NOTES ON MACROECONOMIC THEORY

By

Prof. Humberto Barreto
Dept. of Economics
Wabash College

Not for quotation without the author's permission

Revised 8/90, 8/91, 7/92, 8/93, 8/95

Originally Written 8/87

Many thanks to Prof. Frank Howland for his many suggestions and improvements.

Table of Contents

Chapter 1: Introduction

These are notes on orthodox macroeconomic theory. Originally written during the summer of 1987 in preparation for Econ97 (Senior Seminar) at Wabash College, they were substantially revised during the summer of 1990. The author wishes to thank Prof. Frank Howland for his many editorial suggestions and substantive comments. The author accepts responsibility for all remaining errors. Minor revisions were undertaken in August, 1991 by Prof. Howland. He takes responsibility for all errors that crept in during that revision.

The primary goal of these notes is to enable the undergraduate student to understand conventional macroeconomic models. Particular attention will be paid to the ***derivation*** of the IS/LM—AD/AS framework. Although you have undoubtedly seen much of the material presented here, it is hoped that any misunderstandings can be corrected and a sense of the "overall picture" can be gained.

The analysis will consist of a verbal, graphical and mathematical presentation. The mathematics will include derivations of multipliers using the calculus, but will be supported by graphical analysis. Graphs are used to aid the student's intuition; but, it should be clear that the entire analysis can be presented with mathematical equations.

It is assumed that you have completed a course in intermediate macro and bring this intellectual capital to bear in reading these notes. In particular, you should understand:

national income accounting—especially GNP, C, I, G, T and R and their components

real v. nominal values—including the calculation of price indexes and their function

unemployment—including the types of unemployment

inflation—including the difference between a change in the price level
and a change in the rate of change of the price level.

the basics of the Keynesian macroeconomic model—including the following fundamental concepts:

- Equilibrium
- Endogenous and exogenous variables in a model
- Stock concepts versus flow concepts
- Shift ("autonomous change") v. movement along
- Consumption function
    - MPC
- Investment function
- Inventories
- Full employment
- Multiplier
- Fiscal policy tools
- Money market equilibrium
- Monetary policy

If you find some of these terms unfamiliar or confusing, you are urged to review your notes and/or textbook before continuing.

Finally, these notes are not meant to be exhaustive—a great deal of material has been omitted. Only those elements absolutely essential for understanding the fundamentals of macroeconomic theory as captured by the IS/LM—AD/AS analysis have been included. Thus, these notes are not a substitute for a textbook/lecture (i.e., class) approach to macroeconomics. (The most important omission is the fact that these notes do <u>not</u> cover dynamic macroeconomic models in any detail.)

Organization:
The exposition will proceed as follows:

Chapter 2: Short Run, Fixed Price Keynesian Models

A review and comparison of the family of Keynesian macro models that holds the price level constant. This will enable the student to focus on the role of aggregate demand in generating an equilibrium solution for the output, employment, and interest rate endogenous variables.

Chapter 3: Short Run, Flexible (to Varying Degree) Price Models

By making price endogenous, a more complete, and complicated, model emerges. The various IS/LM—AD/AS models depend on the crucial assumption of price flexibility and how fast markets clear.

Chapter 4: Conclusion

One last attempt is made at convincing the student of the repetitive, consistent patterns contained in the set of models reviewed in this reading. This may be the most important lesson of all.

We will slowly build a rather complicated model—you are urged to work patiently and diligently through these notes. I will constantly remind you to stop and take stock of what's been said or to spend time on the solution to a particular problem. Such a strategy should pay handsome dividends in terms of understanding modern macro theory—and in doing well on comps!!!

WARNING: A knowledge of dynamic macroeconomic theory is required to do well on the comprehensive exams. This topic is not treated in any depth in these notes.

Chapter 2: Short Run, Fixed Price Keynesian Models

Section 1: The Simple Keynesian Model

Although highly abstract (even for a macro model!), the Simple Keynesian Model is helpful for its ability to highlight the fundamental equilibrating forces common to all Keynesian macro models. After reviewing the most important assumptions, we turn to verbal, graphical, and mathematical expositions of this model. A detailed and rigorous analysis of the comparative statics properties of this model is conducted before the final section, the summary, is presented.

Fundamental Assumptions:[1]

(1) Output is demanded by three types of agents: consumers, firms, and the government.

(2) Individual consumers' demands across products can be aggregated and represented by a consumption function. Furthermore, consumption is completely determined by disposable income ($Y-t_0Y$) (where "t_0" is a given flat tax rate and is constant across all income levels). Then, we can write

$$C = c_0 + MPC(Y-t_0Y).$$

(3) Individual firms' demands across products can be aggregated and represented by an investment function. In addition, investment is determined exogenously; that is, the level of investment at any point in time is given and unaffected by changes in other variables. Then, we can write,

$$I = I_0.$$

(4) Government demand is exogenously determined and can be represented by the government spending function:

$$G = G_0.$$

(5) The price level is held constant. Therefore Y, C, I, and G are all real, not nominal flows. (This assumption is relaxed in Chapter 3.)

[1]"Fundamental" for, if we really got serious and listed all of the assumptions, the task would be quite time-consuming. Closed economy, no capital depreciation, fixed prices, and a series of other implicit assumptions would have to be enumerated.

Verbal analysis:

Equilibrium (defined as a state in which there is **no tendency to change**) will be found when the desired demands of all the agents in the economy exactly equals the amount produced. Clearly, the total desired demands, or ***aggregatedemand*** (AD), is the simple sum of the consumption function, investment function, and government spending—i.e., the sum of the demands of the three types of buyers.

At any level of income, aggregate demand may be greater than, less than or equal to the amount of goods and services produced by the economy in the period (i.e., ***actual GNP***). (For purposes of measurement of economic flows, the period of time chosen is almost always one year, e.g., GNP is the market value of goods and services produced in one year's time. Adjustment to equilibrium may take considerably less than one year's time.) However, only in the last case (AD=actual GNP) will the economy be in equilibrium. If AD does not equal actual GNP, the system has a tendency to change to a different level of output (and national income).

For a given level of income, if AD is greater than actual GNP, firms will be forced to meet demand by depleting their inventories. In response to this, firms will **produce more** (increase Y) in the next period (assuming some "optimal" level of inventories). Because there is a tendency to change, this cannot be the equilibrium level of income.

Suppose at the new, higher level of output that AD is now less than actual GNP. Firms will be unable to sell all of the output and inventories will rise. In an attempt to return inventories to their optimal level, firms will **produce less** (decrease Y) in the next period. Once again, this level of output has a tendency to change—this eliminates it from consideration as the equilibrium level of output.

In fact, under certain conditions (primarily, a well-behaved AD function), there is only one level of output that has no tendency to change—that is, the level of output where AD exactly equals actual GNP. Firms find that the output produced is exactly sold, with neither a depletion, nor an addition to optimal inventory levels. In response to this, they produce the **exact same** level of output next period—and every period after that as long as AD=actual GNP. For this reason, this level of output is called the ***equilibrium level of output (or national income)***—i.e., the level of output (or national income) at which there is no tendency to change.

Two points should be emphasized:

(1) This model is completely demand driven. Demanders always get what they want. Even when the sum of consumer, firm, and government demands is greater than what is produced in any given period, firms can always meet demand by "going to the back room" and selling output produced in previous periods—i.e., inventories. Equilibrium occurs only when the amount that demanders get is exactly equal to the amount suppliers produced that period because then the "optimal inventory level" remains unchanged.

(2) There is a crucial relationship between the amount produced and the amount consumers want to buy. This relationship drives the model to equilibrium. Remember, firms and the government want to buy the same amount no matter what their income level; consumers' demand, however, is a function of disposable income.

If little output is produced in one period, that means little labor is employed. Consequently, consumers have little disposable income and aggregate demand is low. A basic assumption of the consumption function is that the low AD will be higher than the little output produced during the period. Since inventories are depleted, firms produce more—this means more labor is hired. As consumers' disposable income increases, so does aggregate demand.

If a great deal of output is produced in one period, that means a great deal of labor is employed. Consequently, consumers have a great deal of disposable income and aggregate demand is high. A basic assumption of the consumption function is that the high AD will be lower than the great deal of output produced during the period. Since inventories swell, firms produce less—this means less labor is hired. As consumers' disposable income decreases, so does aggregate demand.

Equilibrium in this model is the point where the amount produced requires a level of employment that generates a level of disposable income for consumers such that their demands for output, when joined with the exogenous demands of the firms and the government, just exactly equals the amount produced. It's the relationship between amount produced, disposable income, and consumers' demand that guarantees equilibrium. Perhaps a look at a graphical exposition will serve to clarify and reinforce this fundamental point.

Graphical analysis:

The consumer, firm and government demands can be represented graphically. The assumption that the consumption function is linear and the other two demands are exogenous simplifies the analysis.

In Figure 2.1, c_0 represents some exogenous "starvation" or minimum level of consumption expenditures. The slope of line C is constant and less than one reflecting the assumed properties of the MPC and the tax rate. I and G reflect the exogenously determined investment and government demands.[2] AD is a simple sum of the three demands for each given level of income, Y. Note that (1) AD is parallel to C because the other two demands have a zero slope and that (2) the distance between AD and C equals the sum of I_0 and G_0 because $AD = C + I_0 + G_0$.

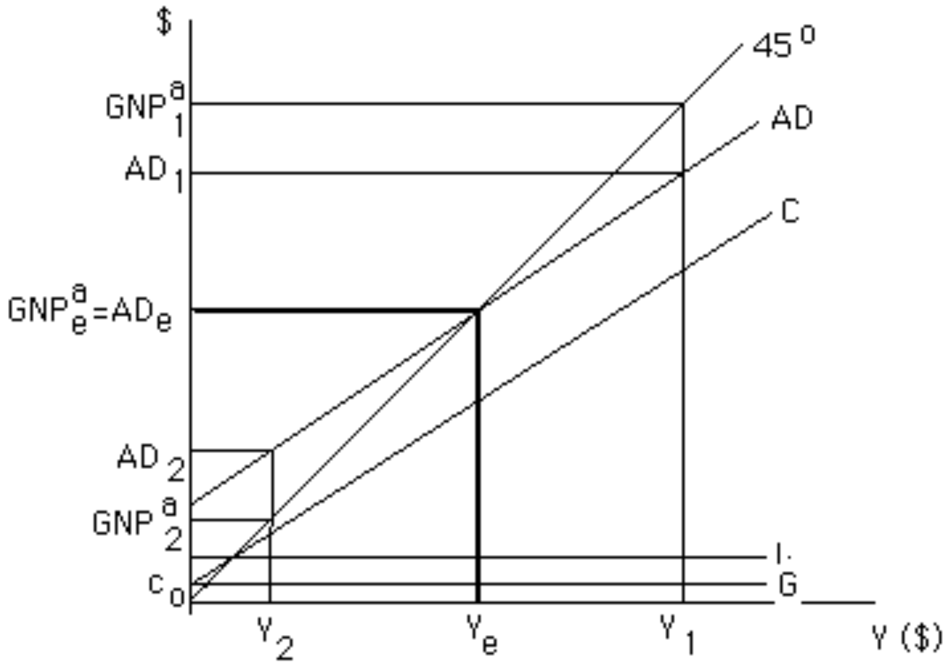


FIGURE 2.1: The Keynesian Cross: Equilibrium Income Determination

[2]To remind the reader, "exogenous" means that the level of these variables is given from somewhere outside ("exo" = outside of) the model and that I and G are completely unresponsive to changes in any variables within the model (especially income).

A common source of confusion is the units and variables on the axes. The y-axis is measured in dollars per year. C, I, G, AD, and actual GNP (GNP^a) can all be read off the y-axis. The x-axis is also measured in dollars per year and, importantly, the variable Y plays a dual role. By making certain simplifying assumptions regarding indirect business taxes, Y represents the actual GNP produced in one year **and** the national income in that year. Y as actual GNP can be easily measured on the y-axis by use of the 45^o line where it can be compared to AD. Y as national income allows the consumption function to be plotted and, hence, for AD to be determined.

Equilibrium occurs at Y_e because this is the only level of output at which there is no tendency to change. The 45^o degree line translates actual output on the horizontal axis to the vertical axis. The 45^o line allows us to compare a given level of actual GNP and AD on the vertical axis. If they are not equal, we know from the discussion above that firms will adjust output and, consequently, that level of output cannot be the Y_e.

At Y_1, for example, actual GNP (GNP^a_1) is greater than AD (AD_1) and we know firms will respond to increases in inventory by decreasing output. At Y_2, actual GNP (GNP^a_2) is less than AD (AD_2) and, thus, Y will increase as firms rebuild their diminished inventories. Only at Y_e, where actual GNP (GNP^a_e) exactly equals AD (AD_e), is there no tendency to change—because inventories are unchanged.

