bar above their corresponding symbols: $I=\overline{I}$, $T=\overline{T}$, and $G=\overline{G}$. These values can be substituted into equation (2.1) and combined with (2.2) to write the aggregate demand function as:

$$Z=\left(c_0-c_1\overline{T}+\overline{I}+\overline{G}\right)+c_1Y, \qquad (2.3)$$

***Aggregate supply has no effect on the equilibrium level of income*** because firms produce as many goods and services as demanded in the economy.[4] Analytically, aggregate supply is written as:

$$Y=Z, \qquad (2.4)$$

where the symbol $Y$ indicates production or, equivalently, income, or GDP.

The equilibrium level of output, $Y^*$, in the goods market is determined by the equality between aggregate supply and aggregate demand and it is given by:

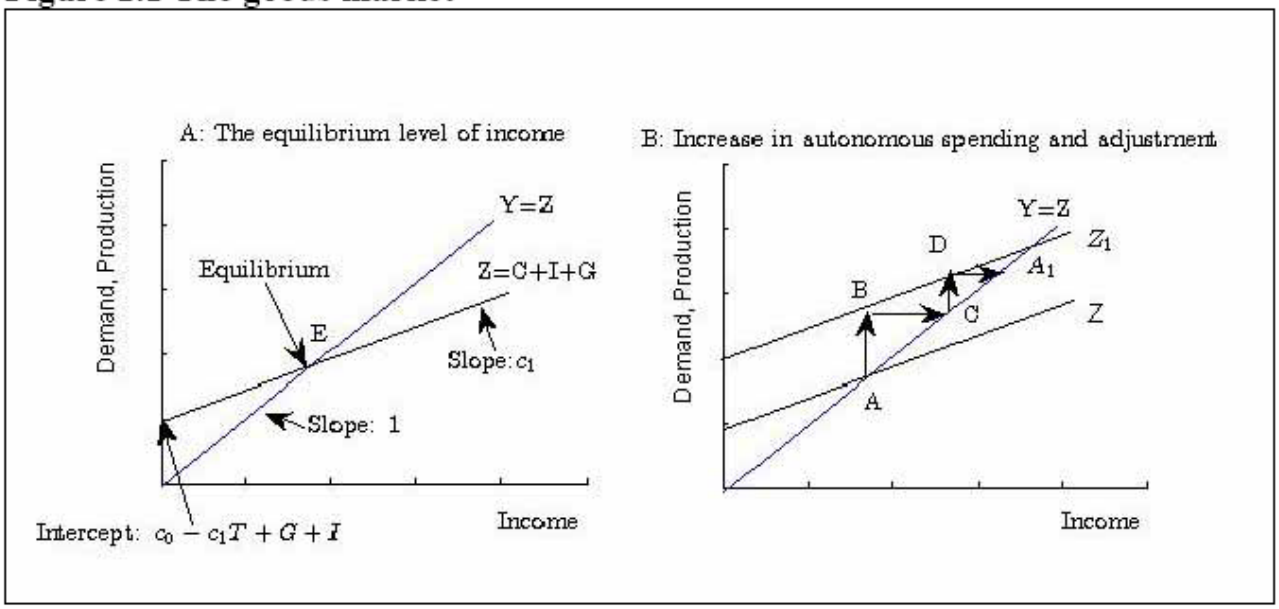
$$Y^*=\frac{1}{1-c_1}\left(c_0-c_1\overline{T}+\overline{I}+\overline{G}\right). \qquad (2.5)$$

Equation (2.5) shows that the equilibrium level of output is equal to the product between the ***multiplier***, $1/(1-c_1)$, and ***autonomous spending***, $c_0-c_1\overline{T}+\overline{I}+\overline{G}$.
Autonomous spending measures the level of aggregate spending which is independent of income. The multiplier indicates the overall effect of a change in autonomous spending on income, precisely the cumulative increase in the level of income resulting from a one unit increase in the level of autonomous spending. In the Keynesian Cross model, the multiplier is larger the greater the propensity to consume.

Figure 2.1 gives a graphical interpretation of the equilibrium in the goods market in the income – demand space. Panel A plots the aggregate demand and supply schedules. The aggregate supply schedule has slope equal to 1, since production always equals demand. The

slope of the aggregate demand schedule depends only upon the marginal propensity to consume: an increase (decrease) in $c_1$ makes the aggregate demand schedule steeper (flatter), since households consume more (less) for every unit of disposable income. The intercept of the aggregate demand schedule depends only upon the level of autonomous spending: an increase (decrease) in autonomous spending shifts the aggregate demand upwards (downwards). Panel B shows the effect of an increase in autonomous spending on the level of output. The initial equilibrium output is in point A, where aggregate demand *Z* intersects aggregate supply. A one unit increase of autonomous spending shifts the aggregate demand upwards (from A to B). Firms respond to the increase in demand by increasing production (from B to C). The increase in production raises income and consumption by $c_1$, in turn leading to a further increase in demand (from C to D). The new increase in demand further stimulates production, income and demand by $c_1 \times c_1$. This sequence of increases in demand, production and income continues until the economy reaches the new equilibrium in point $A_1$.

**Figure 2.1 The goods market**




## Investment

An important extension of the Keynesian Cross is obtained by assuming that investment spending depends positively on income (sales) and negatively on the interest rate. Analytically, this can be written as:

$$I = I\left(\underset{+}{Y}, \underset{-}{i}\right),$$

where $i$ indicates the interest rate.[8] An increase in the level of income determines an increase in production, which in turn raises demand for business fixed investment by firms. In addition, the increase in income raises, also, demand for residential investment as consumers can afford to buy more houses. Firms must borrow the funds necessary to carry out new investment. The interest rate represents the cost of new investment: the higher the interest rate, the lower the level of investment.

Assuming the function $I(.)$ to be linear, the demand for investment can be written as:

$$I = b_1 - b_2 i\,, \qquad (2.5)$$

where $b_1$ is a constant that computes the effect on investment of any variable other than the interest rate, such as income but also business confidence; whereas $b_2$ measures the sensitivity of investment to the interest rate.

The linear investment function in (2.5) can be substituted into equation (2.3) to write the aggregate demand as:

$$Z = \left(\mathrm{c}_0 - \mathrm{c}_1\overline{T} + b_1 - b_2 i + \overline{G}\right) + \mathrm{c}_1 Y\,,$$

which shows that the position of the aggregate demand depends positively upon business confidence, and negatively on the interest-elasticity of investment, and the interest rate. An increase (reduction) in the interest rate shifts the aggregate demand curve downward (upward). The larger the interest rate elasticity of investment the greater the response of aggregate demand to changes in the interest rate.
The equilibrium condition in equation (2.5) is written as:

$$Y = \left(\mathrm{c}_0 - \mathrm{c}_1\overline{T} + b_1 - b_2 i + \overline{G}\right) + \mathrm{c}_1 Y\,,$$

which can be solved to compute the new equilibrium level of income as:

$$Y^* = \frac{1}{1-\mathrm{c}_1}\left(\mathrm{c}_0 - \mathrm{c}_1\overline{T} + b_1 - b_2 i + \overline{G}\right). \qquad (2.6)$$

Therefore, under the specification of the investment function in equation (2.5), the multiplier is still entirely determined by the marginal propensity to consume, whereas autonomous spending now depends upon business confidence, the interest rate, and the responsiveness of investment to the interest rate. The interest rate multiplier is negative, since an increase in the interest rate reduces income by $b_2/(1-\mathrm{c}_1)$: the more investment is sensitive to the interest rate, the larger is the reduction in output following an increase in the cost of borrowing.

