Chapter 11, 8th and 9th Editions

Chapter 10 in the 7th Edition

The Economy in the Short-run
Aggregate Demand I:
Building the IS-LM Model

Motivation

- The Great Depression caused a rethinking of the Classical Theory of the macroeconomy. It could not explain:
  - Drop in output by 30% from 1929 to 1933
  - Rise in unemployment to 25%
- In 1936, J.M. Keynes developed a theory to explain this phenomenon.
- We will learn a version of this theory, called the ‘IS-LM’ model.

Growth rates of real GDP, consumption

Real GDP growth rate
Consumption growth rate

Percent change from 4 quarters earlier
Average growth rate about 3% - 3.5%


Average growth rate about 3% - 3.5%
Growth rates of real GDP, consumption, investment

Unemployment

Okun’s Law

\[ \Delta Y = 3 - 2\Delta u \]
Time horizons in macroeconomics

- **Long run**
  Prices are flexible, respond to changes in supply or demand.

- **Short run**
  Many prices are “sticky” at a predetermined level.

*The economy behaves much differently when prices are sticky.*

Chapter 11 In this chapter:

- the IS curve, and its relation to:
  - the Keynesian cross
- the LM curve, and its relation to:
  - the theory of liquidity preference
- how the IS-LM model determines income and the interest rate in the short run when $P$ is fixed
- Continue to assume a closed economy

Context

- **Short run**
  - prices fixed
  - output determined by aggregate demand
  - unemployment negatively related to output
  - Demand oriented model

- **Long run**
  - prices flexible
  - output determined by factors of production & technology
  - unemployment equals its natural rate
  - Supply oriented model
The Keynesian Cross (Simple Keynesian) Model – Econ 201 stuff

- A simple closed economy model in which income is determined by spending.

- Notation:
  \[ I = \text{planned investment} \]
  \[ PE = C + I + G = \text{planned expenditure} \]
  (NOTE): Older edition uses \( E = C + I + G \)

- \( Y = \text{real GDP = actual expenditure} \)

- Difference between actual & planned expenditure = unplanned changes in inventory - (so sales at Nordstrom)

Elements of the Keynesian Cross Model

- Disposable income: \( Y_d = (Y - T) \)
- Consumption function: \( C = C(Y - T) \)
- Government policy variables: \( G = \bar{G}, \ T = \bar{T} \)

  For now, planned investment is exogenous: \( I = \bar{I} \)

  Planned expenditure: \( PE = C(Y - T) + \bar{I} + \bar{G} \)

  Equilibrium condition: actual expenditure = planned expenditure
  \( Y = PE \)

Planned Consumption Expenditure

\[ C = a + mpc \times (Y - T) \]

The Keynesian consumption function has a constant term and we assume its linear.
Graphing planned expenditure:
Remember I and G are exogenous.

\[ PE = C + I + G \]

\[ C = a + mpc \times (Y - T) \]

45° line - Graphing the equilibrium condition

\[ PE = Y \]

The equilibrium value of income

\[ PE = Y \]
Why this is the equilibrium value of income

PE > Y: Unplanned reduction in inventories: must produce more.
PE < Y: unplanned increase in inventories: must produce less.

An increase in government purchases

At Y₁, there is now an unplanned drop in inventory... so firms increase output, and income rises toward a new equilibrium.

Why the multiplier is greater than 1

- Def: Government purchases multiplier: \( \frac{\Delta Y}{\Delta G} \)
- Initially, the increase in G causes an equal increase in Y: \( \Delta Y = \Delta G \)
- But \( \uparrow Y \Rightarrow \uparrow C \)
  \( \Rightarrow \) further \( \uparrow Y \)
  \( \Rightarrow \) further \( \uparrow C \)
  \( \Rightarrow \) further \( \uparrow Y \)
- So the government purchases multiplier will be greater than one, i.e., \( \Delta Y > \Delta G \)
Sum up changes in expenditure

\[ \Delta Y = \Delta G + (\text{MPC} \cdot \Delta G) + \text{MPC} (\text{MPC} \cdot \Delta G) + \ldots \]
\[ = \Delta G + (\text{MPC} \cdot \Delta G) + (\text{MPC} \cdot \Delta G) + (\text{MPC} \cdot \Delta G) + \ldots \]

This is a standard geometric series from algebra:

\[ = \frac{1}{1 - \text{MPC}} \Delta G \]

So the multiplier is:

\[ \frac{\Delta Y}{\Delta G} = \frac{1}{1 - \text{MPC}} > 1 \text{ for } 0 < \text{MPC} < 1 \]