Figure 2.1, is often referred to as the "Keynesian cross" because of the upward sloping AD and 45^o lines. It is important to know that the intersection of these two lines yields the equilibrium level of national income, but it is much more important to know **why**.

Before we turn to the mathematical exposition, you should use the graph to reinforce your understanding of the crucial equilibrating role played by the consumption function. Given a positive c_0, a slope less than one is needed if the model is to reach equilibrium. Reread Point (2) in the Verbal Exposition (p. 8). Does this make sense? Test yourself: *What would happen if the MPC were greater than one?*

Mathematical analysis:

A Brief Suggestion:

The math of the Simple Keynesian Model is straightforward and instructive. If you suffer from "math anxiety" you should **not** quickly rush over this section. On the contrary, a slow, careful approach will provide the best chance of understanding the mathematical exposition. There can be no doubt that the mathematical form is the shortest, most common, and most powerful (as we shall see) presentation of orthodox macroeconomic models. Remember, slow and steady!

I) Setting Up the Problem

We begin construction of our mathematical model by laying out the pieces. We first separate all of the variables into two mutually exclusive categories called "endogenous" and "exogenous" variables. The endogenous variables are those that are determined by the forces in the system. In the Simple Keynesian Model, the only endogenous variable is the level of output (which is identical to national income). The exogenous variables are those fixed, given conditions that comprise the environment in which the system works. The exogenous variables of primary importance in the Simple Keynesian Model include: the components of the consumption function (i.e., intercept, marginal propensity to consume, and income tax rate), investment spending, and governmentspending.

The next step in building a mathematical equilibrium model is to write the "system" as a set of equations. There are three structural equations in the Simple Keynesian Model that represent the four demands for output and their sum:

$$C = c_0 + MPC(Y - t_0Y)$$

$$I = I_0$$

$$G = G_0$$

$$AD = C + I + G$$

The final pieces to be laid out are the equilibrium conditions. Once again, the model we are constructing here is the ultimate in simplicity, for it has only one equilibriumcondition:

$$Y = AD.$$

That is, the equilibrium level of output will be that level that satisfies the condition that actual GNP (Y on the left hand side) equals the sum of the demands of all the agents in the economy (the right hand side).

II) Finding the Equilibrium Solution

To solve for Y_e, we must find that level of output that satisfies the equilibrium condition. The notation is crucial here—Y_e is one particular level of output; one point among the infinite possible levels the variable Y could be. In verbal terms, we are searching for the level of output (and national income) where the amount produced is just exactly equal to the amounts desired by the consumers, firms, and the government. In graphical terms, we are searching for the intersection point of AD and the 45^{o} line.

We find the equilibrium solution by substituting the structural equations, the three demands for output, into the equilibrium condition:

$$Y_e = c_0 + MPC(Y_e - t_0 Y_e) + I_0 + G_0.$$

The subscript "e" is immediately attached to "Y" because we are saying, *the moment we write the equation*, that Y_e represents the equilibrium value of output—that is, the value of output that makes actual GNP equal to the sum of the demands. All that remains to be done is to manipulate the equation algebraically so that we get a cleaner description of Y_e:

(1) Factor Y_e out of $(Y_e - t_0 Y_e)$:

$$Y_e = c_0 + MPC(1-t_0)Y_e + I_0 + G_0$$

(2) Put all the terms with Y_e on the left hand side:

$$Y_e - MPC(1-t_0)Y_e = c_0 + I_0 + G_0$$

(3) Factor out Y_e from the left hand side:

$$[1 - MPC(1-t_0)]Y_e = c_0 + I_0 + G_0$$

(4) Solve for Y_e:

$$Y_e = \frac{c_0 + I_0 + G_0}{1 - MPC(1-t_0)} \qquad \text{(Equation 1)}$$

Equation 1 is a "reduced form" of the system of equations that compose this model because it expresses the equilibrium value of the endogenous variable as a function of exogenous variables alone. Equation 1 can be evaluated at any combination of exogenous variables in order to determine Y_e.

An example may help you understand the mathematics more clearly:

Example 1:

Suppose $C = 200 + .8(Y - .0625Y)$

$I = 200$

$G = 100$

Then, as above, Y_e can be found by solving the equilibrium condition for Y. Applying the steps above:

$Y_e = 200 + .8(Y_e - .0625Y_e) + 200 + 100$

(1) $Y_e = 200 + .8(1 - .0625)Y_e + 200 + 100$

(2) $Y_e - .8(1 - .0625)Y_e = 200 + 200 + 100$

(3) $[1 - .8(1 - .0625)]Y_e = 200 + 200 + 100$

(4) $Y_e = \{200 + 200 + 100\}/[1 - .8(1 - .0625)] = \$2000$

Note that we needn't have done the calculations from the beginning—we could have simply used the "reduced form equation" or general solution for Y_e given by Equation 1 above.

Either way, we note that $Y_e = \$2000$. At any other level of output, AD will not exactly equal actual GNP. For example, if actual GNP is \$1500, AD will be \$1625 (i.e., 200 + .8[(1500)-(.0625)(1500)] + 200 + 100). Thus, we know that inventories will be unintentionally depleted and firms will respond by increasing output. On the other hand, if actual GNP is \$3000, AD is \$2750 (you should perform this calculation). In this case, inventories "pile up" above their optimal levels and firms will decrease output in the next period. Neither \$1500 nor \$3000 can be the equilibrium level of output (and national income) because they each have a tendency to change. In fact, any other value other than \$2000 suffers from this same tendency to change.

Note that there is a surplus in the federal budget at this equilibrium level of income. Calculating revenues minus expenditures (a positive number indicating a surplus and a negative result a deficit), we find:

Revenues: $t_0Y = (.0625)(2000)$

$= \$125$

Expenditures: $G_0 = \$100$

Budget Surplus: +\$25.

As the level of income falls, revenues decrease—this is why governments are more likely to run deficits during recessions (i.e., periods of decrease in Y).[3]

III) Comparative Statics

Now that we have found the equilibrium level of output (and analyzed Y_e verbally, graphically and mathematically), we will focus on an examination of how changes in exogenous variables affect Y_e. In particular, we will consider the following two types of problems:

1) If an exogenous variable (c_0, MPC, t_0, I_0, G_0) changes, how will Y_e (the endogenous variable) change?

2) How and by how much do we need to change G_0 and/or t_0 (our fiscal policy variables) to get a desired change in Y_e?

It is not an exaggeration to say that these are the two fundamental questions asked of every macroeconomic model. There are always variables that are determined by forces outside the model and, hence, are considered given and unresponsive to

[3]To be technical and precise, a "recession" occurs when actual GNP falls for two consecutive quarters. There is no generally agreed upon number of consecutive quarters of declining GNP needed for a depression.

changes in other variables in the model. In contrast to these exogenous variables, endogenous variables are determined by the interplay of forces within ("endo" = inside) the model. A "shock" is a change in one exogenous variable (holding all others constant). The natural questions are: (1) How does a shock affect an endogenous variable? and, (2) What kind of a shock would be needed to get a given effect on an endogenous variable? These are, of course, the two fundamental questions! Note that the questions can be answered qualitatively or quantitatively. The former implies an answer based on the direction of the change (up or down, higher or lower, increase or decrease); while the latter requires a more precise measure, for both direction and magnitude are needed (how much higher or lower).

Before we begin consideration of these two questions, an often leveled criticism should be mentioned. "Comparative statics" analysis means that the investigator "compares" two alternative positions, the initial and new levels of the endogenous variable(s). The macroeconomist notes, for example, the initial equilibrium value of output, determines the shock (say, an increase in government spending), calculates the new equilibrium value of output, and compares the two. Focus is kept on initial and new (or final) in order to facilitate comparison. A pure comparative statics methodology implies no consideration of the process by which the economy moves from initial to new equilibria. Economists are paying increasing attention to issues such as process, speed of response, and the microeconomic details of how the economy moves from initial to new equilibria.

Question 1: Effect of a shock on Y_e?

In the model above, assume that G, for some reason, increases by \$100, *ceteris paribus*. What is the effect of this shock on Y_e?

There are two methods of solving this problem. First, we can recalculate Equation 1—changing G_0 from its old \$100 value to its new \$200 value. Calculating, the new equilibrium level of output, Y_e', is \$2400 (see Figure 2.2 below).

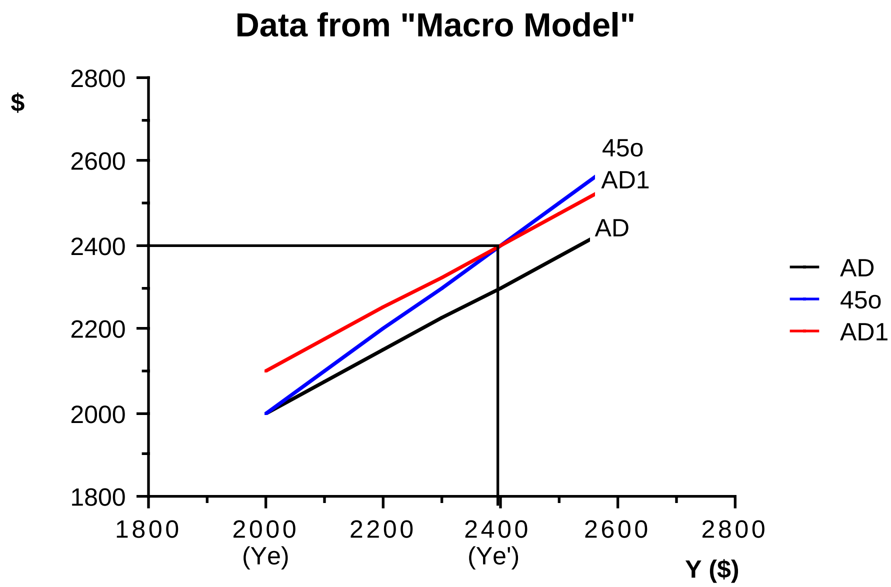


FIGURE 2.2: The Effect on Y_e from an Increase in G

The fact that the equilibrium level of income increased by more —four times more—than the increase in government spending is evidence of the "multiplier" (Note: you should review your notes and/or textbook if this is unfamiliar). In this case, the multiplier is 4—every $1 increase in AD results in a $4 increase in Y_e.

The second method of calculating the new Y_e explicitly derives the multiplier and then uses it to determine the new equilibrium level of income. Equation 1

$$Y_e = \frac{c_0 + I_0 + G_0}{1 - MPC(1-t_0)}$$

tells us the equilibrium level of income given the exogenous variables on the left hand side. We want to determine how Y_e will change for a given change in G_0. Mathematically, we want to find the derivative of Y_e with respect to G_0; that is, the rate of change in Y_e with respect to G_0:

$$\frac{dY_e}{dG} = \frac{1}{[1 - MPC(1-t_0)]}$$

$$\left.\frac{dY_e}{dG}\right|_{\substack{MPC=.8 \\ t_0=6.25\%}} = \frac{1}{[1 - .8(1- .0625)]}$$

$$\frac{dY_e}{dG} = 4$$

Here we have a general solution to Type 1 problems concerning G (i.e., What is the effect on Y_e of a given change in G?). We need not recalculate for every change in G—we simply take the given change, multiply by 4, and add it to the old equilibrium level of output.[4]

What we are actually doing is examining how the endogenous variable, Y_e, responds to a change in an exogenous variable, G. Therefore, we should be able to graph thisrelationship:

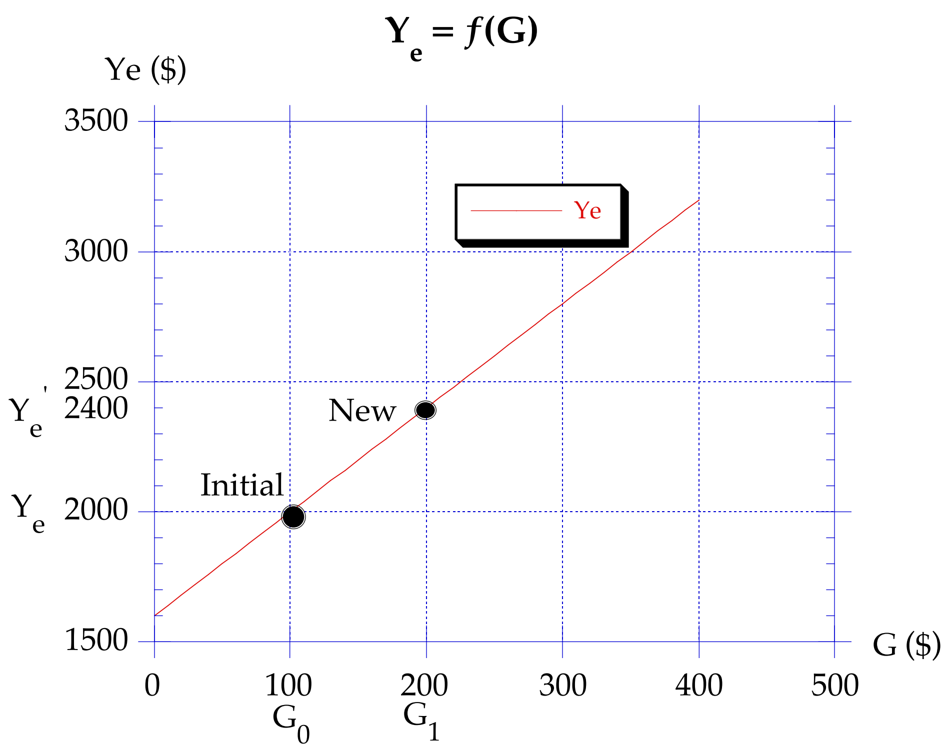


Figure 2.2.a: Equilibrium Output as a Function of Government Spending

Note the linear relationship and the fact that this graph can be used to easily answer "Given a shock in G, what's the new Y_e?" questions. You should also see the similarity between the presentation of this relationship and that of a *demandcurve*. Think!!! *These are both presentation graphs.*

You should derive dY_e/dI and dY_e/dc_0 (Note: this is lower case c_0—theintercept term in the consumption function) and confirm that they are identical to the multiplier above. Intuitively, these multipliers are identical because G, I and c_0 affect AD the same way—i.e., a shift of the intercept and no change in the slope. For this reason, graphs of the relationship between Y_e and I_0 or c_0 will be linear.

