The IS-LM Model

Introduction to Macroeconomics

WS 2011

October 4th, 2011
Recapitulation of the last lectures

- We have already analyzed the equilibrium on the goods market and on the financial market separately.
- In the full IS-LM model both markets must however be in equilibrium at the same time.
- Today we will discuss how the goods market equilibrium depends on the interest rate \((i)\) and how the financial market equilibrium depends on real GDP \((Y)\).
- Using this, it will be possible to determine unique values for the interest rate and for real GDP for which both markets are in equilibrium simultaneously.
What we already know about the Goods Market

Equilibrium

The goods market is in equilibrium if supply and demand for the unique good in the economy are equal, i.e. if

\[ Y = Z \equiv C + I + G \]  

(1)

where so far we have assumed that private consumption \( C \) is a linear function of disposable income and that investment demand and government consumption are exogenously given.
Investment Demand

- Taking investments as exogenously given was a simplification, but cannot be justified on other grounds.
- Actually, investments will depend on:
  - the production $Y$ (real GDP). A higher production implies that firms need more machines, ... Therefore, investments of firms will be higher the higher their production.
  - the interest rate $i$. Usually, firms finance their investments by borrowing money. If the interest rate is high, this is expensive and so firms will decide to invest less.
- Therefore, we can characterize investment demand through a function with the following properties:

\[ I = I(Y, i) \text{ with } \frac{\partial I}{\partial Y} > 0 \text{ and } \frac{\partial I}{\partial i} < 0 \]
A linear Investment Function

- For simplicity, we can assume that investment demand is a linear function of $Y$ and $i$:

$$I = b_0 + b_1 Y - b_2 i \text{ where } b_0, b_1, b_2 > 0$$

- Inserting this into the equilibrium condition on the goods market shows that the equilibrium level for $Y$ can be written as:

$$Y = \frac{1}{1 - c_1 - b_1} \left( c_0 - c_1 \bar{T} + b_0 - b_2 i + \bar{G} \right) \quad (2)$$
The Goods Market Equilibrium

From (2) we see the following:

- Compared to a situation with an exogenously given investment demand, the multiplier is larger. This is the case since the increase in real GDP due to an increase in autonomous spending does not only have an effect on private consumption as before, but also increases the investment demand.

- The level of $Y$ for which the goods market is in equilibrium is a function of the interest rate $i$. This is the case since changes in the interest rate result in changes in investment demand.

**IMPORTANT**

For each interest rate $i$ equation (2) gives us the value of real GDP $Y$ for which the goods market is in equilibrium. We will represent this relation by the IS-curve.
The Goods Market Equilibrium - A Graphical Analysis

In order to represent the goods market equilibrium graphically, it is not necessary to assume a linear investment function. However, we still assume that demand is flatter than supply (empirically justified).

[Graph showing demand and supply curves intersecting at point A, with the demand curve drawn flatter than a 45-degree line to indicate a less than one-for-one increase in demand with output increase.]
The Goods Market Equilibrium - A Graphical Analysis

If the interest rate increases, the demand curve shifts down due to the decrease in investment demand (this means that for any income $Y$ demand decreases):

![Graph showing the IS curve](image-url)
The IS-Curve - A Graphical Analysis

- The points on the IS-curve characterize combinations of $Y$ and $i$ for which the goods market is in equilibrium.

- More precisely, the IS-curve associates to any given interest rate $i$ the level of real GDP $Y$ for which the goods market is in equilibrium.

- Graphically, this curve can be obtained as follows:
Shifts of the IS-Curve

Changes in the **exogenous variables** result in shifts of the IS-curve, whereas changes in the endogenous interest rate correspond to a movement along the IS-curve.