Algebra example

Suppose consumption function: \( C = a + b(Y - T) \)

where \( a \) and \( b \) are some numbers (MPC = \( b \))

and other variables exogenous:

\( I = \overline{I}, T = \overline{T}, G = \overline{G} \)

Use Goods market equilibrium condition:

\[ Y = C + I + G \]

Algebra example

\[ Y = C + I + G \]
\[ Y = a + b(Y - \overline{T}) + \overline{I} + \overline{G} \]

Solve for \( Y \):

\[ Y - bY = a - b\overline{T} + \overline{I} + \overline{G} \]
\[ (1 - b)Y = a - b\overline{T} + \overline{I} + \overline{G} \]

\[ Y = \frac{1}{1 - b}\overline{G} + \frac{1}{1 - b}\overline{I} + \frac{a}{1 - b} - \frac{b}{1 - b}\overline{T} \]

So if \( b = \text{MPC} = 0.75 \), multiplier = \( 1/(1 - 0.75) = 4 \).
Solving for $\Delta Y$

\[ Y = C + I + G \]  
\text{equilibrium condition}

\[ \Delta Y = \Delta C + \Delta I + \Delta G \]  
in changes

\[ = \Delta C + \Delta G \]  
because $I$ exogenous

\[ = \text{MPC} \times \Delta Y + \Delta G \]  
because $\Delta C = \text{MPC} \Delta Y$

Collect terms with $\Delta Y$ on the left side of the equals sign:

\[ (1 - \text{MPC}) \times \Delta Y = \Delta G \]

Solve for $\Delta Y$:

\[ \Delta Y = \left( \frac{1}{1 - \text{MPC}} \right) \times \Delta G \]

The simple government spending multiplier

Definition: the increase in income resulting from a $1 increase in $G$.

In this model, the govt purchases multiplier equals

\[ \frac{\Delta Y}{\Delta G} = \frac{1}{1 - \text{MPC}} \]

Example: If $\text{MPC} = 0.8$, then

\[ \frac{\Delta Y}{\Delta G} = \frac{1}{1 - 0.8} = 5 \]

An increase in $G$ causes income to increase 5 times as much!

An increase in lump-sum taxes

Initially, the tax increase reduces consumption, and therefore $PE$.

\[ \Delta C = -\text{MPC} \Delta T \]

...so firms reduce output, and income falls toward a new equilibrium.

At $Y_2$, there is now an unplanned inventory buildup...
Algebra example

\[ Y = C + I + G \]

\[ Y = a + b(Y - \bar{I}) + \bar{I} + \bar{G} \]

Solve for \( Y \):

\[ Y - bY = a - b\bar{I} + \bar{I} + \bar{G} \]

\[ (1 - b)Y = a - b\bar{I} + \bar{I} + \bar{G} \]

\[ Y = \frac{1}{1 - b} \bar{G} + \frac{1}{1 - b} \bar{I} + \frac{a}{1 - b} - \frac{b}{1 - b} \bar{I} \]

So if \( b = \text{MPC} = 0.75 \), multiplier = \(-0.75/(1 - 0.75) = -3 \).

Solving for \( \Delta Y \)

\[ \Delta Y = \Delta C + \Delta I + \Delta G \]

eq'n condition in changes

\[ = \Delta C \]

\[ I \text{ and } G \text{ exogenous} \]

\[ = \text{MPC}(\Delta Y - \Delta T) \]

Solving for \( \Delta Y \): \((1 - \text{MPC}) \times \Delta Y = -\text{MPC} \times \Delta T \)

Final result:

\[ \Delta Y = \left( \frac{-\text{MPC}}{1 - \text{MPC}} \right) \times \Delta T \]

The tax multiplier

def: the change in income resulting from a $1 increase in \( T \):

\[ \frac{\Delta Y}{\Delta T} = \frac{-\text{MPC}}{1 - \text{MPC}} \]

If \( \text{MPC} = 0.8 \), then the tax multiplier equals

\[ \frac{\Delta Y}{\Delta T} = \frac{-0.8}{1 - 0.8} = \frac{-0.8}{0.2} = -4 \]
The tax multiplier

...is negative:
A tax increase reduces \( C \), which reduces income.

...is greater than one \((\text{in absolute value})\):
A change in taxes has a multiplier effect on income.