[4]For the concrete example at hand, $\Delta G=+\$100$, multiplier = 4, and initial $Y_e = \$2000$, we know that $\Delta Y_e = \$400$ (= 4 * \$100) and new $Y_e = \$2400$ (= initial $Y_e + \Delta Y_e = \$2000 + \$400$).

On the other hand, changes in the tax rate or MPC change the slope without changing the intercept. Thus, we would expect a different multiplier. Calculating dY_e/dt is conceptually identical to the above, but the actual calculation of the derivative is more difficult because t appears in the denominator. For this reason, we leave this as an aside below. Note, however, a qualitative difference between G and t: an **increase** in t will lead to a **decrease** in Y_e—as the tax rate increases, consumers will have less disposable income and consumption will fall (the consumption function will rotate downward along the unchanged intercept); leading to a fall (rotating downward along AD's unchanged intercept) in AD and, of course, Y_e (See Figure 2.3).

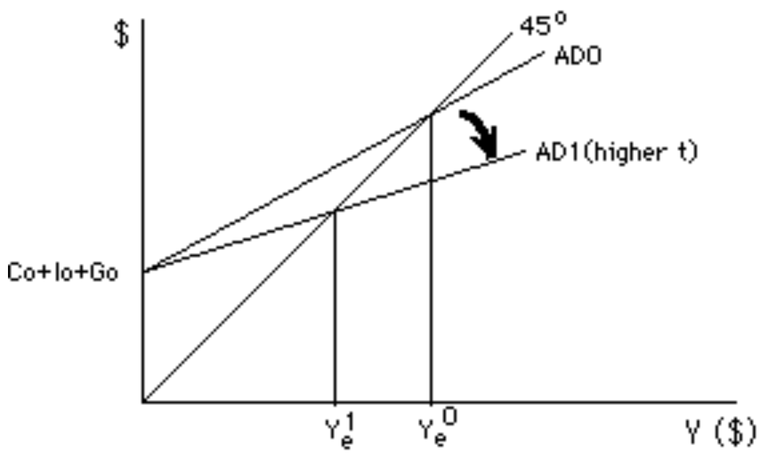


FIGURE 2.3: The Effect on Ye from an Increase in t

ASIDE: $Y_e = f(t)$ and finding dY_e/dt

Remembering that $y = u/v = uv^{-1}$ and the chain rule (if $y=f(v)$ and $v=g(x)$ then $dy/dx=(dy/dv)(dv/dx)$), we can mitigate the pain of solving for the tax multiplier.

First, we rewrite the reduced form,

$$Y_e = \frac{c_0 + I_0 + G_0}{1 - MPC(1-t_0)} = [c_0 + I_0 + G_0]\cdot[1 - MPC(1-t_0)]^{-1}$$

Then, we take the derivative with respect to t in order to find the tax multiplier,

$$\frac{dY_e}{dt} = -\frac{MPC[c_0 + I_0 + G_0]}{[1 - MPC(1-t_0)]^2}$$

Evaluating this equation at the initial values of the exogenous variables gives,

$$\left.\frac{dY_e}{dt}\right|_{\substack{MPC=.8 \\ c_0=200 \\ I_0=200 \\ G_0=100 \\ t_0=.0625}} = -6400$$

This tells us that an infinitesimal increase in t will lead to a 6400-fold decrease in Y_e. I say "infinitesimal increase" instead of 1% increase because Y_e is non-linear in t. This means that the tax multiplier depends on both the magnitude of the increase and the initial value of the tax rate. It is not true that, as in the case of a change in G, that the tax multiplier will always be the same.

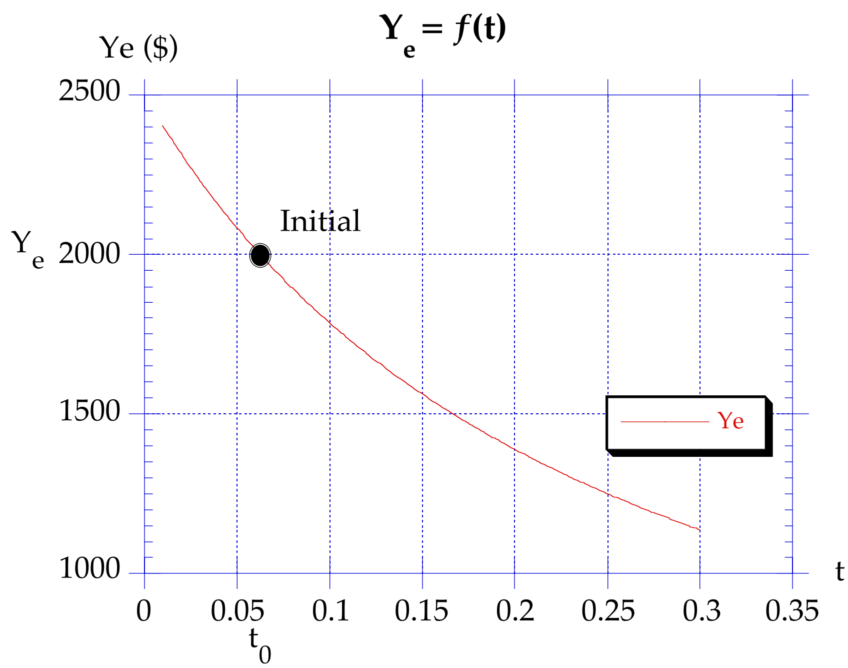


Figure 2.3.a: Equilibrium Output as a Function of the Tax Rate

Question 2: Shock needed to generate desired Y_e?

The second major question we ask in macroeconomics concerns the choice of policy tools to move Y_e to a desired level. In Keynesian models, a "full-employment" level of output, Y_f, is often postulated and the policy maker is responsible for ensuring that the economy's equilibrium level of output matches the given full-employment level.

For example, considering our first concrete model above:

$$C = 200 + .8(Y - .0625Y)$$
$$I = 200$$
$$G = 100,$$

we found that Y_e = \$2000. Suppose, however, that Y_f = \$2500.

The policy maker needs to reduce the GNP Gap ($Y_f - Y_e$) to zero. Usually, c_0 and MPC are considered beyond the reach of systematic government manipulation. The government could launch a campaign to encourage consumer spending—thereby shifting and/or rotating the consumption function; but the analysis usually focuses on G, t and I. In the Simple Keynesian Model, moreover, there is no way to influence I—leaving us with only the fiscal policy tools of G and t.

The policy maker must calculate the multiplier in order to determine the correct "shock" that needs to be administered.[5] We found above that $dY_e/dG = 1/[1-MPC(1-t_0)]=4$. Above, we knew the change in G and by multiplying by 4, found the change in Y_e. In this case, however, we know the desired change in Y_e (that is, $\Delta Y_e = Y_f - Y_e = \$500$) and seek the needed change in G. In other words, we have:

$$\$500/dG = 4$$
$$dG = \$125$$

A \$125 increase in G will increase Y_e by \$500 which will move the equilibrium level of output to \$2500. Since this level of output is the full-employment level, the policy maker has accomplished her task. Figure 2.4 provides a graphical representation of this example.

---

[5]A process of iteration using the "recalculate for every given shock" method is possible, but clearly tiring!

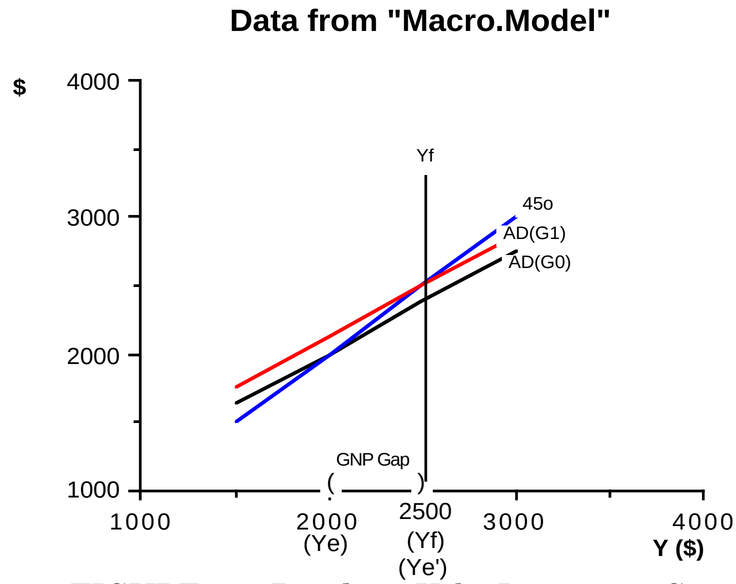


FIGURE 2.4: Reaching Y_f by Increasing G

Note that the government is now running a deficit. Revenues have increased (because national income increased) to (.0625)($2500) = $156.25; while expenditures have risen to $225 (i.e., the previous level of G plus the additional $125 in expenditures). This $68.75 budget deficit is not problematical in this model because there are no mechanisms by which the deficit can affect Y_e.

The policy maker could also lower the tax rate in an attempt to increase AD and, consequently, Y_e. In this example, the policy maker would have to set t=0 in order to get the required change in Y_e. The reader is left with the task of working out the mathematics of the solution, but a graphical representation (Figure 2.5) is shown below.

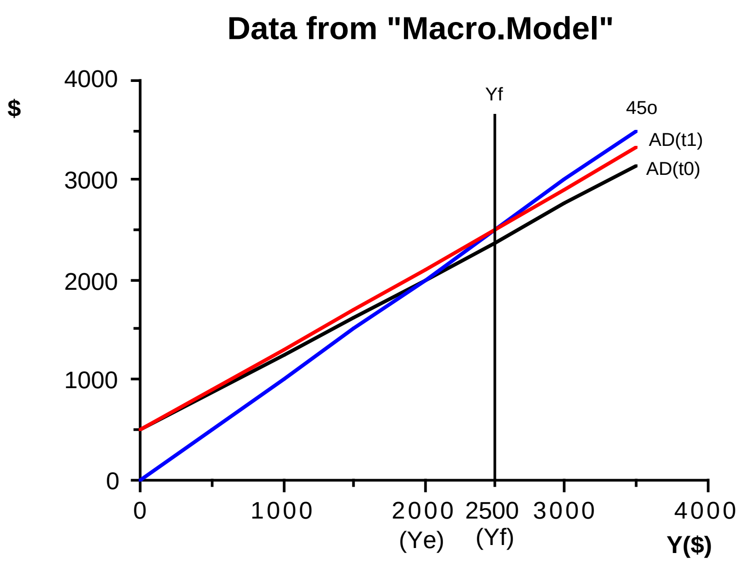


FIGURE 2.5: Reaching Y_f by Decreasing t

For the sake of completeness, we should mention that a combination policy could also be used. There are many mixes of changes in G and changes in t that will force $Y_e = Y_f$. In fact, it is even possible to find a G-t mix that simultaneously balances the budget and eliminates the GNP Gap. In this example, increasing G by \$400 to G_0 = \$500 and increasing taxes to t_0=20% yields $Y_e = Y_f$ = \$2500 and a balanced budget (revenues = \$500 = expenditures). You should be able to show graphically the separate effects of the changes in G and t and the total, or combined, effect of these changes.