**Figure 2.2 Investment spending**

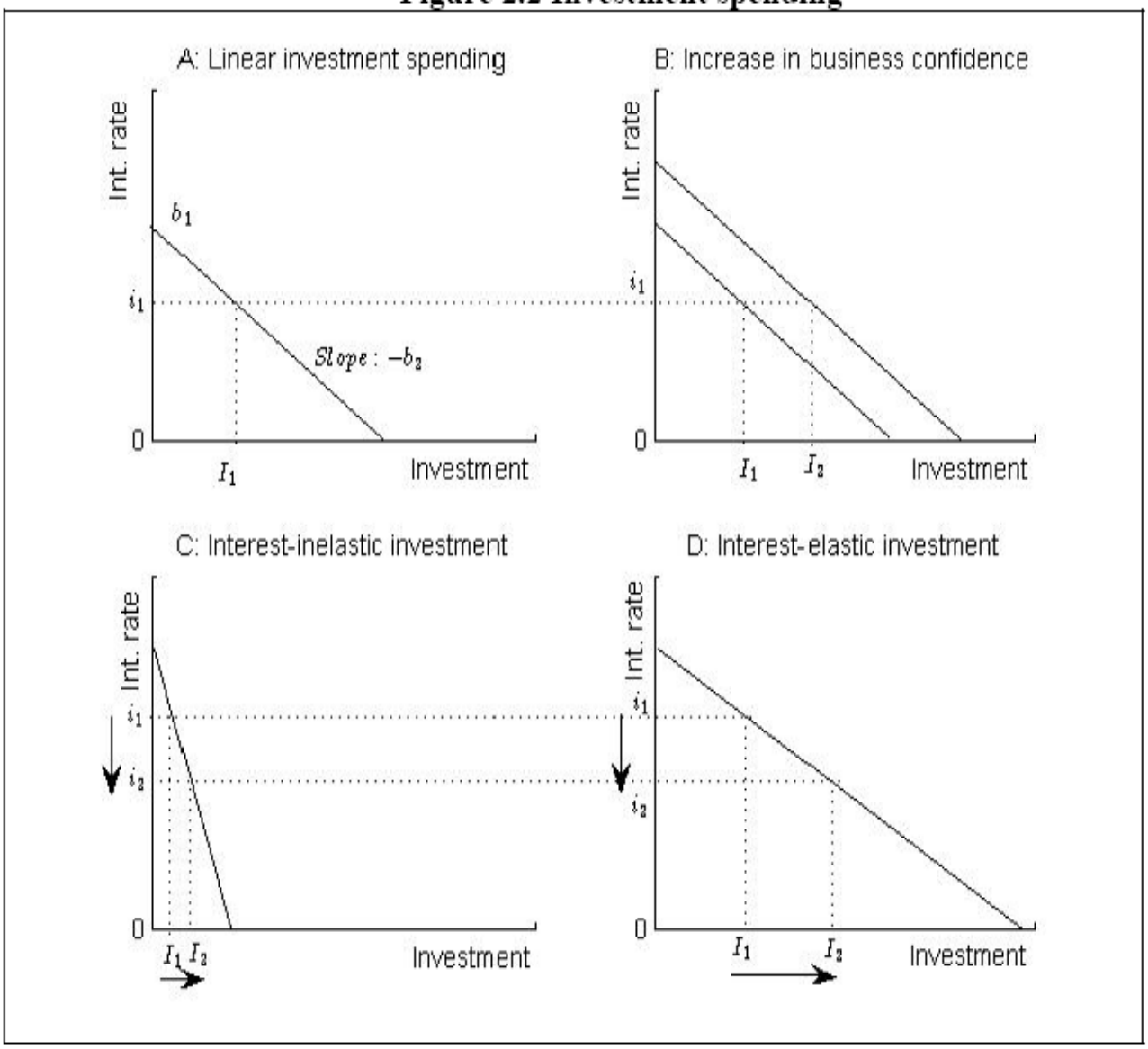



Figure 2.2 provides a graphical analysis of investment spending in the investment –interest rate space. Panel A plots the linear investment function for a specific level of income. Panel B shows that an increase in business confidence (or, similarly income) shifts the investment curve upwards. The slope of investment spending measures the elasticity of investment to changes in interest rates. Investment is ***interest-inelastic*** if a given change in the interest rate causes a relatively small response in investment (Panel C). In contrast, if a given change in the interest rate determines a significant change in investment, investment spending is described as ***interest-elastic*** (Panel D). As a result, the higher the investment elasticity to the interest rate is, the flatter the investment curve. Note in figure 2.2. how a similar reduction in the interest rate from $i_1$ to $i_2$ increases investment more in panel D than in panel C.

Note that investment spending could also be specified as:

$$I = b_1 Y - b_2 i \,. \qquad (2.7)$$

In this case, investment spending is proportional to income and $b_1$ is a parameter which measures the responsiveness of investment spending to increase in demand. Under this specification, the aggregate demand is given as:

$$Z = \left(c_0 - c_1 \overline{T} - b_2 i + \overline{G}\right) + \left(c_1 + b_1\right) Y \,,$$

which shows that business confidence affects the slope rather than the position of aggregate demand: the greater business confidence, the larger the response of aggregate demand to an increase in income (via investment), the steeper the aggregate demand schedule. Finally, it is easy to show that the equilibrium level of income would be given as:

$$Y^* = \frac{1}{1 - c_1 - b_1}\left(c_0 - c_1 \overline{T} - b_2 i + \overline{G}\right)$$

which shows that business confidence affects the magnitude of the income multiplier rather than aggregate spending. Note that, under this specification, the multiplier is larger than 1 only if $c_1 + b_1 < 1$, which is a condition required for the existence of the equilibrium in this extended version of the model. In addition, the multiplier is larger than under the standard model, $1/\left(1 - c_1 - b_1\right) > 1/\left(1 - c_1\right)$, since an increase in income has a more than proportional effect on both consumption and investment spending.

## The IS Curve

The equilibrium condition in equation (2.6) describes the IS curve, which includes combinations of income and interest rate, such that the goods market is in equilibrium. The IS curve is negatively sloped in the income – interest rate space; an increase in the interest rate reduces aggregate demand through investment spending, thus reducing the equilibrium income.

Analytically, the equation of the IS curve is computed by solving the equilibrium condition in equation (2.6) for the interest rate:

$$i^* = \frac{1}{b_2}\left(c_0 - c_1 \overline{T} + b_1 + \overline{G}\right) - \frac{1 - c_1}{b_2} Y^* \,. \qquad (2.8)$$

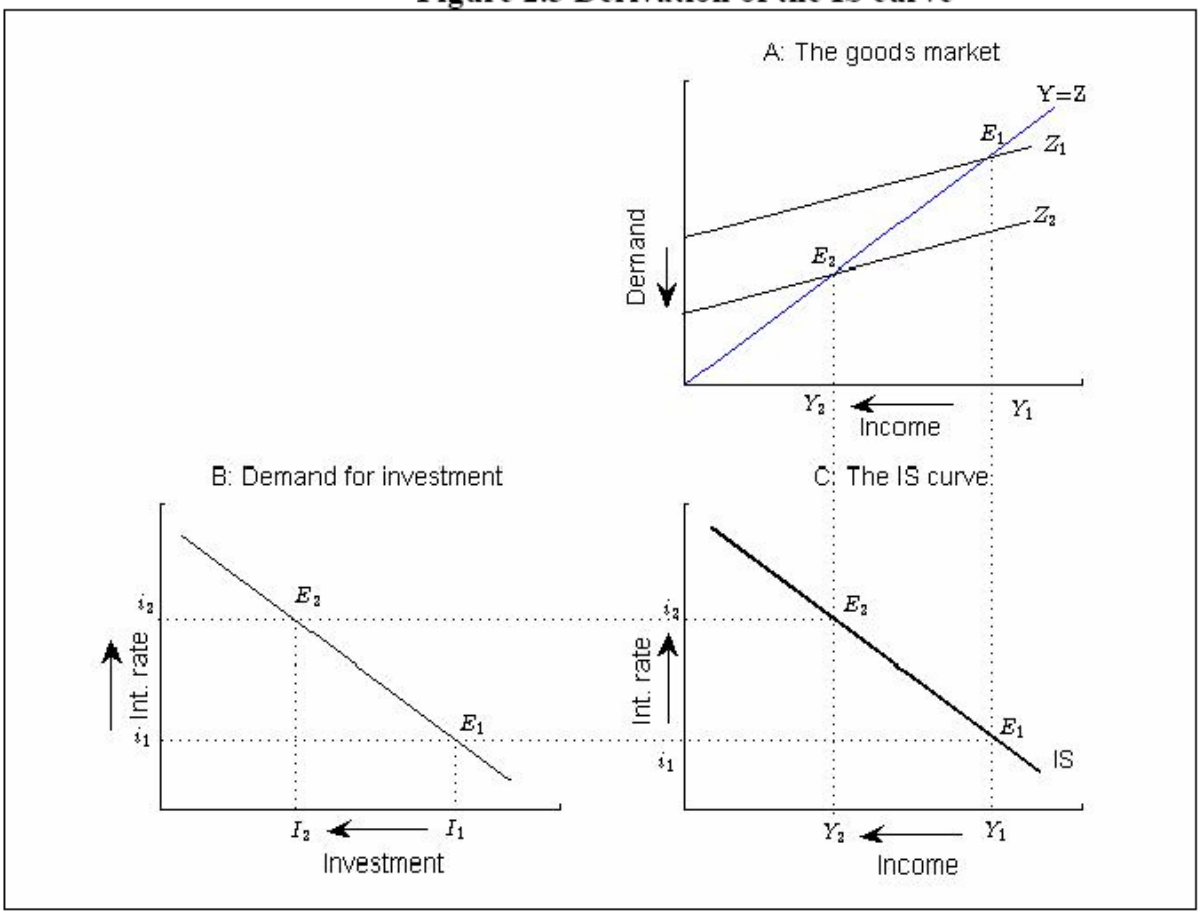
Note that if investment spending is proportional to income as in equation (2.7), the analytical solution to the IS curve is:

$$i^* = \frac{1}{b_2}\left(c_0 - c_1\overline{T} + \overline{G}\right) - \left(\frac{1 - c_1 - b_1}{b_2}\right)Y^*,$$

which shows that business confidence would affect the slope rather than the position of the IS curve: an increase in business confidence makes the IS curve flatter, since investment spending responds more to income for any given interest rate.

Equation (2.7) shows the position and the slope of the IS curve are affected by private sector and policy shocks, i.e. changes in the private sector behaviour – as captured by the parameters $c_0$, $c_1$, $b_1$, and $b_2$ – and monetary and fiscal policy changes.

**Figure 2.3 Derivation of the IS curve**




Note that if investment spending is proportional to income as in equation (2.7), the analytical solution to the IS curve is:

**Activity 1**

- Suppose the government estimates the households' propensity to consume in equation (2.5) to be equal to 0.9. What is the effect on income of an increase in public spending by 100?
- How much should the government cut taxes in order to increase income by the same amount?
- Calculate the balanced budget expansion required in order to increase income by the same amount.
- Suppose the government raises its revenue by levying a tax on consumers' income at the rate $\tau$. Write the new linear consumption function and describe the effect of income taxes on the equilibrium in the goods market.

**Activity 2**

Consider an economy described by the following equations:
Aggregate consumption: $C = 400 + 0.2(Y - T)$;
Aggregate investment: $I = 120 - 10i$;
Government sector: $G = T = 100$.

- Derive the aggregate demand function;
- Calculate the equilibrium level of income.
- What is the effect of an increase in the interest rate on the equilibrium level of income?

## Activity 3

In January 2007, fear of an imminent economic recession convinced the United States central bank (FED) to cut the interest rate by 0.75 per cent.

- Employ the IS curve in equation (2.8) to predict the likely effect of this policy on the equilibrium level of income under the two following assumptions: (i) interest-inelastic investment spending and (ii) interest-elastic investment spending.
- Can you think of any reason why investment spending could be relatively inelastic to the interest rate?

**The money market**

The interest rate is determined by the equilibrium condition in the money market. The Keynesian Liquidity Preference theory, which you have already encountered in Introduction to Economics, describes the money market equilibrium under the following assumptions:

1. the financial market includes only two assets: money and bonds
2. ***money*** is a liquid asset, in the sense that it can be used to purchase goods and services, and pays no interest[9]
3. ***bonds*** are issued by the government, cannot be used for transactions, but pay a positive interest rate $i$
4. Real wealth is fixed in the short run

The **supply of nominal money**, $M^s$, is independent from the interest rate and it is directly controlled by the central bank. The central bank can change money supply through open market operations. An **expansionary open market operation** occurs when the central bank buys bonds to increase money supply. When the central bank buys bonds from the private sector, the increase in demand for bonds raises the price of bonds, in turn reducing the interest rate. This reduction in the opportunity cost of holding money, in turn increases money demand. In contrast, a **contractionary open market operation** occurs when the central bank sells bonds. As a result, bond price falls, the interest rate increases, and money demand decreases. Analytically, real money supply, $M^s/P$, is written as:

Analytically, real money demand is described as:

$$\frac{M^d}{P} = L\underset{+}{(Y}, \underset{-}{i}),$$

which shows that real money demand depends positively on income and negatively on the interest rate. The above equation shows that demand for money is ultimately a demand for real balances, $M^d/P$, rather than nominal balances, $M^d$. The underlying assumption behind this specification is that individuals are free from ***money illusion***, i.e. the tendency of individuals to think of currency in nominal terms rather than taking into account its purchasing power.

If the function $L(.)$ is linear, real money demand can be written as:

$$\frac{M^d}{P} = h_1 Y - h_2 i, \qquad (2.10)$$

where the parameters $h_1$ and $h_2$ measure money demand elasticity to income and the interest rate, respectively.

Analytically, real money supply, $M^s/P$, is written as:

$$\frac{M^s}{\overline{P}} = \frac{M}{\overline{P}}, \qquad (2.10)$$

where $M$ is the level of nominal money supply chosen by the central bank. The money market equilibrium occurs when real money balances equal real money supply. Analytically, the money market equilibrium is obtained by combining equations (2.9) and (2.10) as follows:

$$\frac{M}{\overline{P}} = h_1 Y - h_2 i \qquad (2.11)$$

The equilibrium condition shows an important feature of the money market. Suppose the central bank increases nominal money supply to $M_1 > M$ , so that the money market is in disequilibrium:

$$\frac{M_1}{\overline{P}} > h_1 Y - h_2 i \, .$$

Equilibrium can be restored either by increasing income, or by reducing the interest rate, or a combination of both. If income is fixed, an increase in money supply determines a reduction in the equilibrium interest rate. This is because an increase in money supply comes as a result of an expansionary monetary policy, which increases the demand for bonds from the central bank, which, in turn, raises bond price and reduces the interest rate. In contrast, a reduction in the money supply determines an increase in the equilibrium interest rate.

**Activity 4**

Consider a money market in which money demand is described by the following equation:
$\frac{M^d}{\overline{P}} = 100 + Y - 50i$ .
Assume that the equilibrium level of income is $Y = 100$, the price level is $P = 1$, and the current level money supply is $M^s = 100$.

- Calculate and describe graphically the money market equilibrium.
- Suppose the economy is hit by a adverse real shock that reduces income to $Y = 80$. Illustrate (both numerically and graphically) the effect of the shock on the money market equilibrium.
- Illustrate (both numerically and graphically) the central bank response to the shock, if its objective is to keep money supply constant over time.
- Illustrate (both numerically and graphically) the central bank response to the shock, if its objective is to keep the interest rate constant over time.

**The LM curve**

The LM schedule includes combinations of interest rate and income, so that the money market is in equilibrium. Because an increase in income determines an increase in the equilibrium interest rate, at any given the level of money supply, the LM curve is positively sloped in the income – interest rate space. When money demand is linear, the LM curve is a linear function of income. In this case, the LM curve is derived by solving the money market equilibrium condition in equation (2.11) for the interest rate as follows:

$$i^* = -\frac{1}{h_2}\frac{\overline{M}}{P} + \frac{h_1}{h_2}Y^*. \qquad (2.12)$$

The slope of the LM curve depends on the sensitivity of money demand on income and interest rate, as measured by the coefficient $h_1/h_2$. The more money demand is sensitive to income, relative to the interest rate, the steeper the LM curve. On the other hand, the less money demand is income-elastic ($h_1$ small) and the more interest is elastic ($h_2$ large), the flatter the LM curve. If money demand is completely interest inelastic, $h_2 = 0$, the LM curve is vertical. This situation of a vertical LM curve is often referred to as **the classical case**. In contrast, if money demand is very sensitive to the interest rate, $h_2 = \infty$, the LM curve is horizontal. This case of a horizontal LM curve is often referred to as the **liquidity trap**.

Equation (2.12) shows that the position and the slope of the LM curve are affected by private sector and policy shocks, specifically changes in the private sector behaviour through the parameters $h_1$, and $h_2$ and monetary and fiscal policy changes, through the variables $M$ and $Y$.