...is smaller than the govt spending multiplier:
Consumers save the fraction \((1 - MPC)\) of a tax cut, so the initial boost in spending from a tax cut is smaller than from an equal increase in \( G \).

What is the formula for the Investment Multiplier?

The Math:
Deriving the Multipliers with Lump Sum Taxes

\[
C = a + b(Y - T) \\
Y = C + I + G \\
Y = a + b(Y - T) + I + G \\
Y = a + bY - bT + I + G \\
Y - bY = a + I + G - bT \\
Y(1 - b) = a + I + G - bT \\
Y = \frac{1}{(1 - b)}(a + I + G - bT)
\]
More realistic Model:

Tax Revenues Depend on Income: \( T = T_0 + tY \), \( t = \text{tax rate} \)

\[
C = a + b(Y - T)
\]
\[
C = a + b(Y - T_0) - tY
\]
\[
C = a + bY - bT_0 - btY
\]

Through substitution we get

\[
Y = a + bY - bT_0 - btY + I + G
\]

\[
Y = \frac{1}{1 - b + bt} (a + I + G - bT_0)
\]

Solving for \( Y \):

This means that a $1 increase in \( G \) or \( I \) (holding \( a \) and \( T_0 \) constant) will increase the equilibrium level of \( Y \) by

\[
\text{Spending Multiplier} = \frac{1}{1 - b + bt} = \frac{1}{1 - \text{mpc} + (\text{mpc} \times t)}
\]

Holding \( a \), \( I \), and \( G \) constant, a fixed or lump-sum tax cut (a cut in \( T_0 \)) will increase the equilibrium level of income by

\[
\text{Lump Sum Tax Multiplier} = \frac{-b}{1 - b + bt} = \frac{-\text{mpc}}{1 - \text{mpc} + (\text{mpc} \times t)}
\]

Comparison of simple multiplier to more realistic multiplier.

Suppose \( \text{MPC} = 0.8 \) and \( t = .25 \).

Simple multiplier

\[
\frac{\Delta Y}{\Delta G} = \frac{1}{1 - \text{mpc}} = \frac{1}{1 - .8} = 5
\]

Multiplier with \( t = .25 \):

\[
\frac{\Delta Y}{\Delta G} = \frac{1}{1 - \text{mpc} + \text{mpc}(t)} = \frac{1}{1 - .8 + .8(,25)} = 2.5
\]

\[
\text{NOTE} \frac{\Delta Y}{\Delta G} = \frac{1}{1 - \text{mpc}(1-t)} = \frac{1}{1 - .8(,75)} = 2.5
\]
Numerical Example: TAX REVENUES DEPEND ON INCOME

\[ T = -200 + 1/3(Y) \]

\[ Y_d = Y - T \]
\[ Y_d = Y - (-200 + 1/3Y) \]
\[ Y_d = Y + 200 - 1/3Y \]

\[ C = 100 + .75Y_d \]
\[ C = 100 + .75(Y + 200 - 1/3Y) \]

Solving for \( Y \) (Equilibrium):

\[ Y = C + I + G \]
\[ Y = 100 + .75(Y + 200 - 1/3Y) + 100+100 \]
\[ C \]
\[ I \]
\[ G \]
\[ Y = 100 + .75Y + 150 - 25Y + 100+100 \]
\[ Y = 450 + .5Y \]
\[ .5Y = 450 \]
\[ Y = 900 \]

A Warning on Multipliers

\[ \text{• Government spending multiplier is about 1.5 - not large!} \]
\[ \text{• Changing } G \text{ or } T \text{ is not always easy.} \]
\[ \text{• Response in } C \text{ or } I \text{ (and imports in an open economy) are not certain} \]
\[ \text{• Anticipations are likely to matter} \]
\[ \text{• Budget deficits and public debt may have adverse implications in the long-run.} \]
The short-run IS-LM model: The IS curve

Up to this point we have held \( r \) constant.

