Session 1: Simple IS-LM Model

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1 The Topic

Today's topic is the numerical implementation of a simple version of the IS-LM model. The IS-LM model is a business cycle model based on the assumption that there are barriers to the instantaneous adjustment of nominal prices.[1] Typically the price level is fixed and lies above the general market-clearing value. The excessive price level leads to an excess supply of goods. This situation causes changes in the aggregate demand for goods at a given level of prices to affect the amount that firms produce. As a result, purely monetary disturbances can affect real variables like employment and output.

The set-up of the typical IS-LM begins by directly specifying relationships among aggregate variables, i.e. between aggregated production, consumption, investment, government spending, money supply, etc. In a simple version of the IS-LM model these relationships are static.

Such a simple model of aggregate demand can be used to analyse many issues such as the reaction of the economy to changes in policy variables or to changes in the specification of the interaction between endogenous variables. A very general description of the interaction between the different variables allows us to get *qualitative* results of these reactions, e.g. investment falls with increased government spending. However, often we are interested in *quantitative* results, i.e. we want to know not only the direction but the extent of these reactions. To do so we have to make specific assumptions regarding the functional form of the interaction between the variables in the model. We consider here a particularly simple textbook version which involves contemporaneous variables, only; therefore we call it a *static* version (compare Mankiw , 1997, pp. 294).[2]

*Slightly rearranged by Jürg Adamek and Philipp Wegmüller

[1] There are other possibilities of nominal rigidities. For a more comprehensive discussion of the IS-LM model see e.g. Mankiw (1997), Romer (1996), or Barro (1997).

[2] A more sophisticated, dynamic version of the IS-LM model would also include lagged variables (as proxies for expected future income, e.g.) and a price adjustment equation (a so-called Phillips curve).

1.1 An Algebraic Version of the IS-LM Model (Mankiw 1997, pp. 294)

exogenous variables:

G government spending

T tax on income

M money supply

P price level (fixed in the short-run)

endogenous variables:

Y production

C consumption

I investments

R interest rate

parameters:

a, b, c, d, e, f

assumption 1: output equals aggregate demand

$$Y = Y^d \equiv C + I + G \tag{1}$$

assumption 2: Keynesian consumption function

$$C = a + b(Y - T) \tag{2}$$

assumption 3: investment function

$$I = c - dR \tag{3}$$

assumption 4: monetary equilibrium

$$M = M^d \equiv P(eY - fR) \tag{4}$$

Assumption (1) to (3) lead to the IS-curve, the interest rate-savings (investment) relationship

$$Y = \frac{a+c}{1-b} + \frac{1}{1-b}G + \frac{-b}{1-b}T + \frac{-d}{1-b}R \tag{5}$$

The rearranged assumption (4) is the LM-curve, the liquidity-money relationship

$$R = \frac{e}{f}Y - \frac{1}{f}M/P \tag{6}$$

The equilibrium production in this simple model is already a rather complicated function:

$$Y^* = \frac{x(a+c)}{1-b} + \frac{x}{1-b}G + \frac{-xb}{1-b}T + \frac{d}{(1-b)[f + de/(1-b)]}M/P \tag{7}$$

where $x = f/[f + de/(1-b)]$. The equilibrium values for the other variables can be found using the LM curve and assumption (1) to (3).

1.2 Calibration: Parameters for Switzerland

We assume for Switzerland (in billion[3] Swiss Francs):

a = 55, b = 0.63, c= 47, d = 1500, e= 0.6, f = 2700.

(For the policy variables and the fixed price level compare the Excel sheet below.)

[3] A billion is in German called “eine Milliarde”.

2 The Method

The numerical implementation of the algebraic version of the simple IS-LM model does not need a lot of mathematics. The model is already solved analytically without the help of a computer. The equilibrium solution are functions for the endogenous variables Y, R, I, C with respect to the exogenous variables G, T, M, P and the (for the time being assumed) known parameters a, b, c, d, e, d. We can know calculate the equilibrium values for any given set of exogenous variables. Changing the value of one or more exogenous variables and recalculating the equilibrium allows us to do *comparative statics*.

3 The Software

We will implement the above model in *Microsoft Excel*. We assume you to have basic knowledge of Excel. In particular, you should know how to assign a function of other cells to a cell, the difference between relative (e.g. B2) and absolute (B2) references and how to make graphs from data.

A feature in Excel that is very useful when dealing with complicated functions is the assignment of *names* to cells. This allows us to refer to the parameters and the variables with the same abbreviations as in the model, e.g. G, instead of referring to the cell, e.g. C8.

How to assign a name to a cell in Excel (German version):

(1) mark the cell you want to assign a name to, e.g. B2

(2) ⇒ Excel 2010: go to “Formeln”/“Namensmanager”/“Neu”
⇒ Excel 2007: go to “Formeln”/“Definierte Namen”/“Namen definieren”
⇒ Excel 97-2003: go to “Einfügen”/“Namen”/“Festlegen” ...