**IMPORTANT:**

Exogenous variables affecting the goods market equilibrium are the parameters of the consumption and investment function (i.e. \( c_0, c_1, b_0, b_1 \) and \( b_2 \)), government consumption \( G \) and taxation \( T \).
Changes in government consumption $G$ and in taxation $T$ are referred to as fiscal policy:

- If the public deficit $G - T$ decreases (can be due to a decrease in $G$ or an increase in $T$), the policy is referred to as fiscal consolidation or fiscal contraction.
- If the public deficit $G - T$ increases (can be due to an increase in $G$ or a decrease in $T$), the policy is referred to as fiscal expansion.
The IS-Curve - Fiscal Policy

Given any interest rate $i$, a fiscal consolidation (i.e. a decrease in the public deficit $G - T$) reduces demand. Therefore, the level of $Y$ for which the goods market is in equilibrium is lower for any given interest rate $i$. In the diagram this is represented by a shift of the IS-curve to the left:
Recall that equilibrium on the money market is characterized by the following condition

\[ M = $YL(i) \] (3)

where \( M \) is the exogenously given money supply, \( $Y \) denotes nominal GDP (income), and where \( L(i) \) is a decreasing function of the interest rate.
Real GDP vs. Nominal GDP

In order to establish the link with the goods market, it is convenient to rewrite nominal GDP in terms of real GDP:

- We can normalize the base year price of the unique good in the economy to 1.
- Then the real GDP $Y$ is just given by the quantity consumed of this good (which is what we care about on the goods market), whereas nominal GDP $\$Y$ is given by the expenditures for this good (price $P$ times quantity).
- Therefore, it holds that $\$Y = P \cdot Y$.
The Money Market Equilibrium

Inserting this relationship between $Y$ and $Y$ into the money market equilibrium condition (3) yields:

$$\frac{M}{P} = YL(i)$$

which states that real money supply $\frac{M}{P}$ must be equal to real money demand.

Note, that real money supply measures how many units of the good can be bought with the given nominal money supply $M$. 
The Money Market Equilibrium

From the previous equilibrium condition it can be seen that the interest rate for which the money market is in equilibrium is an increasing function of $Y$:

- If $Y$ increases, the volume of transactions people need to make increases.
- Therefore, given the interest rate $i$, people will want to hold more money which is only possible if they sell bonds.
- Since this results in an excess supply of bonds, the price of bonds will decrease.
- As we have discussed last time, this implies that the interest rate will increase.
The Money Market Equilibrium

This can also be depicted in a diagram:

![Diagram of the Money Market Equilibrium](image-url)
The LM-Curve - A Graphical Analysis

Similarly to the IS-curve, all points on the LM-curve (LM stands for liquidity and money) are combinations of $Y$ and $i$ for which the money market is in equilibrium.

Graphically, the LM-curve can be obtained as follows:

![Graph of the LM-curve](image)
Changes in **exogenous variables** result in shifts of the LM-curve, whereas changes in the endogenous variable $Y$ are captured by movements along the LM-curve.

**IMPORTANT**

Since the only exogenous variable affecting the money market equilibrium is real money supply, only changes in $\frac{M}{P}$ will shift the LM-curve!
The LM-Curve - Expansionary Monetary Policy

Given a certain level of transactions (i.e. given $Y$), a larger money supply implies that the demand for bonds increases and that thus the interest rate decreases in equilibrium. Therefore, an increase in the (real) money supply is associated with a downwards shift of the LM-curve:

![Graph showing the LM-curve before and after an expansionary monetary policy](image-url)
Putting the Two Markets together

- In the IS-LM model, both the goods and the financial market must be in equilibrium simultaneously.
- Algebraically, the equilibrium conditions for the goods market and the financial market (i.e. equations (1) and (4)) constitute a system of two equations in two unknowns (the equilibrium levels of $Y$ and $i$) which has a unique solution.
- Graphically, we can determine the equilibrium levels for $Y$ and $i$ through the intersection of the IS and the LM-curve:
### Goods Market

Assume that as before consumption is a linear function of disposable income, investment demand is a linear function of production and the interest rate and that government expenditures and taxes are constant and exogenously determined.

As we saw before, equilibrium on the goods market and therefore also the IS-curve is characterized by equation (2).

### Money Market

Assume that real money demand $Y_L(i)$ is given by $\frac{aY}{i}$ and that real money supply is exogenously given.