The IS-curve: a graph of all combinations of \( r \) and \( Y \) that result in goods market equilibrium

\[ i.e. \quad \text{actual expenditure } Y(\text{output}) = \text{planned expenditure} \]

The equation for the IS curve is:

\[ Y = C(Y - T) + I(r) + G \]

\[ Y = C(Y - T) + I(i - \pi^e) + G \]

Deriving the IS curve: \( \pi^e = 0 \)

From Chapter 3

45° diagram

\[ \Delta I \quad PE \quad Y \]

\[ PE = C + I(r_1) + G \]

\[ PE = C + I(r_2) + G \]

\[ IS \]

\[ I_1 \quad I_2 \]

\[ r_1 \quad r_2 \]

\[ Y_1 \quad Y_2 \]

Understanding the IS curve’s slope

- The IS curve is negatively sloped.
- Intuition:
  - A fall in the interest rate motivates firms to increase investment spending, which drives up total planned spending \((PE)\) and output \((Y)\) increases.

\[ r \downarrow \Rightarrow I \uparrow \Rightarrow PE \uparrow \Rightarrow Y \uparrow \]
Fiscal Policy and the IS curve

- We can use the IS-LM model to see how fiscal policy (G and T) can affect aggregate demand and output.
- Let’s start by using the Keynesian Cross to see how fiscal policy shifts the IS curve...

Shifting the IS curve: ΔG

At any value of r,

\[ \uparrow G \Rightarrow \uparrow PE \Rightarrow \uparrow Y \]

...so the IS curve shifts to the right.

The horizontal distance of the IS shift equals:

\[ \Delta Y = \frac{1}{(1 - mpc)} \Delta G \]

or

\[ \Delta Y = \frac{1}{(1 - mpc(1-t))} \Delta G \]

NOW YOU TRY:

Shifting the IS curve: ΔT

- Suppose T is reduced.
Equation For the IS-Curve; the real side of the economy

<table>
<thead>
<tr>
<th>EqNo.</th>
<th>Equation Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>( Y = C + I + G ). Output equals aggregate demand, the equilibrium condition</td>
</tr>
<tr>
<td>(2)</td>
<td>( C = a + b(Y_D) ). Consumption function, ( b ) is the mpc.</td>
</tr>
<tr>
<td>(3)</td>
<td>( Y_D = Y - T ). Definition of disposable income</td>
</tr>
<tr>
<td>(4)</td>
<td>( T = T_0 + tY ). Tax function; ( T_0 ) is lump sum taxes, ( t ) is marginal tax rate.</td>
</tr>
<tr>
<td>(5)</td>
<td>( I = d - e_i ). Investment function ( if ( \pi_e = 0 ), ( i = r ) ) ( e = \frac{\Delta I}{\Delta i} ). Sensitivity of investment (I) to the interest rate (i).</td>
</tr>
<tr>
<td>(6)</td>
<td>( G = G_0 ). Government spending on goods and services, exogenous</td>
</tr>
</tbody>
</table>

Equation For the IS-Curve; the real side of the economy

Substitute (2)-(6) into (1): yields:

(7) \( Y = a + b(Y_D) + d - e_i + G_0 \)

(8) \( Y = a + b(Y - (T_0 + tY)) + d - e_i + G_0 \)

Solve for \( Y \) as a function of \( i \):

(9) \( Y = \frac{1}{1 - b + bt} \left[ (a - bT_0 + d + G_0) - e_i \right] \) IS-curve

Solve for \( i \) as a function of \( Y \):

(10) \( i = \frac{(d - bT_0 + d + G_0) - \left( \frac{1 - bt}{b} \right) Y}{e} \) IS-Curve

Shift variables Slope

Observations: as \( e \) ↑ =⇒ slope decreases

as: \( a, d, \) or \( G \) increase =⇒ IS shifts to the right.

The IS curve:

![IS curve diagram](image-url)
The Theory of Liquidity Preference

- Due to John Maynard Keynes.
- A simple theory in which the interest rate is determined by money supply and money demand.
- Two financial assets – Money and bonds.

Money supply

The supply of real money balances is fixed:

\[
\left( \frac{M}{P} \right)^s = \frac{\bar{M}}{\bar{P}}
\]

M and P are exogenous.

Money demand

Demand for real money balances:

\[
\left( \frac{M}{P} \right)^d = L(i, Y)
\]
Equilibrium

The interest rate adjusts to equate the supply and demand for money:

$$\frac{M}{P} = L(r)$$

Excess supply of money

Excess demand for money

How the Fed raises the interest rate

To increase $r$, Fed reduces $M$
CASE STUDY: Monetary Tightening & Interest Rates

- Late 1970s: \( \pi > 10\% \)
- Oct 1979: Fed Chairman Paul Volcker announces that monetary policy would aim to reduce inflation
- Aug 1979-April 1980: Fed reduces \( M/P \) 8.0%
- Jan 1983: \( \pi = 3.7\% \)

How do you think this policy change would affect nominal interest rates?

Monetary Tightening & Interest Rates, cont.