(3) fill the name, e.g. Y, in the field and press “OK”

(4) the new name will appear on the left side of the “Bearbeitungsleiste”

How to use a name in a formula:
Just use the new name in the formula instead of the cell reference, e.g. = a+b*(Y-T) instead of = $F16+I16*(F27-F9)$

Note: Excel does not distinguish between capital and small letters. You cannot assign ‘K’ to one cell and ‘k’ to another one.

4 References

Barro, Robert J. (1997). *Macroeconomics*, 5th edition. The MIT Press.

Mankiw, N. Gregory (1997). *Macroeconomics*, 3rd edition. New York: Worth.

Romer, David (1996). *Advanced Macroeconomics.* McGraw-Hill.

5 Today's Task

Exercise 1: numerical implementation of the model

We will produce an Excel worksheet that contains the values of exogenous variables, parameters and the endogenous variables in equilibrium. The appendix shows how such a worksheet may look like.

a) Make a sketch of what you want to put where on your Excel sheet.

b) Open a new worksheet in Excel.

c) Choose for each exogenous variable a cell in which you put its value. Assign names from the model to these cells. Describe their contents in another cell next to it.

d) Do the same for the model parameters.

e) Choose cells for the equilibrium values of the endogenous variables.

f) Insert equation 7 in the cell for the equilibrium production.

g) Insert the formulas for the further equilibrium values in their cell. You can refer to the already calculated equilibrium values.

h) Put in reasonable values for the exogenous variables and parameters. That is, use the calibration from above and set the price equal to 1.04.

i) Make the sheet look appealing by setting titles, number formats, additional descriptions, colours, etc.

Exercise 2: graphs

Let us display the *Keynesian Cross* and the *IS-LM diagram*.

a) Find a place for a table with 5 columns and 11 rows in the worksheet from exercise 1. The first column contains given values for the production Y from 0 to 500. The second column contains the corresponding consumption C from equation 2. The third column is the investment at the current equilibrium value of the interest rate (equation 3). The fourth column is total expenditure $E \equiv Y^d = C + I + G$. The last column stands for the 45°-line and repeats the Y values.

b) Make a scatterplot with Y on the horizontal and Y^d on the vertical axis. Also include a 45°-Line. This is the *Keynesian cross* at the current equilibrium interest rate.

c) Find a place for another table with 5 columns and 11 rows. Again, the first column contains given values for the production Y from 0 to 500 and the second column contains the corresponding consumption C from equation 2. The investment in the third column is now such that the Keynesian cross given Y is in equilibrium, i.e. equation 1 is satisfied. The fourth column is the interest rate in the IS-curve. It corresponds to the above investment according to equation 3. The last column is the interest rate in the LM curve that goes with the production in the first column (equation 6).

d) Make a scatterplot with Y on the horizontal and the IS and LM interest rate on the vertical axis. *This is the IS-LM diagram.* The crossing of the two curves yields the equilibrium interest rate and production.

Exercise 3: understand and use the numerical model

a) Suppose, the government cuts non-distorting (lump sum) taxes without changing government spending; the resulting budget deficit is financed by borrowing to the public (we call this a *deficit-financed tax cut*). If taxes are cut by 1 billion (without changing government spending), by how much do GDP, consumption, investment, and interest rates change?[4]

b) Go back to the initial setting. Suppose, the government increases government spending by 1 billion; the resulting budget deficit is covered with additional taxes. By how much do GDP, consumption, investment, and interest rates change?

c) Go back to the initial setting. Suppose, the government increases government spending by 1 billion; the resulting budget deficit is financed by borrowing to the public. Explain step by step how the increase in government spending influences production. Look how the curves move in the graphs. Does the change depend on the level of government spending? Does it depend on other exogenous variables? Derive the effect of government purchases on equilibrium production analytically. Compare it with the numerical result. Is this the so-called Multiplier (Mankiw 1997, p. 253)?

d) Go back to the initial setting. Increase the money supply by one unit (= 1 billion) and study the implications. Explain step by step how the monetary transmission mechanism works. (Consult any good macro introductory textbook, if necessary.)

e) Go back to the initial setting. Suppose, the government increases government spending by 1 billion; the resulting budget deficit is financed by borrowing to the central bank. By how much do GDP, consumption, investment, and interest rates change? Compare the outcome to the debt financed increase of government consumption.

f) Which parameter contains implicitly the size of the economy?

g) To have an overview of policies, fill out the following table:

Table 1: Summary of effects of fiscal and monetary policies

Policy	IS-curve	LM-curve	Income Y	Interest Rate R
$\Uparrow T$	shift left	no shift	$\Downarrow$	$\Downarrow$
$\Uparrow G$				
$\Uparrow M$				

[4] From previous courses we know that in a dynamic general equilibrium model with flexible prices under certain conditions the Ricardian equivalence holds. That is, the public understands, that the government cannot cut taxes (leaving government expenditures unaffected) without raising taxes in the future to pay off principal and interest on the debt. Under those conditions, people would save the entire tax cut, buy the bonds issued by the government, and use the interest on the bonds to pay the higher future taxes; the deficit-financed tax cut would have no real effects. Not so in the IS-LM model! Here, a deficit financed tax cut makes people feel wealthier (possible reasons are consumers shortsightedness or borrowing constraints – compare any good macro introductory textbook).