This is not an idle suggestion, dear reader. You should be able to easily manipulate the Simple Keynesian Model and solve such fairly straightforward problems. This will greatly improve your chances of fully understanding the more advanced macro models we will soon consider.

<u>Summary:</u>

In this section, we have analyzed the Simple Keynesian Model. You should understand how equilibrium is determined and how changes in exogenous variables affect the equilibrium level of output.

To Review:

<u>Equilibrium:</u> Any given level of income will determine a level of aggregate demand. If that level of aggregate demand does not exactly exhaust actual GNP, there is a tendency for output (and, by definition, income) to change:

If AD>actual GNP ==> depletion of inventories ==> increased Y next period

If AD<actual GNP ==> addition to inventories ==> decreased Y next period

If AD=actual GNP ==> unchanged inventories ==> unchanged Y next period

The last case is equilibrium because there is no tendency to change—the economy will continue producing the same level of output in every time period.

<u>Comparative Statics:</u> Changes in any exogenous variable (i.e., c_0, MPC, t_0, I_0, G_0,) will change the endogenous variable (Y_e). Graphically, such changes are represented by shifts in AD (in the case of c, I and G) or rotations along the intercept (in the case of MPC and t). Increases in c, I, G and MPC lead to increases in Y_e; however, increases in t lead to decreases in Y_e. Mathematically, we are able to derive not only the qualitative, but also the quantitative change in Y_e for a given change in an exogenous

variable. In order to do this, we can recalculate Y_e by including the new values of the exogenous variable; or, we can, having taken dY_e/dexogenous, apply the multiplier to a given change.

The two fundamental questions: In every macroeconomic model, we will ask the following two fundamental questions:

(1) How do changes in exogenous variables (in this case, we examined G and t) affect the endogenous variable(s) (in this case, Y_e)?

(2) What can policy makers do (in this case, G and t are the policy variables) to eliminate the GNP Gap?

The Simple Keynesian Model lacks many features that we will incorporate in succeeding models. It does, however, show quite clearly the concepts of "equilibrium" and "multiplier"—two crucial notions in all macroeconomic models. In addition, the tools used here will be applied to more complicated models. To the first of these models, we now turn.

Section 2: The Partial Equilibrium Keynesian Model

In the Simple Keynesian Model, the emphasis was on understanding the role of aggregate demand in determining equilibrium. We saw how governmental authorities could manipulate G and t—the former directly affecting AD through G itself and the latter indirectly affecting AD through C—to move Y_e. There are, however, three parts to aggregate demand. In this section, we examine how I is determined and how the government can affect AD and, hence, Y_e through the level of investment.

The organization is identical to that of the first section. We consider the assumptions of the Partial Equilibrium Keynesian Model, then turn to the verbal, graphical, and mathematical expositions. After considering the two fundamental comparative statics questions, a short summary is provided.

<u>Assumptions:</u>

We carry over the assumptions from the Simple Keynesian Model and include the following:

(1) There is only *one* rate of interest (i) and it determines the price of borrowing for all debtors and the rate of return for all creditors. Be aware that this, like many other assumptions, is a tremendous simplification of reality. Most macroeconomists believe, however, that additional realism changes the quantitative, but not qualitative results.

Given that the interest rate is the cost of borrowing, it follows that investment is inversely correlated with the interest rate. We assume that firms adopt only those investment projects with a positive Net Present Value. Clearly, if the interest rate is lower, there is a greater chance that a particular project will the pass the test and the investment will be made.

Mathematically, we will assume that the investment function is linear:

$$I = e_0 - e_1 i \, ;$$

where e_0 is the intercept the e_1 is the slope, and both are positive.

(2) We need a money market in order to determine the equilibrium rate of interest. Thus, we need a money supply, money demand, and equilibrium condition that are describedbelow:

(2a) The money supply (M^s) is assumed to be exogenously determined by the Federal Reserve System (the Fed). It is important to note that, in the United States, the Federal Reserve System is ***not*** equivalent to the Congress. That is, the fiscal policy tools (G and t) are handled by a different set of policy makers (Congress and the Executive—the federal government) than the monetary policy tool (M^s—which is controlled by the Fed). To reiterate, the Fed is not the federal government; it is the Federal Reserve System. Alan Greenspan, Chair of the Fed, is not a member of Congress and not the Chair of the House Ways and Means Committee.

(2b) Money demand, or liquidity preference, can be derived two ways. A Keynesian would argue that money demand is composed of three "subdemands"—transactions, precautionary and speculative demands. It is the last of these that gives M^d its downward slope.

A more modern, portfolio theory derivation of the money demand curve would apply optimization theory. The phrase "money demand" is actually quite misleading. The question is not, "How much money do you want?" (the answer to which is obvious); but "How much of your wealth do you wish to hold as money?" To simplify the problem, we assume that there are only two assets—bonds and money. We assume that, at a given interest rate, people maximize satisfaction and determine how much of their wealth they wish to hold in money and how much in bonds. Money is liquid, but it generates no return; bonds are not as liquid, but they do generate a positive return. If the interest rate, i, increases, agents will wish to hold less of their wealth in money because this choice has become more "expensive." Thus, as the interest rate increases, the opportunity cost of holding money (the foregone income from interest payments on bonds) also increases. When i=1% per year, holding $100 "costs" you $1 per year because, had you invested that money (bought a bond), you would have gained $1 in interest. At i=10% per year, you are foregoing $10 in income per year. Clearly, as the interest rate increases, agents will wish to hold more of their wealth in bonds, which by definition means that there is a decrease in the quantity demanded of money.

Mathematically, we assume a linear money demand function that is given by:

$$M^d = d_0 - d_1 i;$$

where d_0 is the intercept and d_1 is the slope, and both are positive.

(2c) The equilibrium interest rate is found at the intersection of the money supply and money demand curves **and** the intersection of the bond supply and bond demand curves as in Figure 2.6.

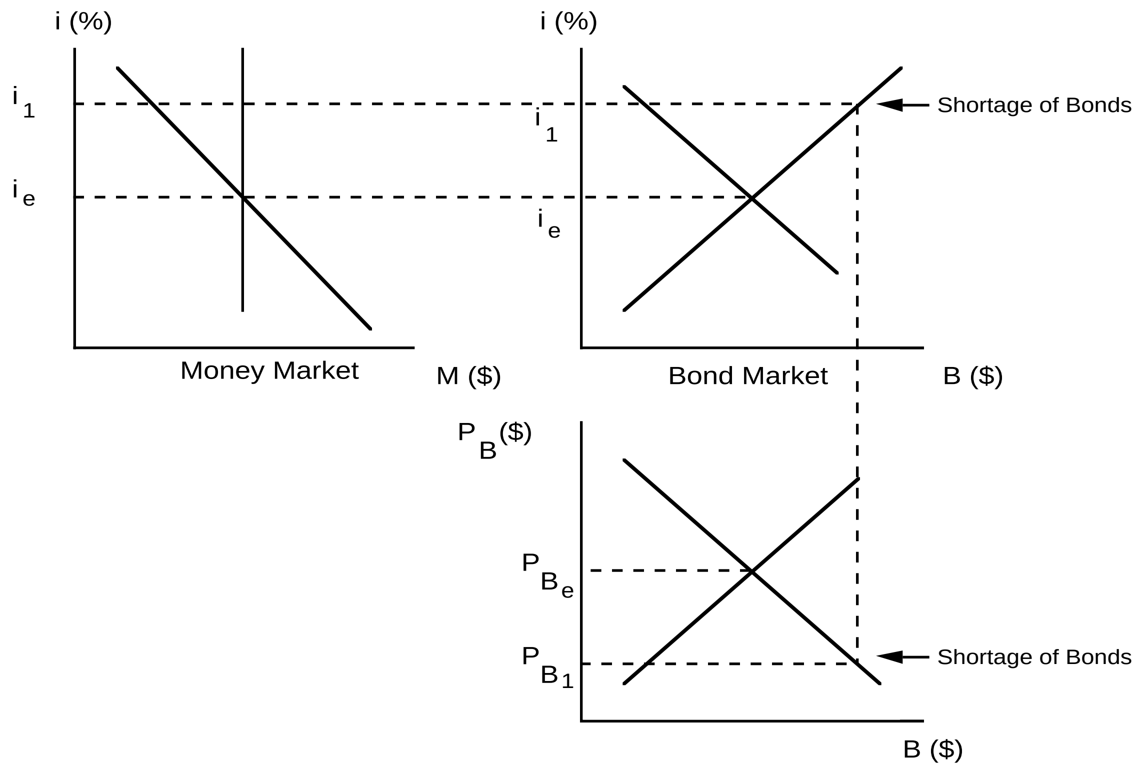


Figure 2.6: Determining the Interest Rate

At i_1, the interest rate is high enough so that agents don't want to hold the amount of money available (there is an excess supply of money); they prefer, instead, to hold most of their wealth in interest-bearing bonds. *The money market, however, does not equilibrate like commodity markets.* Instead, it utilizes the bond market to determine the rate of interest. When $i=i_1$, people will want to hold much of their wealth as bonds. Since we are assuming only two assets, the bond market must be characterized by an excess demand for bonds. As the shortage of bonds forces up the price of bonds, it lowers the interest rate (because of the inverse relationship between bond prices and interest rates—you are urged to review your Econ 4 notes and/or textbook if this argument is confusing). The price of bonds will continue to rise and the interest rate will continue to fall until the bond market is in equilibrium; or, in other words, the excess demand for bonds is eliminated. At this point, bond demand will equal bond supply and, by definition, money demand will equal money supply. I invite you to work out the equilibrium process of an interest rate that initially generates an excess demand in the money market.

The relationship between money and bond markets is an important one. Money markets, in and of themselves, have no "market process" by which to reach equilibrium. It is activity in the bond market which forces equilibrium in the money market.

Thus, we have augmented the Simple Keynesian Model with (1) an investment demand function and (2) a money market. We now turn to the verbal, graphical and mathematical analyses of this model.

Verbal analysis:

The analysis of the equilibrium level of output (and national income) and the role of aggregate demand in determining Y_e carries through to the Partial Equilibrium Model without conceptual modification. The only changes we need to make concern the incorporation of the investment demand function and the money market. You need to think logically and sequentially in order to understand the equilibrium process in this model.

As before, any given level of income will determine a level of aggregate demand. The only difference is that investment demand is longer exogenous, but is determined by the interest rate, which is in turn determined by the money demand and supply curves as explained above. Once the equilibrium interest rate is reached, the investment demand function will determine the level of investment for that particular interest rate. The level of investment is then added to C and G in order to determine AD. As before, if AD is less than actual GNP, inventories "pile up" and less is produced; if AD is greater than actual GNP, inventories are depleted
and more is produced. Only when AD exactly equals actual GNP is the economy in equilibrium.

The interest rate is determined in the bond market and is found at the intersection of M^d and M^s. This equilibrium interest rate (i_e) is then used by firms to decide how much they want to invest (i.e., buy intermediate goods and services—machinery, plant, etc.).

This level of investment is a component, along with C and G, of aggregate demand. AD determines Y_e exactly as it did in the Simple Keynesian Model.

The introduction of the investment demand function and the money market generates one more policy tool. Governmental authorities can now influence AD through changes in the money supply. (Recall that changes in the discount rate, changes in the reserve requirement, and open market operations are the three ways the Fed can change M^s). Increasing the money supply will cause an excess supply of money at the initial equilibrium interest rate. The resulting decrease in i_e (through changes in the bond market) will lead to an increase in I (because of the negative relationship between i and I) and, clearly, an increase in AD (since AD=C+I+G).

Thus, if the Fed has information on the GNP Gap, the empirical values of the investment and money demand functions, the consumption function, and government expenditures; it can, by manipulating M^s, drive $Y_e = Y_f$. Increases in the money supply will increase the equilibrium level of income; while decreases in M^s will lower Y_e.