<table>
<thead>
<tr>
<th>The effects of a monetary tightening on nominal interest rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>model</td>
</tr>
<tr>
<td>prices</td>
</tr>
<tr>
<td>prediction</td>
</tr>
<tr>
<td>actual outcome</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The \( LM \) curve

Now let’s put \( Y \) back into the money demand function:

\[
\left( \frac{M}{P} \right)^d = L(r,Y)
\]

The \( LM \) curve is a graph of all combinations of \( r \) and \( Y \) that equate the supply and demand for real money balances.

Equating \( M/P \) to \( M^d \), the equation for the \( LM \) curve is:

\[
\frac{\tilde{M}}{\tilde{P}} = L(r,Y)
\]
Deriving the $LM$ curve

(a) The market for real money balances

(b) The $LM$ curve

Understanding the $LM$ curve’s slope

- The $LM$ curve is positively sloped.

- Intuition:
  An increase in income raises money demand.

Since the supply of real balances is fixed, there is now excess demand in the money market at the initial interest rate.

Sell bonds, the interest rate rises to restore equilibrium in the money market.

How $\Delta M$ shifts the $LM$ curve
Equation For the LM-Curve; the financial side of the economy

(1) \( M_0/P = L(r, Y) \), Equilibrium condition

(2) \( M_0 = \) nominal money supply

(3) \( (M/P)^d = f + gY - hi \), money demand

Substitute (2) and (3) into (1) and solve for \( Y \):

\[
Y = \frac{M_0}{gP} - \left( \frac{f}{g} \right) + \left( \frac{h}{g} \right)i \quad \text{LM-curve}
\]

Solve for \( i \) (remember \( r = i \)):

\[
i = \left( \frac{f}{h} \right) + \left( \frac{g}{h} \right)Y - \left( \frac{1}{h} \right)\left( \frac{M_0}{P} \right) \quad \text{LM-curve}
\]

**Graph the LM curve: remember \( r = i \)**

<table>
<thead>
<tr>
<th>r</th>
<th>LM</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>( \frac{f}{h} ) + ( \frac{g}{h} )Y - ( \frac{1}{h} )( \frac{M_0}{P} )</td>
</tr>
</tbody>
</table>

A steep LM curve (\( g/h \) large) means that a rise in output implies a big rise in interest rate to maintain equilibrium.

Causes of this:
- Money demand is not very responsive to interest rate (\( h \) is small)
- Money demand is very responsive to output (\( g \) large)

**NOW YOU TRY:**

**Shifting the LM curve**

- Suppose a wave of credit card fraud causes consumers to use cash more frequently in transactions.
- Use the liquidity preference model to show how these events shift the LM curve.
The short-run equilibrium

The short-run equilibrium is the combination of \( r \) and \( Y \) that simultaneously satisfies the equilibrium conditions in the goods & money markets:

\[
Y = C(Y - T) + I(r, \bar{G}) \tag{1}
\]

\[
M/P = L(r, Y) \tag{2}
\]

Remember: \( \pi^e = 0 \):

\[
Y = C(Y - T) + I(\pi^e + \bar{G}) + M/P = L(r, Y) \tag{3}
\]

The Big Picture

- Keynesian Cross
- IS curve
- LM curve
- IS-LM model
- Explanation of short-run fluctuations
- Model of Agg. Demand and Agg. Supply
- Agg. demand curve
- Agg. supply curve
- Theory of Liquidity Preference
Preview of Chapter 11

In Chapter 11, we will

- use the IS-LM model to analyze the impact of policies and shocks.
- learn how the aggregate demand curve comes from IS-LM.
- use the IS-LM and AD-AS models together to analyze the short-run and long-run effects of shocks.
- use our models to learn about the Great Depression.

Chapter Summary

1. Keynesian cross
   - basic model of income determination
   - takes fiscal policy & investment as exogenous
   - fiscal policy has a multiplier effect on income

2. IS curve
   - comes from Keynesian cross when planned investment depends negatively on interest rate
   - shows all combinations of r and Y that equate planned expenditure with actual expenditure on goods & services

Chapter Summary

3. Theory of Liquidity Preference
   - basic model of interest rate determination
   - takes money supply & price level as exogenous
   - an increase in the money supply lowers the interest rate

4. LM curve
   - comes from liquidity preference theory when money demand depends positively on income
   - shows all combinations of r and Y that equate demand for real money balances with supply
Chapter Summary

5. *IS-LM model*
   - Intersection of *IS* and *LM* curves shows the unique point \((Y, r)\) that satisfies equilibrium in both the goods and money markets.