Recall that the description of the conduct of monetary policy, at this stage of the course, is based upon the following simplifying assumptions:

1. the central bank has direct control over money supply through open market operations
2. the government issues bonds on behalf of the central bank; the central bank does not directly issues bonds, but can only print out money to buy bonds issued by the government
3. individuals are always willing to trade bonds, i.e. bonds demand from the private sector is unlimited

Figure 2.5 shows how the LM curve is derived from the money market. In Panel A, the increase in income from $Y_1$ to $Y_2$ is associated with a large increase in the interest rate on the LM curve, since money demand is relatively interest-inelastic. In Panel B, the same increase in income is associated with a smaller increase in the interest rate on the LM curve, since money demand is relatively interest-elastic. Thus, the steeper money demand is, the steeper the LM curve.

Note that under the specification in equation (2.12), money supply enters the intercept of the LM curve through the $M/h_2\overline{P}$; thus monetary policy can affect the position but not the slope of the LM curve.

**Figure 2.5 The LM curve**

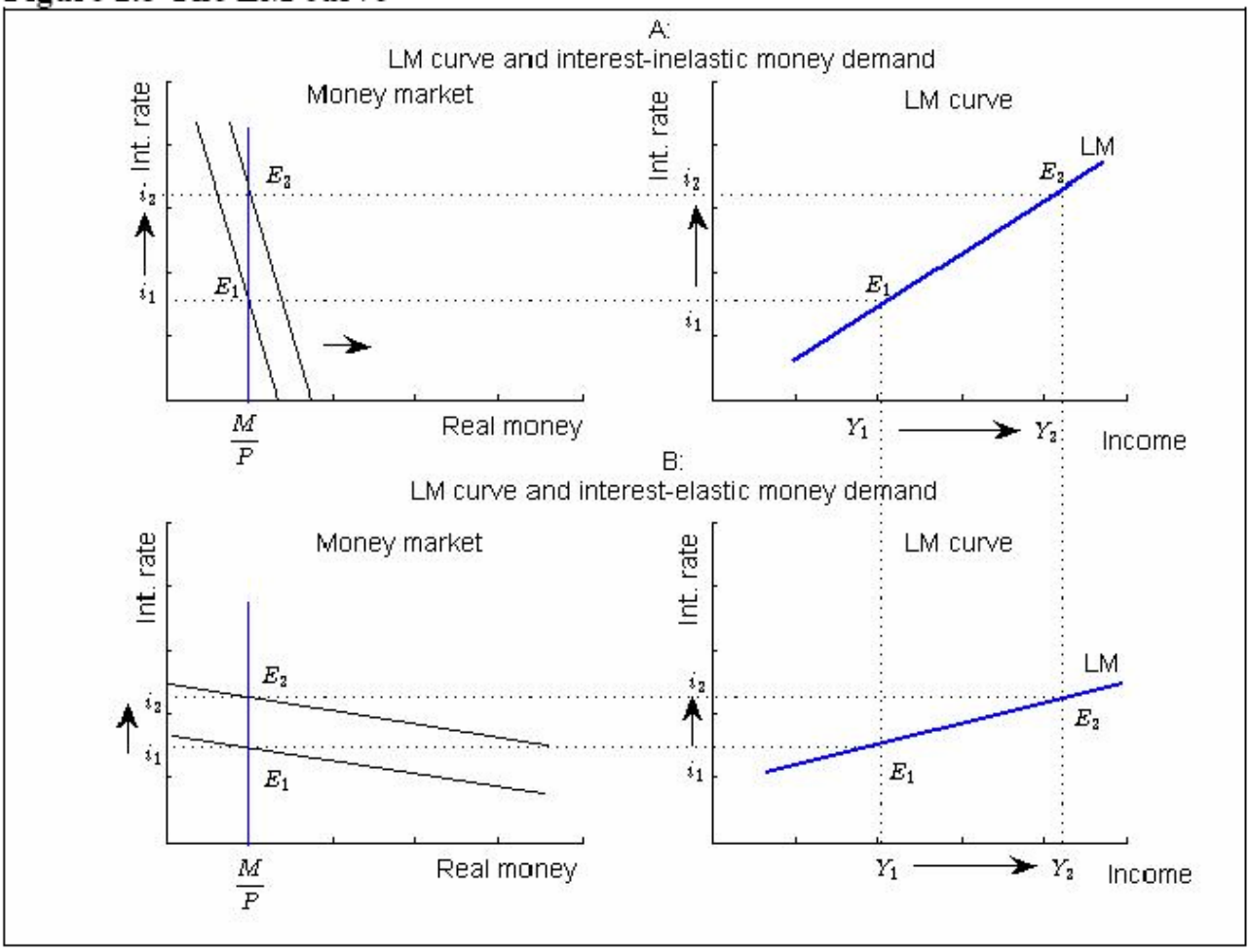
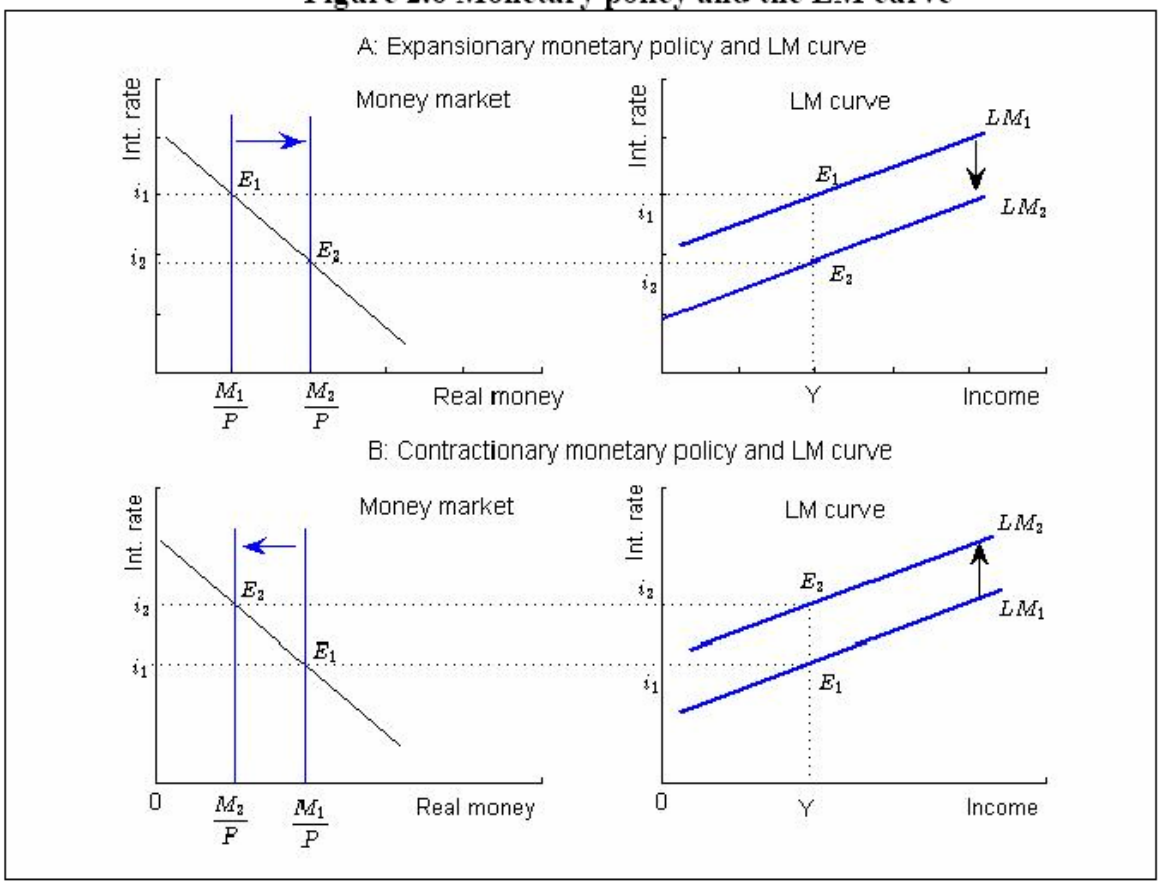