Graphical Analysis:

You may find it instructive to think of the Partial Equilibrium Model as composed of two separate "sectors" (sometimes these are referred to as the money market and goods sectors) and the investment demand function as providing the link between the two. Figure 2.7 shows a graphical representation of the model:

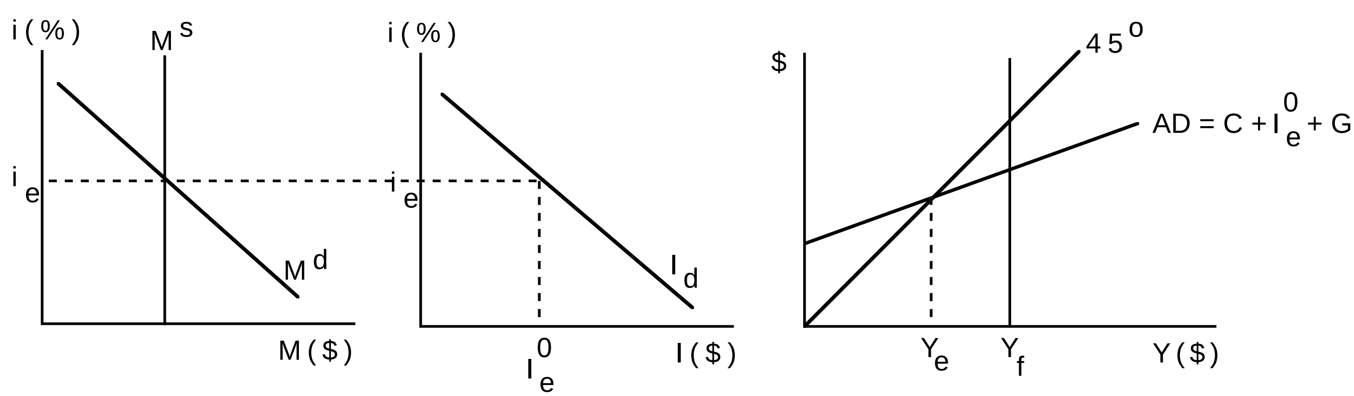


Figure 2.7: The Partial Equilibrium Model

The goods sector (the right most, "Keynesian cross" graph) shows how Y_e is determined, once again, as that point where aggregate demand exactly equals actual GNP (given, of course, by the 45^o line). It also shows how the economy is mired in an unemployment equilibrium because Y_f is greater than Y_e. There are no forces in this model that will force Y_e to move toward the full employment level. This creates the need for the government to actively manage AD in order to ensure that AD intersects the 45^o line at Y_f.

Figure 2.7 also shows how the interest rate (left most, money market graph) determines the level of investment and how the investment demand function (middle graph) provides the link between the money and goods markets. It is important to note that i_e calls forth I_e^0 level of investment and that is the same level of investment that is in the investment portion of AD. In other words, the I_e^0 in the investment demand graph is the exact same I_e^0 in the goods market graph.

Clearly, by manipulating M^s, policy makers can affect the equilibrium level of national income. The process by which this occurs can be thought of as a "chain reaction." Figure 2.8 and the following series of effects show how the chain reaction works.

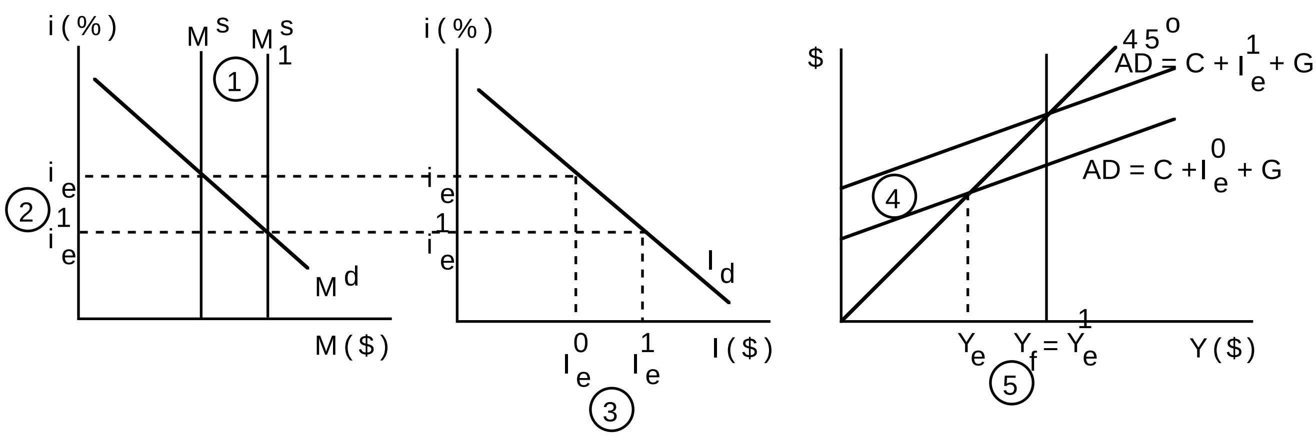


Figure 2.8: The Effect of an Increase in M^S on Y_e

SHOCK 1: An increase in the money supply (caused by a decrease in the discount rate, a decrease in the reserve requirement, and/or the buying of bonds by the Fed in the open market).

CAUSES 2: A decrease in the interest rate (because more money is now available than people want to hold which causes them to want bonds, which causes an increase in bond demand, which leads to an increase in bond prices and a decrease in the interest rate).[6]

CAUSES 3: An increase in investment (because the cost of borrowing has decreased).

CAUSES 4: An increase in AD (because I is in AD).

CAUSES 5: An increase in Y_e.

Note that the magnitude of the change in the equilibrium level of national income is a function of the elasticity of money and investment demand. If M^d is interest elastic (that is, very responsive to changes in i or relatively flat), *ceteris paribus*, the change in M^s will not decrease i by much, which will not increase I by much, which will not increase AD by much, which will not increase Y_e by much. If I^d is interest inelastic (that is, very unresponsive to changes in i or relatively steep), *ceteris paribus*, the change in i will not change I by much which will not change AD by much which will not change Y_e by much.

You should be able to graphically demonstrate these two cases and analyze the M^d inelastic and I^d elastic cases. Once again, active participation is essential. Go to work with paper and pencil!

Mathematical analysis:

I) Setting Up the Problem

As before, we begin construction of our mathematical model by laying out the pieces. We first separate all of the variables into two mutually exclusive categories called "endogenous" and "exogenous" variables. The endogenous variables in the Partial Equilibrium Keynesian Model are the level of output (which is identical to national income) and the interest rate. The exogenous variables of primary importance in the

[6]The reader should note that in the case of Federal Reserve Open Market operations, buying bonds shifts the bond demand curve to the right. In P-B space, this raises the price of bonds, which then lowers the interest rate; more directly, in i-B space (as in Figure 2.6), this lowers the interest rate.

Partial Equilibrium Keynesian Model include: the components of the consumption function (i.e., intercept, marginal propensity to consume, and income tax rate), the determinants of investment spending (i.e., the intercepts and slopes of the investment demand and money demand functions, and the money supply), and government spending.

The next step in building a mathematical equilibrium model is to write the "system" as a set of equations. There are four structural equations in the Simple Keynesian Model that represent the three demands for output and their sum:

$$C = c_0 + MPC(1-t_0)Y$$

$$I = e_0 - e_1 i$$

$$G = G_0$$

$$Y = C + I + G$$

Note that, at this point, the model cannot possibly be solved—without i, we cannot know I. Graphically, we have the goods market and the investment demand "link," but we do not have the money market. We include the money market in our model by first presenting the two structural equations:

$$M^d = d_0 - d_1 i$$

$$M^s = M^{s0}$$

The model then requires two equilibrium conditions, one for the goods market (as before) and one for the money market:

$$Y = AD$$

$$M^d = M^s$$

II) Finding the Equilibrium Solution

We solve this model the same way we analyzed it graphically—find the interest rate from the money market equilibrium, determine the level of investment generated by i_e, and use the goods market equilibrium to find Y_e.

In general, the equilibrium interest rate is given by

$$M^{s0} = d_0 - d_1 i_e$$

$$i_e = \frac{d_0 - M^{s0}}{d_1}$$

Next, we find the level of investment that such an interest rate will generate:

$$I = e_0 - e_1\left(\frac{d_0 - M^{s0}}{d_1}\right)$$

Finally, we solve for equilibrium in the goods market:

$$Y_e = AD = C + I + G$$

$$Y_e = c_0 + MPC(1 - t_0)Y_e + \left[e_0 - e_1\left(\frac{d_0 - M^{s0}}{d_1}\right)\right] + G_0$$

$$Y_e - MPC(1 - t_0)Y_e = c_0 + \left[e_0 - e_1\left(\frac{d_0 - M^{s0}}{d_1}\right)\right] + G_0$$

Equation 2:

$$Y_e = \frac{c_0 + \left[e_0 - e_1\left(\frac{d_0 - M^{s0}}{d_1}\right)\right] + G_0}{1 - MPC(1-t_0)}$$

This rather formidable looking mess is not as complicated as it first appears. In fact, comparing it to Equation 1, we see that the only difference is in the investment term—I_0 has been replaced by the investment demand function, which is in square brackets. Equation 2 tells us exactly the same thing that Equation 1 did—namely, that the equilibrium level of income will be that level at which actual GNP (Y) is exactly equal to the sum of the three types of demand in the economy.

Importantly, M^s is now included in the determination of Y_e. Equation 2 shows how an increase in the money supply will lead to an increase in the equilibrium level of output. (Even though there is a negative sign in front of M^s, note the negative sign in front of e_1—these two negatives cancel each other out and show that M^s and Y_e are positively related.)

Perhaps it would be instructive at this point to work our way through an example.
Example 2:

Suppose $C= 200 + .8(Y - .0625Y)$

$I = 1100 - 50i$

$G = 100$

$M^d = 325 - 12.5i$

$M^s = 100$

Our task is to find Y_e. This can be done by taking three steps—first finding i_e, then I, then Y_e.

(1) i_e: We know the equilibrium interest rate is that i at which money demand equals money supply. Thus,

$325 - 12.5i = 100$

$i_e = 18\%$.

(2) I: Finding i_e enables us to find I by simply "plugging" i_e into the investment demandfunction:

$I = 1100 - 50(18)$

$I = \$200$.

(3) Y_e: Finally, we determine Y_e by solving for the goods market equilibrium:

$Y = (200 + .8(1-.0625)Y) + (200) + (100)$

$Y_e = \$2000$.

Clearly, we would have gotten the identical result by substituting the given values of the coefficients in Equation 2—this simply illustrates that Equation 2 is the general solution to the Partial Equilibrium Model.[7] (It is instructive to graph the money market, investment demand, and goods sector as in Figure 2.7.)

[7]The reader should remember that, more precisely, Y_e is called the "reduced form equation" of this system because it expresses the equilibrium solution of the endogenous variable as a function of exogenous variables alone.

III) Comparative Statics

As before, we now turn to the analysis of exogenous shocks to Y_e. We still ask the same two types of questions:

1) How do changes in exogenous variables (c_0, MPC, t_0, G_0—the same as before; I_0 replaced by: e_0, e_1, d_0, d_1, M^{s0}) affect Y_e?

2) How and by how much can we use our policy tools (G and t from the simple model and, now, M^s) to close the GNP Gap?

<u>Question 1: Effect of a shock on Y_e?</u>

The analysis of G and t is the same as in the Simple Keynesian Model; therefore, we will restrict our attention in this section to the money supply. We have already seen how changes in the money supply affect the equilibrium level of national income in Figure 2.8. We can now determine the magnitude as well as the direction of the effect.

We want to know how much Y_e will change for a given change in the money supply. A mathematician would say, "We want to know the derivative of Y_e with respect to M^s." This is the same work we did before in our analysis of the multiplier.

We proceed by finding, in Equation 2, dY_e/dM^s. Although our task looks difficult, in fact, it is merely an application of the linear derivative rule we used above.

Equation 2:

$$Y_e = \frac{c_0 + \left[e_0 - e_1\left(\frac{d_0 - M^{s0}}{d_1}\right)\right] + G_0}{1 - MPC(1-t_0)}$$

Rewriting,

$$Y_e = \frac{c_0 + \left[e_0 - \frac{e_1 d_0}{d_1} + \frac{e_1 M^{s0}}{d_1} \right] + G_0}{1 - MPC(1-t_0)}$$

Or,

$$Y_e = \frac{c_0 + e_0 - \frac{e_1 d_0}{d_1} + G_0}{1 - MPC(1-t_0)} + \left(\frac{\frac{e_1}{d_1}}{1 - MPC(1-t_0)} \right) M^{s0}$$

This, admittedly hairy-looking creature is simply the equation of a line with messy slope and intercept terms. But the derivative is straightforward:

$$\frac{dY_e}{dM^{s0}} = + \frac{\frac{e_1}{d_1}}{1 - MPC(1-t_0)}$$

To illustrate, suppose the money supply increased by \$100. As before, we can recalculate Equation 2 or we can use the value of the multiplier, dY_e/dM^s, to determine the new Y_e.[8] Recalculating Equation 2 (i.e., using M^s=\$200), we get:

Y_e' = {200 + 1100 - 50[(325-200)/12.5] + 100}/[1 - .8(1-.0625)]

Y_e' = \$3600

Note, the crucial change in the "I" term:

1100 - 50[(325-200)/12.5] = \$600

This is now a bigger number (when M^s = \$100, this term = \$200) which illustrates the increase in AD.[9]

---

[8]The reader should review pp. 15-16 if the "as before" comment seems vague!