The equation for the LM-curve is then given by:

\[ i = \frac{aY}{\frac{M}{P}} \]
An Algebraic Solution - Example

Equilibrium

Inserting this expression for $i$ into the IS-curve yields the equilibrium level for $Y$ as:

$$Y = \frac{\frac{M}{P}}{(1 - c_1 - b_1) \frac{M}{P} + ab_2} \left( c_0 - c_1 \bar{T} + b_0 + \bar{G} \right)$$

Inserting this solution into the LM-curve yields the equilibrium level for $i$ as:

$$i = \frac{a}{(1 - c_1 - b_1) \frac{M}{P} + ab_2} \left( c_0 - c_1 \bar{T} + b_0 + \bar{G} \right)$$
Suppose the economy is characterized by the following equations:

\[ C = 100 + 0.6Y_D \]
\[ I = 20 + 0.3Y - 20i \]
\[ T = 100 \]
\[ G = 20 \]
\[ \left( \frac{M}{P} \right)^d = 0.1Y \]
\[ \left( \frac{M}{P} \right)^s = 300 \]
The Structure of the Model

The level of $Y$ is determined by the equality of production and demand.

The interest rate $i$ is determined by the equality of money demand and money supply.

Shocks on the goods market (i.e. a sudden change in autonomous spending) lead to changes in $Y$ and affect the money market because this causes a change in money demand.

Shocks on the money market (i.e. a sudden change in money supply) lead to changes in $i$ and affect the goods market because a change in the interest rate leads to changes in investment demand.
Analyzing Fiscal Policy

The analysis of fiscal policy always consists of three parts:

1. **Analyze the direct effect** of the policy on the goods market: What effect does the fiscal policy have on the goods market equilibrium? (Does it result in an increase or a decrease of real GDP?)

2. **Response** to the direct effect on the money market: What effect does the change in money demand caused by the change in real GDP in point (1) have on the money market equilibrium? (Does the interest rate increase or decrease?)

3. **Feedback** to goods market: What effect does the change in investment demand caused by the change in the interest rate of point (2) have on the goods market equilibrium? (Does real GDP increase or decrease because of it?)
The Effect of a Fiscal Contraction

A fiscal contraction decreases the public deficit $G - T$. So consider for example an increase in taxation:

1. An increase in taxes implies lower disposable income for households and thus lower demand given a certain interest rate $i \Rightarrow$ the IS-curve shifts to the left and the new goods market equilibrium is at point $D$.

2. At $D$ the financial market is however out of equilibrium: $Y$ and thus also the need for transactions has decreased, thus people hold more money than they actually want to. Therefore people will demand bonds to decrease their money holdings which increases the price for bonds and decreases the interest rate.

3. With the decrease in $i$, investment demand increases. In order to keep the goods market in equilibrium this must lead to an increase in $Y$ $\Rightarrow$ points (2) and (3) correspond to a movement from point $D$ to the new equilibrium $A'$ along the new IS-curve.
The Effect of a Fiscal Contraction

IMPORTANT

Since the money market equilibrium is not directly affected by changes in taxes or government expenditures, the LM-curve does not shift. The movement from $D$ to the new equilibrium $A'$ is along the IS-curve: a decrease in $i$ leads to a gradual increase in $Y$ in order to maintain the goods market equilibrium.
The Effect of a Fiscal Contraction

- Due to the fiscal contraction, both real GDP ($Y$) and the interest rate $i$ decrease.
- Since private consumption ($C$) only depends on disposable income, $C$ decreases.
- The effect on investment is ambiguous: on the one hand investments will decrease because production $Y$ decreases, on the other hand investments will increase because the interest rate $i$ decreases which makes borrowing cheaper.
Analyzing Monetary Policy

The analysis of monetary policy always consists of three parts:

1. **Analyze the direct effect** of the policy on the money market: What effect does the monetary policy have on the money market equilibrium? (Does it result in an increase or a decrease of the interest rate?)

2. **Response** to the direct effect on the goods market: What effect does the change in investment demand caused by the change in the interest rate in point (1) have on the goods market equilibrium? (Does real GDP increase or decrease?)