**Figure 2.6 Monetary policy and the LM curve**




## The IS-LM model

The IS-LM model determines combinations of interest rate and income that simultaneously satisfy the equilibrium condition in the goods market and in the money market. Analytically, the values of output and interest rate, that satisfy simultaneously the equilibrium condition in the goods and money market, $Y^*$ and $i^*$, respectively, can be calculated by solving a system for the IS function in equation (2.8) and the LM function in equation (2.12):

$$\begin{cases} i^* = \dfrac{1}{b_2}\left(c_0 - c_1\overline{T} + b_1 + \overline{G}\right) - \dfrac{1-c_1}{b_2}Y^* \\ i^* = -\dfrac{1}{h_2}\dfrac{\overline{M}}{\overline{P}} + \dfrac{h_1}{h_2}Y^* \end{cases}$$

$$\left[\frac{h_1}{h_2}+\left(\frac{1-c_1}{b_2}\right)\right]Y^* = \frac{1}{b_2}\left(c_0 - c_1\overline{T} + b_1 + \overline{G}\right)+\frac{1}{h_2}\frac{M}{\overline{P}},$$

which yields:

$$Y^* = \frac{\frac{1}{b_2}\left(c_0 - c_1\overline{T} + b_1 + \overline{G}\right)+\frac{1}{h_2}\frac{M}{\overline{P}}}{\frac{h_1}{h_2}+\frac{1-c_1}{b_2}}. \qquad (2.12)$$

Note that all policy variables ($T$, $G$, and $M$) appear on the numerator of the equilibrium level of income. Therefore, expansionary fiscal and monetary policies increase the equilibrium level of income. Conversely, fiscal and monetary contractions reduce the equilibrium level of income.

## Activity 6

Consider an economy in which the price level is equal to one unit and the goods and money market are described by the following equations:

Aggregate consumption: $C = 400 + 0.2(Y - T)$;

Aggregate investment: $I = 80 + 0.5Y - 10i$;

Government sector: $G = T = 100$.

Money demand: $M^d = 100 + Y - 50i$

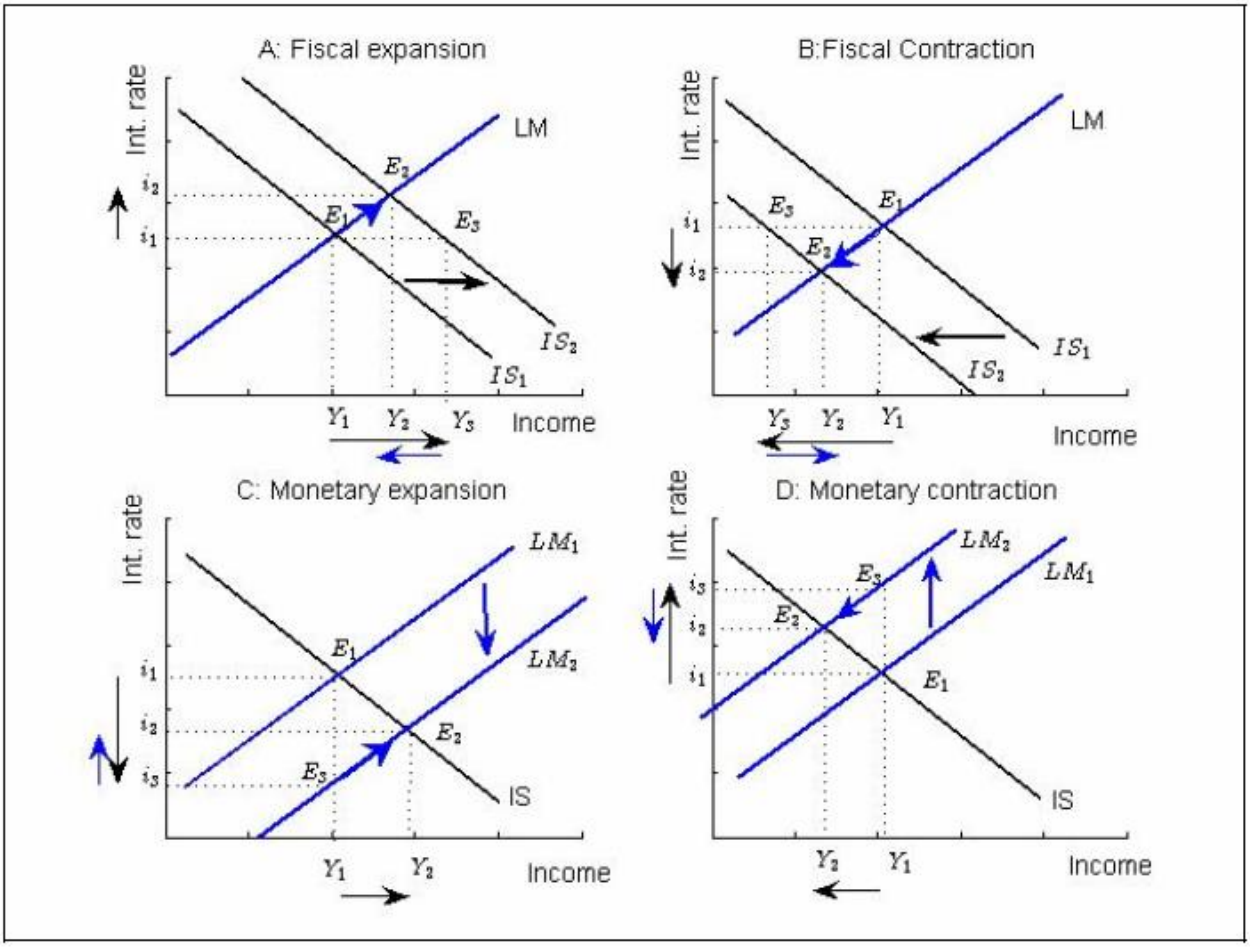
Money supply: $M^s = 100$

- Derive the IS and the LM curve.
- Calculate the equilibrium level of income and interest rate, and plot a graph of the equilibrium of the economy.
- Compute the equilibrium level of consumption and investment.

**Fiscal and monetary policy in the IS-LM model**

Figure 2.7 provides a graphical illustration of the effect of fiscal and monetary policy in the IS-LM model. In each panel, the initial equilibrium is in point $E_1$, which corresponds to a level of income $Y_1$ and interest rate $i_1$. Panel A shows that a fiscal expansion affects both the goods and the money market. In the goods market, the increase in aggregate demand, resulting from the fiscal expansion, raises the equilibrium level of income. Since money supply is fixed, the increase in income increases money demand, which can only be compensated for by an increase in the interest rate. In turn, the increase in the interest rate causes a fall in investment spending (**crowding out effect**), which partially offsets the initial increase in income. The final equilibrium position is indicated in the graph by point $E_2$, but, in general, depends upon the slope of the LM curve relative to the IS curve. Conversely, panel B, shows that a fiscal contraction reduces the equilibrium levels of income and interest rate. Note that the fiscal contraction reduces aggregate demand and income in the goods market. The fall in income causes a contraction in money demand, and the money market equilibrium is compensated for only by the fall in the interest rate. In turn, the fall in the interest rate, stimulates investment spending and contributes to partially offsetting the initial reduction in income. Panels C shows that a monetary expansion shifts the LM curve downwards. At the initial level of income, the interest rate drops from $i_1$ to $i_3$, since the expansionary monetary policy operation raises the price of bonds and reduces the interest rate. The fall in the interest rate stimulates investment spending and increases output. Ultimately, the equilibrium converges to point $E_2$. In general, the flatter the IS curve, the greater the monetary policy stimulus on output. Panels D shows how the IS-LM equilibrium adjusts, as a result of a monetary contraction.