[9]Note that an increase of \$400 in I_0 leads, through the multiplier = 4, to a \$1600 increase in Y_e.

Using the money supply multiplier, we could have simply noted that:

$$dY_e/dM^s = (50/12.5)/[1-.8(1-.0625)]$$

$$= 16.$$

This tells us that every $1 increase in the money supply will generate a $16 increase in the equilibrium level of national income. Since we increased M^s by $100, that would increase Y_e by $1600 from its previous equilibrium level of $2000 to $3600.

The graphical analysis would look exactly like Figure 2.8. You should try to exactly graph the functions used in this example and calculate the changes through the five steps of the "chain reaction." What is the new equilibrium interest rate? What is the new level of investment? What is the new level of aggregate demand?

An alternative approach to presenting the results we have found here would be to graph the relationship between Y_e and M^s, while suppressing all other information:

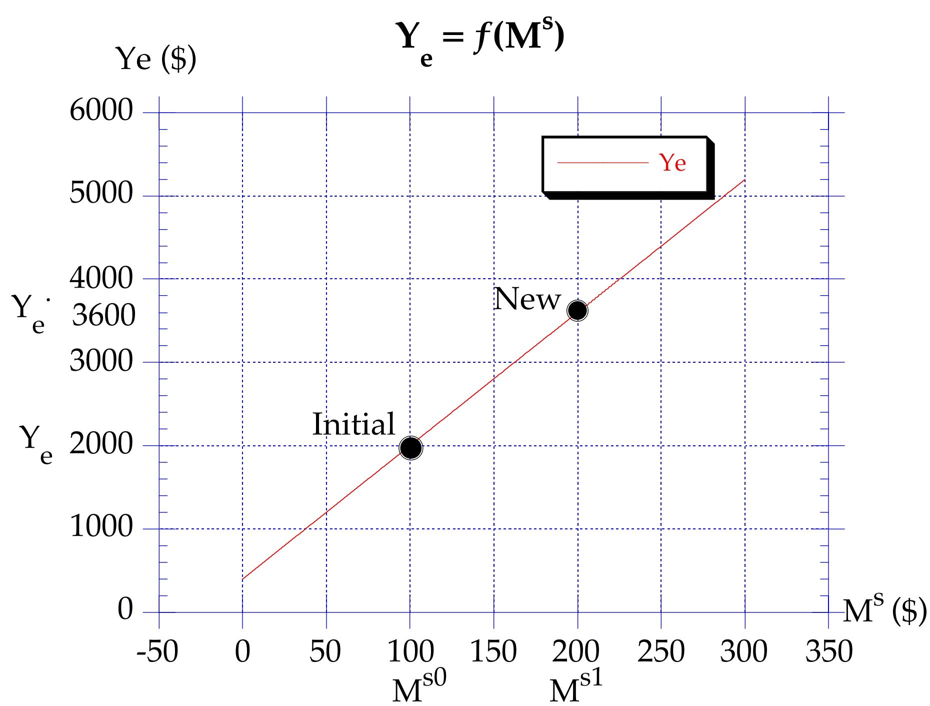


Figure 2.8.a: Equilibrium Output as a Function of the Money Supply

Figure 2.8.a might reasonably be called a presentation graph of the reduced form relationship $Y_e = f(M^s)$. The graph is read as a series of vertical strips. Given any value of the exogenous variable money supply, the line shows the corresponding equilibrium value of the endogenous variable output level.

Question 2: Shock needed to generate desired Y_e?

As before, it is when we turn to the second type of problem that the multiplier becomes indispensable. Given the data in Example 2, suppose the full-employment level of output was $2500. The question then becomes: what monetary policy actions should the monetary authorities take in order to generate full-employment? Graphical and verbal analyses can give the qualitative answer—increase the money supply; but only the mathematical approach can help us determine the magnitude of the increase that wouldberequired.

If Y_f = $2500 and our initial Y_e = $2000, we would need a $500 increase in the equilibrium level of output. We have already calculated the money supply multiplier above and found it equaled 16. Thus, we need an increase in M^s of:

$$\$500/dM^s = 16$$

$$dM^s = \$31.25.$$

You should confirm that an increase in the money supply of $31.25 will increase the equilibrium level of output by $500.

Summary:

In this section, we examined the Partial Equilibrium Keynesian Model. We expanded the simple model by including a money market and an investment demand function. We now have fiscal policy tools (G and t) and a monetary policy tool (M^s) with which to manipulate the equilibrium level of national income. Note how there is a tool to manipulate each component of AD.

This model gave us further practice in analyzing the two fundamental questions asked in macroeconomics and in understanding the multiplier. It also introduced us to what might be termed "macro-reasoning"—that is, the ability to follow a shock through a series of effects. All macro models employ this type of approach; therefore, thinking must be logical and sequential.

To review:

<u>Equilibrium:</u> Same as before

<u>Comparative Statics:</u> The same, conceptually, as before; but it now includes several new, exogenous variables (d_o, d_1, M^s, e_0, e_1) as a result of the expansion of the model.

<u>Money Market:</u> Money demand is not how much money people want, but how they wish to divide their wealth between an easily accessible, non-interest bearing asset (money) and a non-liquid, interest yielding asset (bonds). Importantly, it is the market process in the bond market that determines the equilibrium interest rate.

<u>The Fed:</u> It is important that we keep fiscal and monetary policy alternatives straight and that we understand the institutional structure of this country. There is NO central, unified policy making body in the United States (much to the concern of some economists). In theory, the Constitution gives Congress the power to control G and t; but, in practice, the Executive branch exercises some power in determining these variables. The Federal Reserve system, or the Fed, controls the money supply. Even more fundamentally, increasing M^s has nothing whatsoever to do with G—they are distinct instruments controlled by different policy makers.

<u>The two fundamental questions:</u> The same as always: (1) Given a shock, what's the effect on the endogenous variable; and, (2) What shock is needed to drive an endogenous variable to a desired level? The Partial Keynesian Model has expanded the list of exogenous variables, added an endogenous variable, and provided us with one more policy tool, but the work is identical to the Simple Keynesian Model.

A final word should be said regarding the name of the model discussed in this section. It is called a "partial equilibrium" model because there are no feedback mechanisms. Once a shock occurs, for example, and the chain reaches the endogenous variable (Y), the analysis is complete. In fact, a more truthful representation of the macroeconomy would be a general equilibrium model—that is, a model that takes into consideration reverberations on other endogenous variables of a given shock to the system. In the next section, we consider this type of model.

Section 3: The General Equilibrium Keynesian Model

Let's go straight to the heart of the matter: assume that the Fed, in response to a positive GNP Gap, increases the money supply and raises the equilibrium level of output (and income) to the full employment level. The Partial Equilibrium Model stops there; the General Equilibrium Model does ***not*** stop there—the increased national income will have further effects on variables in the model. In essence, the general equilibrium model is a model that takes into account ***all*** of the effects, initial and subsequent (or "feedback"), of a particular shock to the system.

In particular, raising Y will cause people to have more income and therefore to spend more. If people wish to spend more, they will wish to hold more of their wealth in the form of money for the sake of convenience, i.e., they will demand more money at each and every level of the interest rate.[10] Thus, an increase in Y will cause the money demand curve to shift to the right. This will trigger a second round of effects in the "chain reaction" culminating in a fall in Y. And this resulting fall in Y will trigger yet another round. This will continue until the interest rate and the equilibrium level of income are mutually compatible—i.e., they reach a general equilibrium.

In order to capture these repeated rounds of effects, economists have developed a way of finding the general equilibrium solution from one simple graph—the IS/LM curve graph. In this section, we will show how the IS/LM analysis depicts a general equilibrium and how it can be powerfully applied to a variety of macro problems.

The author is aware that many students are apprehensive and confused when the topic is the IS/LM model. Many students believe that this model is fundamentally incomprehensible—a view that I, obviously, do not hold. I urge you to do two things as you try to understand the foundations of macro theory: (1) concentrate—work out problems as you are told to do so and pay attention to what you are reading; and (2) think logically and sequentially—keep in mind which variables are tied to which variables and how they affect each other. The ability to tie together links in the "chain reaction" is critical to "macro reasoning."

---

[10] I'm not saying they'll hold a greater percentage, but simply more dollars in money. Suppose that with $10,000 I hold $2,000 in cash. With $12,000, I might hold $2,100 in cash. My money demand (at the same interest rate) has increased from $2,000 to $2,100.

In this section, we will combine the verbal and graphical analyses for ease of exposition. After completing this work, we will turn to the mathematical analysis. We complete our examination with sections on comparative statics and a summary. But, before we begin, let's review the assumptions in this model.

Assumptions:

We bring all the assumptions contained in the partial equilibrium model. In addition, we make the following crucial assumption:

(1) Money demand is a positive function of income; that is, a rise in income will generate an increase, or rightward shift, in the money demand function. As stated above, it seems reasonable to assume that people who wish to spend more will demand more money in order to carry out their purchases.

Mathematically (once again, we assume linearity in functional form), this implies that the money demand function has a new term:

$$M^d = d_0 - d_1 i + d_2 Y, \text{ where } d_0, d_1, \text{ and } d_2 \text{ are all positive.}$$

The coefficient on Y, d_2, shows how much of an increase in M^d will result from a given increase in Y.

Verbal and Graphical Analysis:

This seemingly minor change in the model (i.e., adding d_2Y to the money demand function) has a crucial effect on the determination of equilibrium. It provides a feedback mechanism that complicates the problem—"realism" is not costless! You should be able to see, in rather vague terms, how an expansionary policy move (increase G or M^s, decrease t) will generate a smaller increase in Y_e relative to the Partial Equilibrium Keynesian Model. Let's try to make concrete the reasons why this true.

Figure 2.9 is a reproduction of the partial equilibrium model except that money demand is explicitly written as a function of income.

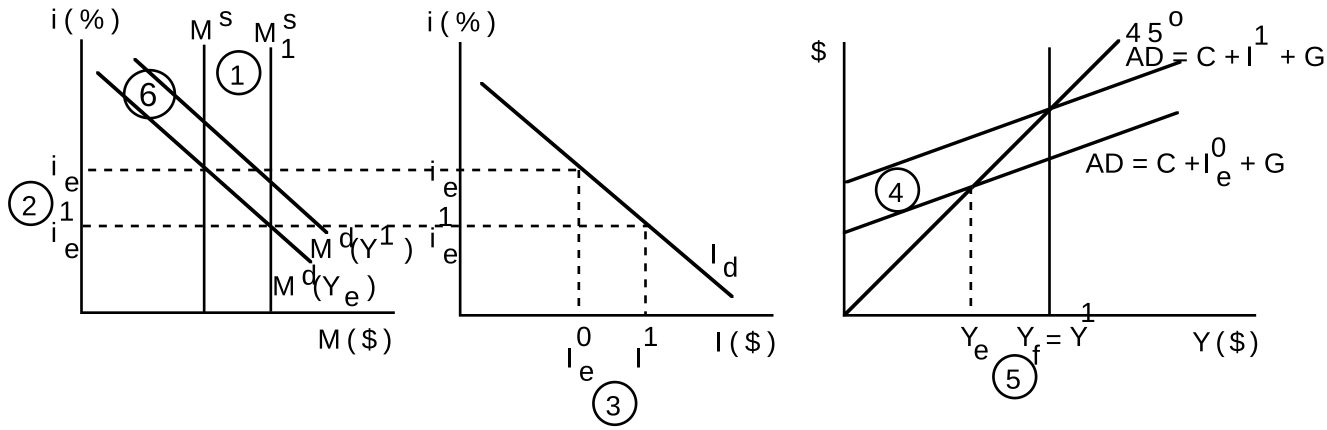


Figure 2.9: The Key to the General Equilibrium Model -- Step (6)

Recall that (1) an increase in M^s (2) lowered i_e, which (3) raised I, which (4) raised AD, which—gasp, finally!—(5) increased Y_e. Now, however, the chain is even longer because there is a feedback mechanism. The (5) increased Y (denoted Y^1 and not Y_e because it is not yet in equilibrium) will lead to a new round of reactions:

CAUSES 6: The money demand function shifts to the right (because people have more income and they'll want to spend more and therefore demand more money at each level of the interest rate). Thus, step (6) holds the key to the general equilibrium model.