3. **Feedback** to money market: What effect does the change in money demand caused by the change in real GDP of point (2) have on the goods market equilibrium? (Does the interest rate increase or decrease because of it?)
The Effect of a Monetary Expansion

A monetary expansion means that the central bank increases the money supply $M$ by buying bonds. This has the following effects:

1. Given the amount of transactions in the economy (i.e. given $Y$), the demand for bonds increases which increases their price. Therefore, the interest rate decreases $\Rightarrow$ the LM-curve shifts downwards and the new money market equilibrium is at point $B$

2. At $B$ the goods market is however out of equilibrium since due to the decrease in $i$, the demand for investments has increased. Therefore, the higher demand does not equal the supply $Y$ any longer. Due to the higher demand, supply and income will gradually increase (multiplier process) leading to a higher $Y$
The Effect of a Monetary Expansion

3. Because of the higher need for transactions associated with a higher real GDP, money demand increases. People start selling bonds, causing an excess supply of bonds which leads to a lower price of bonds and a higher interest rate.

⇒ points (2) and (3) correspond to a movement from $B$ to the new equilibrium $A'$ along the new LM-curve.

IMPORTANT

Since the goods market equilibrium is not directly affected by changes in the money supply, the IS-curve does not shift.
The Effect of a Monetary Expansion

A monetary expansion leads to higher output and a lower interest rate.

Figure 5-8

The IS-LM Model

October 4th, 2011
The Effect of a Monetary Expansion

- Due to a monetary expansion, real GDP \( (Y) \) increases, whereas the interest rate \( i \) decreases.
- Since private consumption \( (C) \) only depends on disposable income, \( C \) increases.
- Investments will increase since on the one hand production \( (Y) \) increases and since on the other hand borrowing money becomes cheaper \( (i \) decreases).
Using Fiscal and Monetary Policy simultaneously

Usually, fiscal and monetary policy are used simultaneously:

- One possibility is that governments and central banks pursue the same goal (fiscal and monetary policy have qualitatively similar effects) - this happened during the US recession in 2001

- Another possibility is that central banks counteract undesired effects of fiscal policy, e.g.:
  - When Bill Clinton decided to reduce the US budget deficit (fiscal contraction), Alan Greenspan used expansionary monetary policy to counteract the reduction in GDP due to the fiscal contraction
  - Due to the German reunification in 1990, government expenditures increased (only part of the expenses of the reunification were financed through increases in taxes) (fiscal expansion), the German central bank reacted with a monetary contraction in fear of an overheating economy (high inflation - not part of the IS-LM model)
The 2001 US recession

- (Autonomous) investment demand declined rapidly due to the end of "irrational exuberance" (term used by Alan Greenspan for optimistic expectations in second half of 1990’s) ⇒ IS-curve shifts to the left which would - without any countermeasures - lead to a decrease in (real) GDP
- Reactions by policy makers:
  - Federal Reserve Bank increases money supply (buys bonds) to counteract economic downturn ⇒ LM-curve shifts downwards
  - One election pledge of George Bush was to reduce taxes. Moreover, government spending (especially defense spending) increased in response to 9/11 ⇒ expansionary fiscal policy ⇒ IS-curve shifts to the right
The 2001 Recession

Figure 4: The U.S. Recession of 2001

The IS-LM Model

- Fiscal expansion
- Monetary expansion
- Drop in investment demand
The 2001 Recession - Effects of Fiscal and Monetary Policy

- Due to the reactions of the Fed and the US government, the interest rate declined.

(Real) GDP also declined, but by a smaller amount than without reactions by the Fed and the government. This result is however sensitive to the actual size of the fiscal and monetary expansion: Larger reactions could have even led to an increase in $Y$.
Adjustment to the new Equilibrium

- When analyzing the effect of fiscal or monetary policy, we were thinking about a dynamic process (policy leads to a temporary disequilibrium on one market, gradual adjustment towards the new equilibrium).

- However, the IS-LM model is static, i.e. all adjustments occur simultaneously (meaning that we do not observe out of equilibrium behaviour). But thinking about the policy changes as triggering successive adjustments is helpful for our understanding.

- In reality, it indeed takes time for the economy to reach a new equilibrium (approximately 1 - 2 years).

- Thus, a dynamic model would probably be better suited. However, such a model would also be more complex!!!