**Figure 2.7**


A: Fiscal expansion
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B:Fiscal Contraction
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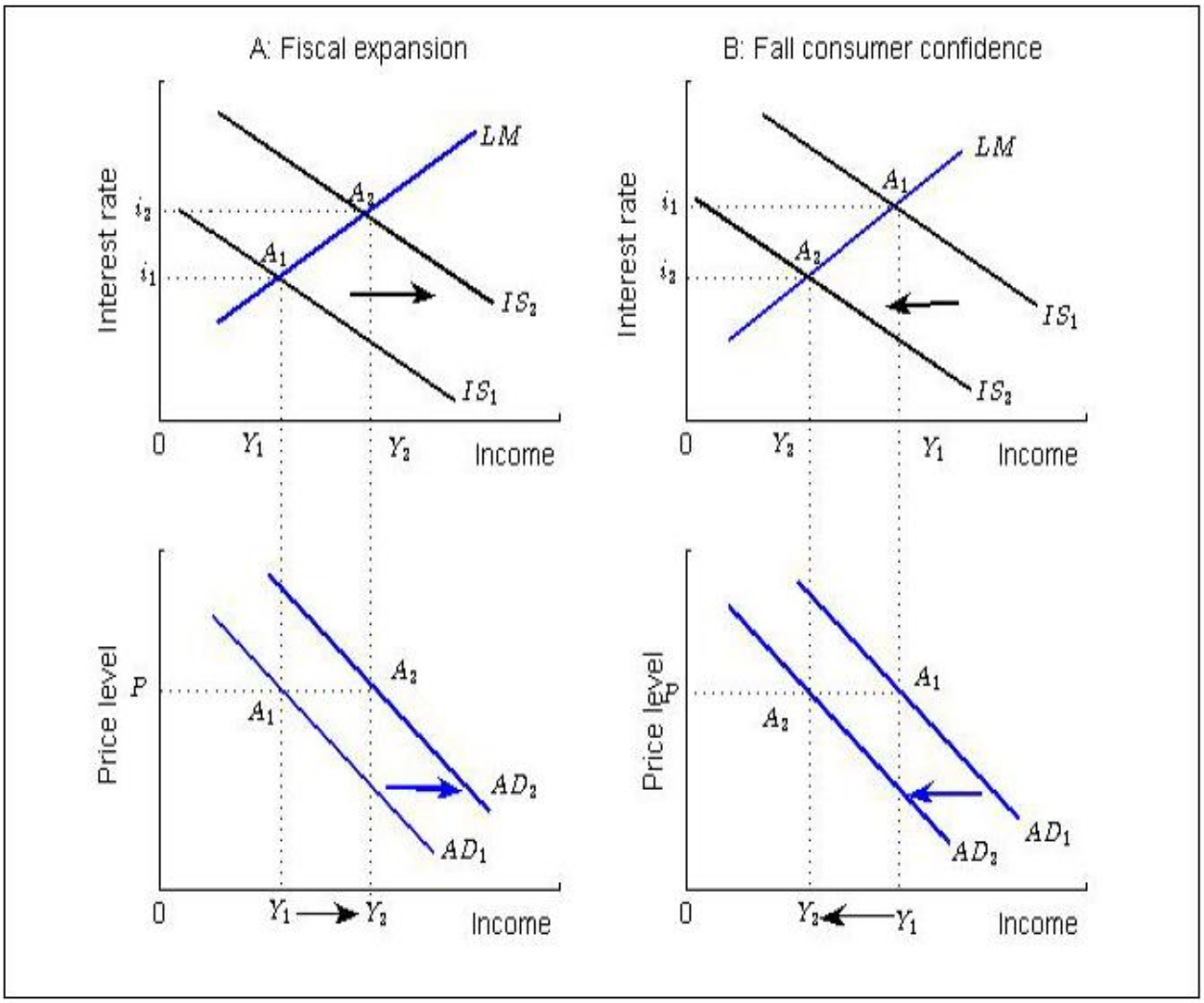
A: Fiscal expansion
B: Fall consumer confidence
Interest rate
LM
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$i_1$
$A_2$
$A_1$
$IS_2$
$IS_1$
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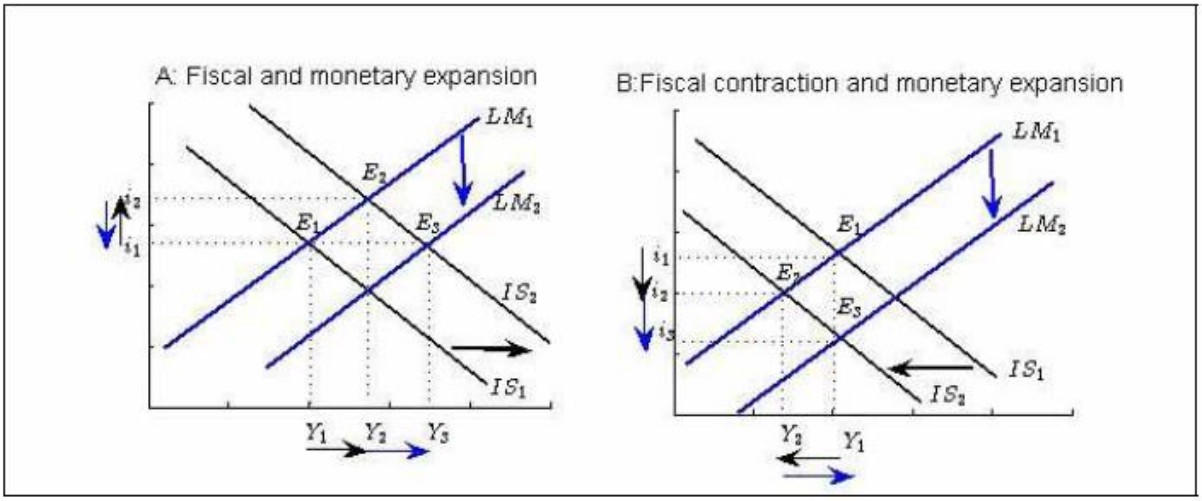
$Y_1$
$Y_2$
Income
Price level
P
$AD_2$
$AD_1$

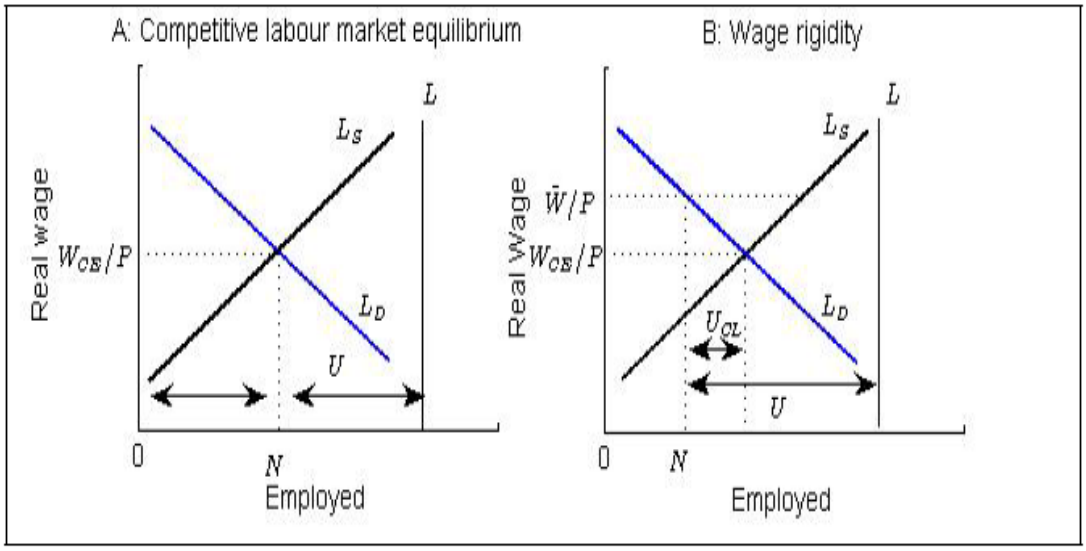

A: Fiscal and monetary expansion
B:Fiscal contraction and monetary expansion
$LM_1$
$LM_2$
$E_1$
$E_2$
$E_3$
$IS_2$
$IS_1$
$i_1$
$i_2$
$i_3$
$Y_1$
$Y_2$
$Y_3$

## Chapter 5: Unemployment and the AD-AS model

### Aims of the chapter

This chapter explores the short and long run determinants of unemployment, output and the price level. We begin exploring the characteristics of the labour market and the different components of unemployment in order to identify appropriate macroeconomic policies to reduce them. Next, we exploit the labour market to derive the Aggregate Supply relation. This is combined with the Aggregate Demand relation obtained from the IS-LM framework to form a completely new model, the AD-AS model, which is used to study how unemployment, output, prices, and the interest rate behave in the short and in the long run. The AD-AS model is then used to explain short-run fluctuations, and to assess to what extent macroeconomic policy can be employed to stabilise the economy over the business cycle.

**Figure 5.1 Labour market and classical unemployment**




There are four main theories of wage rigidities and classical unemployment: minimum-wage, collective bargaining, insiders-outsiders, and efficiency wages.