Step (6) is crucial because of the ramifications that ensue from this rightward shift in M^d. Once again, thinking logically and sequentially, we present the steps:

CAUSES 7: An increase in i_e (because at the existing equilibrium interest rate, i_e', money demand is greater than money supply implying that bond demand is less than bond supply (in P_B-B space). Thus, equilibrium bond prices fall which leads to an increase in the interest rate).

CAUSES 8: A decrease in I (because the cost of borrowing has increased).

CAUSES 9: A decrease in AD (because I is in C+I+G).

CAUSES 10: A decrease in Y_e.

At this point, although we are not finished, a definition is in order: **crowdingout** is any rise in interest rate that decreases (crowds out) the expansionary effect of a given policy move. In this example, the current Y_e is less than Y_e' (the partial equilibrium Y_e) because the resulting increase in i_e (step 6) has lowered I. Thus, we say, "Higher interest rates have crowded out investment and lessened the increase in AD and, consequently, Y_e."

But, we are not yet finished following the chain of events (remember that step 10 was a decrease in Y_e):

CAUSES 11: A decrease in M^d (because, given lower incomes, we assume people will desire to spend less and therefore will lower their demand for money).

CAUSES 12: A decrease in i_e (see step 2).

CAUSES 13: An increase in I (see step 3).

CAUSES 14: An increase in AD (see step 4).

CAUSES 15: An increase in Y_e (see step 5).

CAUSES 16: An increase in M^d (see step 6).

.

.

.

.

.

When will this end??? When an interest rate is found that determines a level of aggregate demand (through its effect on investment) that determines a level of equilibrium national income that determines a money demand that determines the exact same interest rate with which we began this cycle. There must be some ***general equilibrium*** interest rate, i_{ge} (between i_e and i_e' in Figure 2.9) that exactly corresponds to the ***generalequilibrium*** level of income, Y_{ge} (between Y_e and Y_e' in Figure 2.9).

Figure 2.10 is an attempt to show how i, M^d, I, AD, and Y all "bounce around" between the initial ("a" and "0" respectively) and partial equilibrium (pe) values—finally settling somewhere in between at their general equilibrium (ge) values.

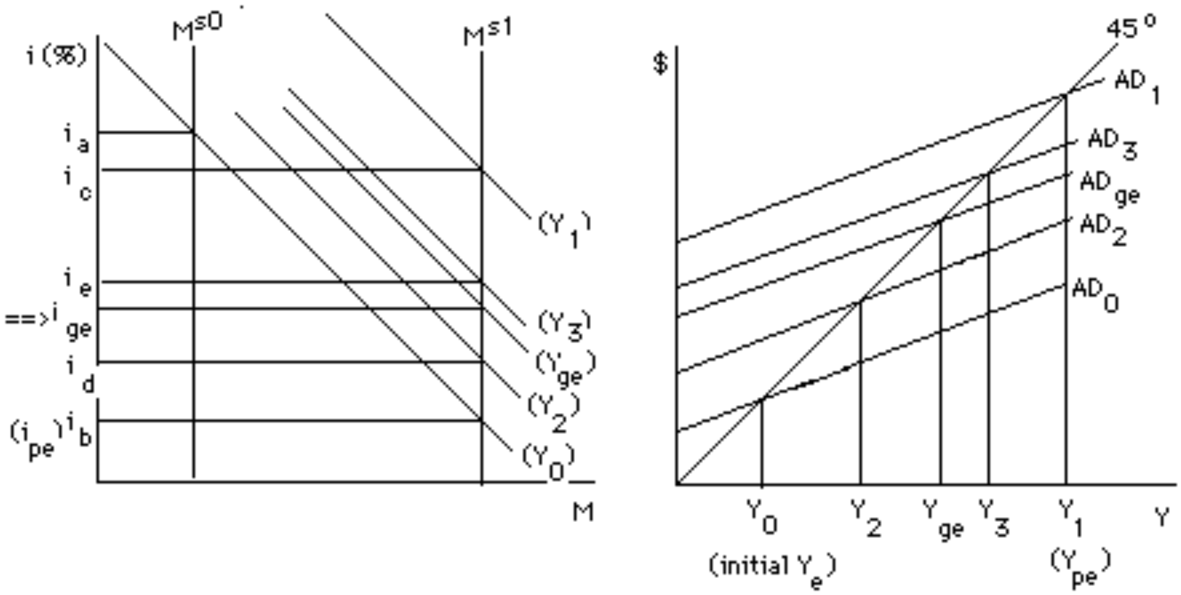


FIGURE 2.10: Reaching General Equilibrium

The interested reader might wonder, "Exactly how long does it take to reach a general equilibrium?" This is an excellent question and one with no consensus answer. Suffice it to say at this point, that the timing of the equilibration process is crucial to the efficacious application of policy. Disagreement over timing is an important, contentious issue in the debate among the different "macro schools."

At this point, you should be able to understand the chain of events in the general equilibrium model. Go back and reread this section carefully if the relationships between the variables are still not clear or if you cannot follow the chain of reasoning. A helpful self test might be to describe the general equilibrium effects of a decrease in G. How might you define "crowding in" or as Dr. Schmutte calls it, "pulling in" in this situation?

<u>Deriving the IS/LM Model:</u>

If you agree that, although you understand the model, it certainly seems rather cumbersome and unwieldy; then you should applaud the creation of the IS/LM model! The IS and LM curves provide in one neat graph the general equilibrium solution. This is the sole purpose for which these curves were first introduced by Nobel Prize winning economist Sir John R. Hicks.

The IS curve represents all the points where AD equals actual GNP. It is sometimes referred to as the "goods market equilibrium." "IS" because the goods market equilibrium can be represented by the equality of planned investment (I) and savings (S).

The LM curve, on the other hand, represents all the points where M^d equals M^s—alias, the "money market equilibrium." For Hicks, an Englishman, money demand was "liquidity preference". Thus, "LM" represents the satisfaction of the equality between liquidity preference (L) and money supply (M).

Note there are two equilibrium conditions in this model—the goods market and the money market. To these correspond two lines—the IS curve and the LM curve. All along the IS curve, AD=actual GNP—the goods market is in equilibrium. In Figure 2.10 above, Y_0, Y_1, Y_2, Y_3 and Y_{ge} are on the IS curve. Similarly, all along the LM curve, $M^d=M^s$—the money market is in equilibrium. In Figure 2.10, Y_0, Y_1, Y_2, Y_3 and Y_{ge} values of Y are on the LM curve. Only one value of Y is simultaneously on both the IS and the LM curves—of course, that value is Y_{ge}.

Let's examine the derivation of the IS curve. We want to find all possible **equilibrium** combinations of interest rate and Y. We know that a given interest rate will yield a level of investment that, in turn, is a component of AD. If i increases, we know that I falls. Therefore, AD will fall and Y_e will decrease. Thus, we see that increases in the interest rate will lower the level of equilibrium output (and income); i.e., the IS curve is negatively sloped. Figure 2.11 shows the graphical derivation of the IS curve:

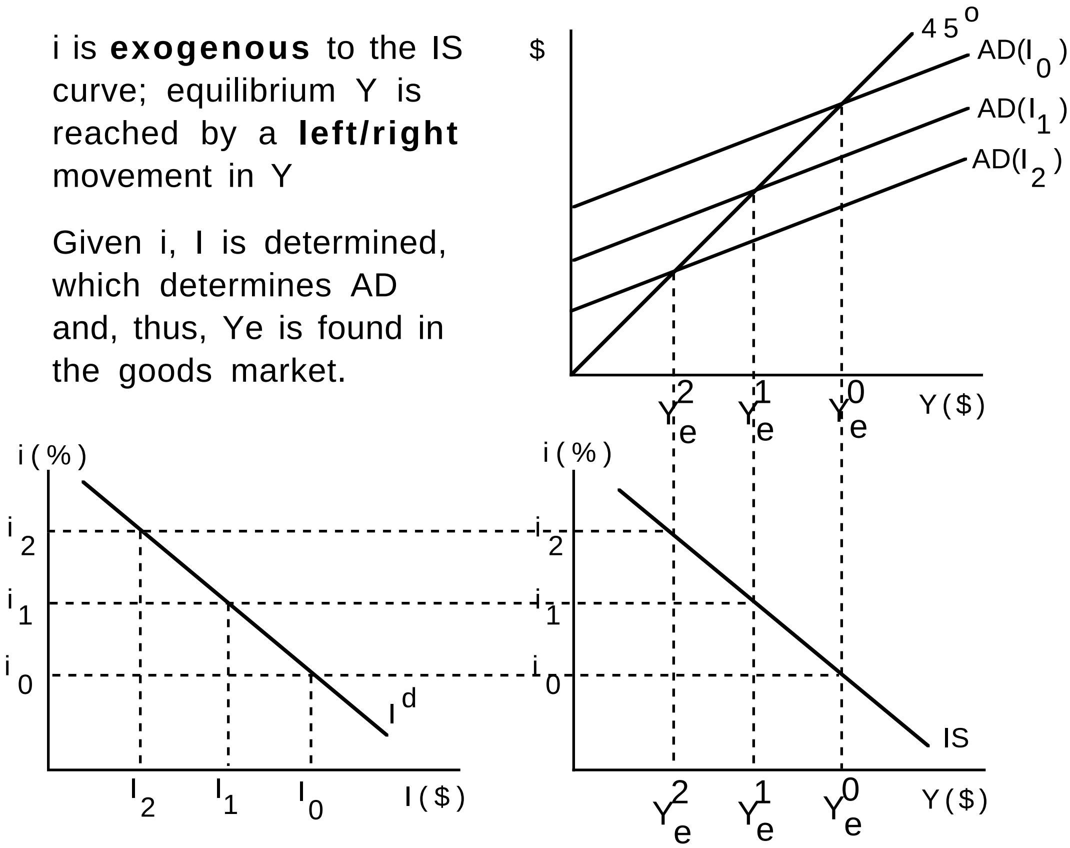


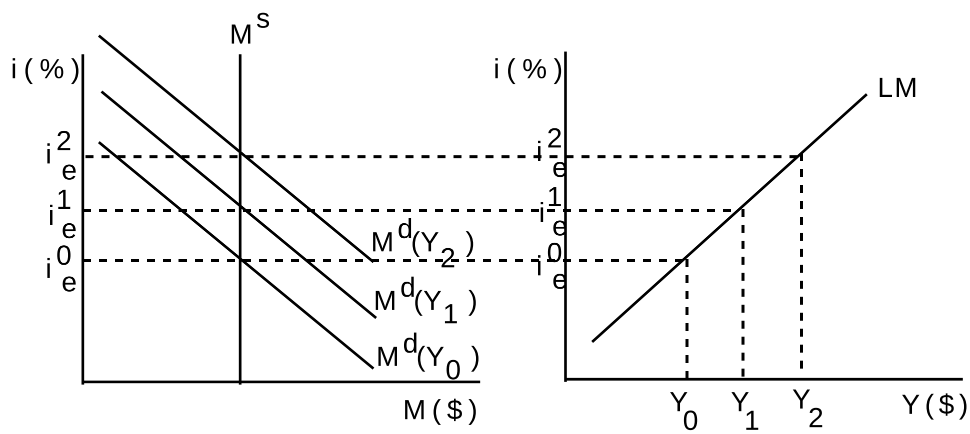
Figure 2.11: Deriving the IS Curve

The notation is crucial here—the three variables, Y, I, and i, are all tied together by the same subscript. When interest rate is i_0, I_0 is the level of investment and, therefore, the equilibrium level of output is Y_e^0. The same logic, of course, is applied to subscripts 1 and 2. The IS curve simply graphs i and Y together, suppressing I for it is not directly relevant. Far from a confusing mess or a tool to terrorize undergrad econ majors, the IS curve is simply a shortcut, a way to express the crucial relationship between the two interwoven endogenous variables, i and Y, while suppressing all other intermediary variables. It is impossible, however, to determine which interest rate-output combination will prevail from the IS curve alone for there is no way of knowing which interest rate is the equilibrium interest rate. Remember, i is exogenous to the IS curve, thus the IS curve cannot tell us i_e.

Another way of understanding the IS curve is to ask, "What does it mean to be off the curve?" The answer, developed more fully in *Understanding Equilibrium in the*

IS/LM Model, is that any point off the IS curve means that the goods market is not in equilibrium and forces drive the point in left/right fashion toward the attracting IS curve. The IS curve is a magnet that attracts points to it in a "horizontal strip" fashion because the interest rate remains fixed as Y equilibrates.