**Minimum-wage** legislations set a legal minimum compensation that firms must pay to their employees. Minimum wage laws result in a real wage higher than the market clearing wage for those workers with low marginal productivity and equilibrium wage, such as low skilled and young workers, who tend to receive part of their compensation as job training and apprenticeships. There is an ongoing debate on whether or not minimum wage laws are beneficial for the labour market and the economy as a whole. Supporters argue that minimum wages increase the average living standards, create incentive to work, do not increase public spending, and stimulate consumption by increasing the purchasing power of low-income people who tend to spend their entire wage. Opponents of minimum wages believe that they ultimately increase unemployment among young or unskilled workers, and should be replaced by income tax credits. Low income households can deduct the tax credit from their tax payments and if the credit exceeds the tax bill, they can also receive a money refund. The tax credit does not raise firms cost and therefore does not distort the labour market equilibrium. However, it has the disadvantage of increasing government spending, especially during economic slowdowns.

In many countries wages are the outcome **collective bargaining**, i.e. negotiations involving unions, firms' associations, and the government. The outcome of the negotiation is known as **wage accord**, which consists in setting a specific level of real wage, then leaving firms free to decide how many workers to hire at the negotiated wage. Collective bargaining results in wage rigidities since the power of unions can push up the negotiated real wage above the equilibrium wage.

**Efficiency wage** theories argue that labour productivity is related to worker compensations, and paying a wage above the market clearing level improves employee morale, thus

increasing production. For this reason, firms may be willing to pay a real wage that exceeds the equilibrium wage in order to boost profits. A high wage may also be beneficial for firms in that it reduces the incentive for workers to quit, and thereby, the cost of advertising, screening, hiring and training new workers.

The final source of wage rigidity arises from the potential conflict of interest between different groups of workers: insiders and outsiders. **Insiders** are those workers already employed by firms, who are interested in keeping real wages high. This clearly contrasts with the interest of those unemployed – **outsiders** – since a wage reduction would increase their chances of employment. If, within a union, the bargaining power of insiders is greater than that of outsiders, the real wage may remain relatively high for a very long period of time, and this may lead to prolonged periods of unemployment. This phenomenon of a high unemployment rate over long periods of time (persistent unemployment) is also known as **hysteresis**. An alternative explanation of **hysteresis** focuses on the role of long-term unemployed in the labour market. Long-term unemployment causes a progressive loss of skills and detachment from the working life (discouraged workers). As a result, long-term unemployed do not have high bargaining power and have a small impact on wage negotiations, which could lead to a prolonged period of high unemployment.

Under imperfect competition, the labour supply curve is replaced by the **Wage-Setting relation**, **WS**, which takes into account the bargaining of workers in wage negotiations. Analytically, the wage-setting relationship is written as:

$$W = \underset{+}{P^e}\, F\left(\underset{-}{u}, \underset{+}{z}\right),$$

where $W$ indicates the nominal wage, $P^e$ is the expected price level, $u$ is the unemployment rate, and $z$ measures structural and institutional factors that contribute to wage determination, such as the level of unemployment benefits, labour market protection, minimum wage legislations, etc. The expected price level $P^e$ is included in the WS relation because wage negotiations take into account the price level that they expect to prevail over the duration of the contract. The higher $P^e$ is, the higher the nominal wage demanded by wage setters. The unemployment rate summarises the labour market conditions, which affect wage bargaining:

the lower unemployment, the stronger the workers power of negotiating higher wages. Consequently, the *WS* curve is negatively sloped in the unemployment-real wage space because the higher the unemployment is, the weaker the bargaining power of wage setters, the lower the real wage. The variable $z$ determines the position of the *WS* curve: an increase in the level of unemployment benefit shifts the *WS* curve upwards, in that it increases real wages at any unemployment level. Under perfect competition, $z=0$, and the WS curve coincides with the competitive market labour supply curve.

If $F(z,u)$ is linear and equal to $1+z-\alpha u$, then the WS relation is linear and can be written as:

$$W = P^e(1+z-\alpha u), \qquad (5.5)$$

where $\alpha$ is the response coefficient of nominal wage to an increase in unemployment.

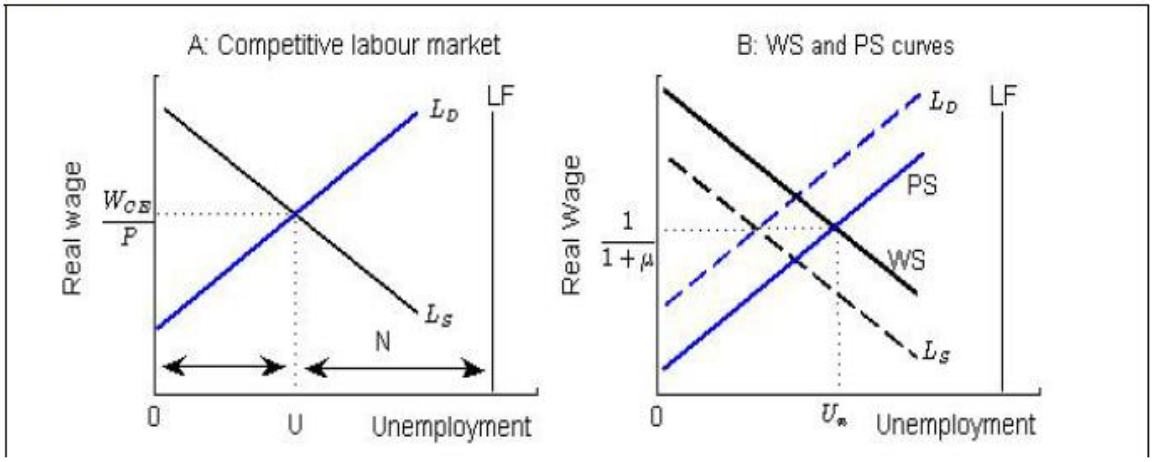
Under imperfect competition firms can set the price level above the marginal cost. Therefore, the labour demand curve is replaced by the **price-setting relation**, **PS**, which analytically is written as:

$$P = (1+\mu)W, \qquad (5.6)$$

where $W$ is the marginal cost of output and $\mu$ is the markup, which reflects the degree of firms' market power. Note that the standard assumptions about the production function imply that the marginal product of labour falls as employment rises. Consequently, the nominal wage increases as unemployment rises and the *PS* curve is upward sloping in the unemployment-real wage space. The markup determines the position of the PS curve: a reduction (increase) in the markup shifts the *PS* upwards (downwards). Under perfect competition, $\mu$ =0 and the *PS* curve coincides with the competitive market labour demand.

Panel B in Figure 5.2 plots the *WS* and the *PS* curves in the unemployment-real wage space. The WS curve is positioned above labour supply curve ($z \neq 0$) and the PS curve is positioned below the labour demand curve ($\mu \neq 0$). The natural unemployment rate is determined by the equality between the *WS* and the *PS* curves. Broadly speaking, the greater the degree of imperfect competition is, the higher the natural unemployment rate.

**Figure 5.2: Labour market under imperfect competition and natural unemployment rate**




The WS and the PS relations can be employed to compute, analytically, the natural rate of unemployment $u_n$. To this end, note that the natural unemployment rate is a medium term concept, which holds when $P=P^e$. Under this assumption, the nominal wage in equation (5.6) can be replaced with the nominal wage in equation (5.5) to obtain:

$$1 = (1 + z - \alpha u_n)(1 + \mu).$$

Taking the natural logarithm of both sides of this expression and simplifying yields:

$0 = z - \alpha u_n + \mu$,[22]

so that the natural unemployment rate $u_n$ is given by:

$$u_n = \frac{z + \mu}{\alpha}, \qquad (5.7)$$

which shows that increases in both $z$ and $\mu$ raises the natural unemployment rate.

The concept of natural unemployment rate implies that of natural levels of employment and output. Since, the number of unemployed people is such that the unemployment rate is at its natural level is consistent with $u_n = U_n / L$, the **natural level of employment** $N_n$ is given by:

$$N_n = L(1 - u_n).$$

If output is produced according to the production function:

$$Y = AN, \qquad (5.8)$$

where $A$ indicates the level of technology, then substitution of the natural level of employment into the production function gives the **natural level of output**:

$$Y_n = AN_n = AL(1 - u_n). \qquad (5.9)$$

## Aggregate Supply

In the IS-LM model firms respond to an increase in demand by increasing production without changing the price level, which is assumed to be fixed. The labour market under imperfect competition can be employed to derive the **Aggregate Supply** (**AS**) relation, which shows how the price level adjusts over time in response to changes in aggregate demand and income The analytical determination of the AS relation requires three equations: the WS relation in equation (5.5), the PS relation in (5.6), and the relation between output and unemployment rate in (5.9).

First, the nominal wage from the WS relation can be substituted into the PS relation to obtain the following expression for the price level:

$$P = (1 + \mu)P^e(1 + z - \alpha u),$$

Equation (5.9) shows that – in general – the unemployment rate can be written as:

$$u = 1 - \frac{Y}{AL}.$$

This result can be substituted in the price level equation to obtain the AS relationship as:

$$P = (1+\mu)P^e\left[1+z-\alpha\left(1-\frac{Y}{AL}\right)\right]. \qquad (5.10)$$

Equation (5.10) shows that the price level and output are positively related. The mechanism of price adjustment includes the following four steps. First, an increase in output leads to an increase in production which increases employment. Second, higher employment results in lower unemployment. Third, the reduction in unemployment leads to higher nominal wages through wage bargaining. Fourth, the increase in the cost of production, due to higher nominal wages, forces firms to raise prices by increasing the markup.

The AS relation in equation (5.10) can be further simplified by observing that when the unemployment rate is at the natural level ($P = P^e \Leftrightarrow u = u_n$), the PS equation implies:

$$\frac{P}{W_n} = 1+\mu = \frac{1}{1+z-\alpha u_n} = \frac{1}{1+z-\alpha\left(1-\frac{Y_n}{AL}\right)},$$

where the term $W_n$ indicates the nominal wage evaluated at the natural unemployment rate. Therefore, equation (5.10) can be written as:

$$P = P^e\frac{\left[1+z-\alpha\left(1-\frac{Y}{AL}\right)\right]}{\left[1+z-\alpha\left(1-\frac{Y_n}{AL}\right)\right]}.$$

Subtracting $P^e$ from both sides in the above and rearranging gives:

$$P - P^e = P^e\frac{\left[\frac{\alpha}{AL}(Y-Y_n)\right]}{W_n/P},$$

which yields the standard form of the AS relation as:

$$P = P^e + \lambda[Y - Y_n], \qquad (5.11)$$

where $\lambda = \frac{P^e}{W_n/P}\frac{\alpha}{AL} \geq 0$ and $Y - Y_n$ computes the so called output gap. Equation (5.11) states that the actual price level deviates from the expected price level to when output

deviates from its natural level. The standard AS relation can also be solved for output to obtain the so called 'surprise-supply' relation:

$$Y = Y_n + \mu\left(P - P^e\right),$$

where $\mu = 1/\gamma > 0$ and the term $P - P^e$ indicates surprise inflation. This relation shows that output exceeds the natural level to the extent that there is ***surprise inflation*** in the economy, i.e. the actual price level exceeds the expected one.

**The SRAS curve**

The AS relation, in equation (5.11), shows that the extent to which output deviates from its natural level depends upon the steepness of the SRAS, as determined by the magnitude of the coefficient $\lambda$. There are four theories that explain why output may deviate from its natural level in the short run: sticky-wages model, workers misperception model, sticky-prices model, and imperfect information or Lucas 'islands' model.

The ***sticky-wage model*** is grounded upon two assumptions. First, nominal wages are sticky in the sense that cannot adjust quickly when the economic condition changes, since they are fixed over long periods of time. Second, collective bargaining determines only the level of nominal wage, whereas employment is determined by firms' labour demand. This implies that, once the real wage has been set at the expected price level, then an increase in the price level above the expected value leads to a fall in real wage and it increases labour demand. In turn, the increase in employment raises output, at least until the next wage negotiation. Analytically, the sticky-wage model is described by three equations:

Actual real wage: $\dfrac{W}{P} = \dfrac{W}{P^e} \times \dfrac{P^e}{P}$;

Labour demand: $N - N_n = -\left(\dfrac{W}{P} - \dfrac{W}{P^e}\right)$;

Output: $Y - Y_n = A\left(N - N_n\right)$.

The first equation shows that the actual real wage $W/P$ deviates (above or below) from the predetermined real wage $W/P^e$ to the extent that the expected price level differs (lower or higher) from the actual price level, $P/P^e$. The second equation shows that labour demand is inversely related to the real wage, and an increase in the price level above the expected level increases employment as it reduces real wages. The final equation shows that output is above the natural level to the extent that firms can hire a number of workers higher than the natural employment level.

The model shows that if after the negotiation the actual price level equals the expected price level, $P = P^e$, then employment equals its natural level, $N = N_n$, and consequently output equals its natural level, $Y = Y_n$. If, however, after the wage negotiation the price level is higher than the expected one, $P - P^e > 0$, then it must be true that output exceeds its natural level, $Y - Y_n > 0$, since firms can employ a number of workers in excess of the natural employment level, $N - N_n > 0$, at least until the next wage negotiation. Vice versa, an unexpected fall in the price level raises the real wage, making labour more expensive. The higher real wage induces firms to reduce employment, and the reduced employment leads to a fall in output. When contracts are renegotiated, workers accept lower nominal wages to restore the original real wage, so employment rises. Therefore, the sticky-wages model predicts that the longer the period is over which wages are negotiated, the flatter the SRAS.

The **worker misperception model** assumes that wages are fully flexible, unlike the sticky-wage model, but workers have imperfect information, in that they suffer from money illusion so they temporarily mistake nominal wage increases for real wage increases. Firms have perfect information and if the price level increases unexpectedly, they offer higher nominal wages which workers mistake for higher real wages. This causes an increase in labour supply and allows firms to temporarily raise output above the equilibrium level, at least until workers realise that the real wage has not risen, so they revise their expectations and reduce labour supply. Under this model, the higher the degree of workers misperception is, the flatter the SRAS.

The **Lucas 'islands' or the imperfect information model** considers an economy including many self-employed individuals, each producing a single product, but consuming many goods. Producers have imperfect information, in that they are only aware of the price of the product that they produce. The model distinguishes absolute changes in the price level, which occur when all prices of produced goods increase by the same proportion, from relative changes in the price level, which occurs when the price of some goods increase more than others.

A relative change in the price level makes better off the producers of the goods the price of which are increasing relative to the overall price level. This is because the price of their output increases to a greater extent than the overall price level. Both the real wage and the nominal wage earned by these producers increase. When an absolute change in the price level occurs, all producers are affected equally and the nominal wage increases while the real wage remains constant.

Imperfect information means that producers are likely to mistake changes in the price of the product that they produce (relative changes in the price level) with changes in the overall price level (absolute changes in the price level). Thus, when a producer sees a change in the price level, he/she is likely to believe that it is a relative change in the price level, even if it is an absolute change in the price level. As a result, the producer works more and this increases the level of output when the price level rises. Thus, the Lucas islands model predicts that the higher the degree of imperfect information is, the flatter the SRAS.

## Activity 3

Consider an economy in which firms' markup over cost is 10 per cent and the WS relation is given by equation (5.5), with $z=0.01$ and $\alpha = 1$. Assume that the marginal product of labour is constant.

a) Compute the real wage and the natural unemployment rate.
b) Calculate how the equilibrium real wage and the natural unemployment rate change if the markup increases to 15 per cent. Discuss your result.
c) Calculate how the equilibrium real wage and the natural unemployment rate change, if the bargaining power of unions increases so that $z=0.4$. Discuss your result.

## Activity 8

Consider an economy in which the Aggregate Demand (AD) relation is: $Y = 10 + G - P$; and the Aggregate Supply (AS) relation is $P - P^e = 0.5(Y - Y_n)$; where $G$ indicates government spending, $P$ is the actual price level, $P^e$ is the expected price level, $Y$ is actual GDP, and $Y_n$ is the natural level of GDP. In addition $G=50$ and $Y_n = 25$.

a) Calculate the expected price level at the long run equilibrium. Plot in the output – price space (i) the aggregate demand curve; (ii) the short-run aggregate supply curve (SRAS); (iii) and the long-run aggregate supply (LRAS) curves.

b) Suppose the economy starts from its equilibrium position, and an adverse demand shock reduces aggregate demand by 5 units at each price level. Compute the new AD curve and calculate the new short-run levels of output and price.
c) Briefly, describe why the economy adjusts to a new long run equilibrium, and calculate the expected price level at the new long run equilibrium.