The derivation of the LM curve has the same goal as the IS curve—to highlight the two key variables, while hiding the rather complicated equilibrating process. We know that increases in Y lead to increases in money demand. Therefore, equilibrium interest rates must rise when Y rises. Thus, we see that increases in Y correspond to increases in i_e in the money market; in mathematical terms, the LM curve is positively sloped (Figure 2.12).



Given Y, M^d is determined and, thus, i_e is found in the money market.

Y is **exogenous** to the LM curve; equilibrium i is reached by an **up/down** movement in i

Figure 2.12: Deriving the LM Curve

Once again, note the how each i, Y pair has the same subscript. The LM curve simply emphasizes that a *given* Y, say Y_1, will place the M^d curve in such a position, $M^d(Y_1)$, that the resulting equilibrium interest rate must be i_e^1. The LM curve cannot tell us, however, which value of Y is the equilibrium level of income.

Another way of understanding the LM curve is to ask, "What does it mean to be off the curve?" The answer, developed more fully in *Understanding Equilibrium in the IS/LM Model*, is that any point off the LM curve means that the money market is not in equilibrium and forces drive the point in up/right fashion toward the attracting LM curve. The LM curve is a magnet that attracts points to it in a "vertical strip" fashion because the level of output (and national income) remains fixed as i equilibrates.

Now, if the IS curve gives equilibrium values for Y given i (through the equilibration process in the goods market) and the LM curve yields equilibrium values for i given Y (through the equilibration process in the money market), it stands to reason that the intersection of these curves will yield i and Y equilibrium values in both markets simultaneously. This intersection point is, in fact, the general equilibrium solution to our model—as shown in Figure 2.13:

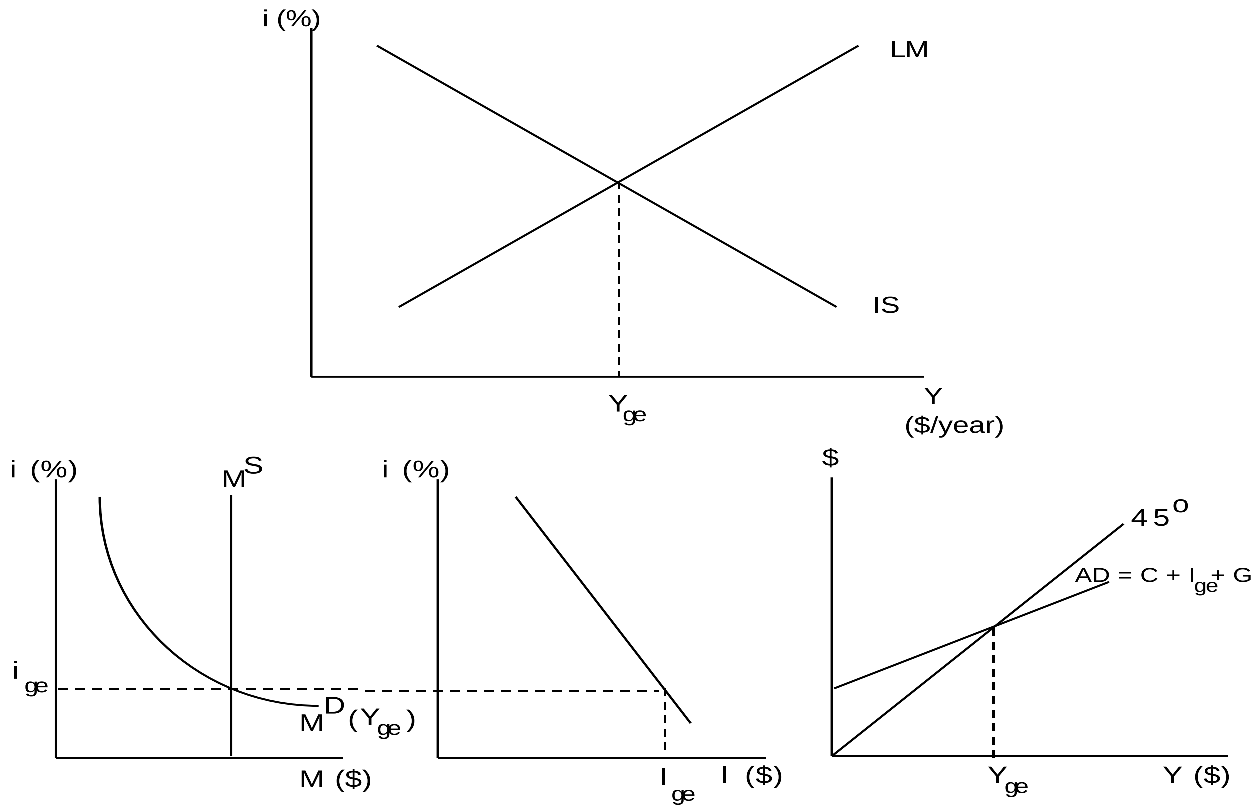


Figure 2.13: Using IS/LM to Show the General Equilibrium Solution

Of course, our fundamental goal is not to find a particular i_{ge}, Y_{ge} combination, but to examine the two fundamental macro questions (how do exogenous shocks affect Y_e and how should we manipulate our policy tools to reach Y_f). Under the general equilibrium model's assumptions, this requires an understanding of how exogenous variables affect the IS or LM curves—an understanding that can be better gained by analyzing the mathematics of IS and LM curves.

Mathematical Analysis:

I) Setting Up the Problem

The endogenous and exogenous variables remain the same as in the Partial Equilibrium Keynesian Model. The familiar structural equations are:

The components of aggregate demand:

$$C = c_0 + MPC(Y-t_0Y)$$

$$I = e_0 - e_1 i$$

$$G = G_0$$

$$AD = C + I + G$$

For the money market, we know:

$$M^d = d_0 - d_1 i + d_2 Y$$

$$M^s = M^{s0}$$

Finally, we have the two equilibrium conditions for the model:

$$Y = AD$$

$$M^d = M^s$$

Note that, in the general equilibrium model looks exactly the same as its partial equilibrium counterpart *except for the crucial d_2Y term*. This highlights the fact that the general equilibrium model contains a feedback mechanism. The two equilibrium equations must be simultaneously satisfied in order to obtain a general equilibrium. In particular, the Y that solves the first equation must also be consistent with the solution in the money market (remember that money demand is now a function of interest rate and **income, i.e., Y**).

II) Finding the Equilibrium Solution

By substituting the structural equations into the equilibrium conditions, we have:

$$Y_e = c_0 + MPC(Y_e-t_0Y_e) + e_0-e_1i_e + G_0$$

$$d_0 - d_1 i_e + d_2 Y_e = M^{s0}$$

Here we have two equations with two unknowns (i_e and Y_e). Solving each equation for the same endogenous variable and then setting the two equations equal to each other is an acceptable solution strategy. Solving the second equation, the money market equilibrium condition, for the interest rate generates the LM curve:

The LM Curve Equation:

$$i_e = \left(\frac{d_0 - M^{s0}}{d_1}\right) + \left(\frac{d_2}{d_1}\right) Y$$

Note that this is a linear function—$(d_0 - M^{s0})/d_1$ is the intercept and d_2/d_1 is the slope. Solving for the equilibrium interest rate in the money market is the mathematical analogue to Figure 2.12. Note that changes in Y will cause movements along, while changes in M^s (or d_0 or d_1) will cause shifts in the LM curve. Finally, note that the interest rate carries the equilibrium subscript, but income does not. This is not a matter of sloppy labeling—for any Y, the LM curve tells us the equilibrium interest rate. However, at this point, we do not know which of the Y's is the equilibrium level of national income.

Similarly, in the goods market, we can solve for i_e and then set the two i_e equations equal to each other in order to obtain Y_e:

$$Y = c_0 + MPC(1 - t_0)Y + e_0 - e_1 i_e + G_0$$

$$e_1 i_e = c_0 - Y + MPC(1 - t_0)Y + e_0 + G_0$$

The IS Curve Equation:

$$i_e = \left(\frac{c_0 + e_0 + G_0}{e_1}\right) - \left(\frac{[1 - MPC(1 - t_0)]}{e_1}\right) Y$$

Once again, the interest rate carries the subscript "e" because for any value of Y, that will be the interest rate needed to make that Y the equilibrium value of Y. But, we don't know which of all the possible Y's is the general equilibrium Y yet. Note also that, although more complicated than the LM curve, the IS curve is also linear—$(c_0 + e_0 + G_0)/e_1$ is the intercept and $-[1-MPC(1-t_0)]/e_1$ is the slope.

All we have left to do is set the LM equal to the IS equation—that is a mathematical way of identifying the level of output that satisfies both the goods and money market equilibria. (In graphical terms, we are finding the intersection point in Figure 2.13). We can rewrite the solution in a more easily recognizable form by solving for Y_e.

$$\left(\frac{d_0 - M^{s0}}{d_1}\right) + \left(\frac{d_2}{d_1}\right) Y_e = \left(\frac{c_0 + e_0 + G_0}{e_1}\right) - \left(\frac{[1 - MPC(1-t_0)]}{e_1}\right) Y_e$$

$$\left(\frac{[1 - MPC(1-t_0)]}{e_1} + \frac{d_2}{d_1}\right) Y_e = \frac{c_0 + e_0 + G_0}{e_1} - \frac{\left(d_0 - M^{s0}\right)}{d_1}$$

The Y_e Equation:

$$Y_e = \frac{\dfrac{c_0 + e_0 + G_0}{e_1} - \dfrac{\left(d_0 - M^{s0}\right)}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}}$$

This Y_e corresponds exactly to the Y_{ge} in Figure 2.13. Note that the "g" has been dropped because we know we are working with the general equilibrium model. For easier reading, reference to "Y_e" from this point forward means "the general equilibrium level of output (and income)."

The equilibrium interest rate can now be obtained by substituting Y_e into either the IS or LM curve equation—they should provide equivalent solutions.

Once again, the "don't panic" suggestion should be made. The Y_e Equation result is messy and not intuitive, but you should understand the process of its derivation. The steps correspond exactly to the steps taken in building the graphical exposition. Perhaps an example of the mathematical exposition of the general equilibrium analysis will help inunderstanding.

Example 3:

Suppose $C = 200 + .8(Y - .0625Y)$

$I = 1100 - 50i$

$G = 100$

$M^d = 300 - 12.5i + .0125Y$

$M^s = 100$

Our task is to determine the endogenous variables—i.e., the equilibrium level of national income (or output) and the equilibrium interest rate. We know that there are two equilibrium conditions that must be simultaneously fulfilled:

$Y = C + I + G$

$M^d = M^s$

Our first step, then, is to substitute the appropriate functions into the equilibrium conditions:

$Y_e = 200 + .8(Y_e - .0625Y_e) + 1100 - 50i_e + 100$

$300 - 12.5i_e + .0125Y_e = 100$

Now you can clearly see that this is a system of equations with two equations and two unknowns. Our task is to solve for i_e and Y_e. We proceed by solving each equation for i_e, setting the resulting equations equal, and solving for Y_e.

From the goods market, we have:

$Y = 200 + .8(1 - .0625)Y + 1100 - 50i_e + 100$

$Y = 1400 + .75Y - 50i_e$

$50i_e = 1400 - Y + .75Y$

$50i_e = 1400 - .25Y$

Thus, the IS Curve: $i_e = 28 - .005Y$.

From the money market, we have:

$$300 - 12.5i_e + .0125Y = 100$$

$$12.5i_e = 200 + .0125Y$$

Thus, the LM Curve: $i_e = 16 + .001Y$.

Note the negative slope on the IS curve and the positive slope on the LM curve. This shows that in the goods market, lower interest rates are needed to support higher equilibrium income because increased investment requires lower interest rates. In the money market, higher income implies increased money demand and, therefore, a higher equilibrium interest rate.

We proceed with our solution strategy by setting the IS equal to the LM curve:

$$28 - .005Y_e = 16 + .001Y_e$$

and solving for Y_e:

$$12 = .006Y_e$$

$$Y_e = \$2000.$$

Finally, substituting into the LM curve,

$$i_e = 16 + .001(2000)$$

$$i_e = 18\%.$$

(Verify that substituting Y_e into the IS curve yields the same result).

As in the earlier models when we could have used the general solutions to find Y_e, we could have used the Y_e Equation directly in order to find the equilibrium level of national income. We would have:

$$Y_e = \frac{\dfrac{200 + 1100 + 100}{50} - \dfrac{300 - 100}{12.5}}{\dfrac{[1 - .8(1-.0625)]}{50} + \dfrac{.0125}{12.5}}$$

$$Y_e = \$2000.$$

Graphically, the general equilibrium values of income and the interest rate are shown by Figure 2.14.

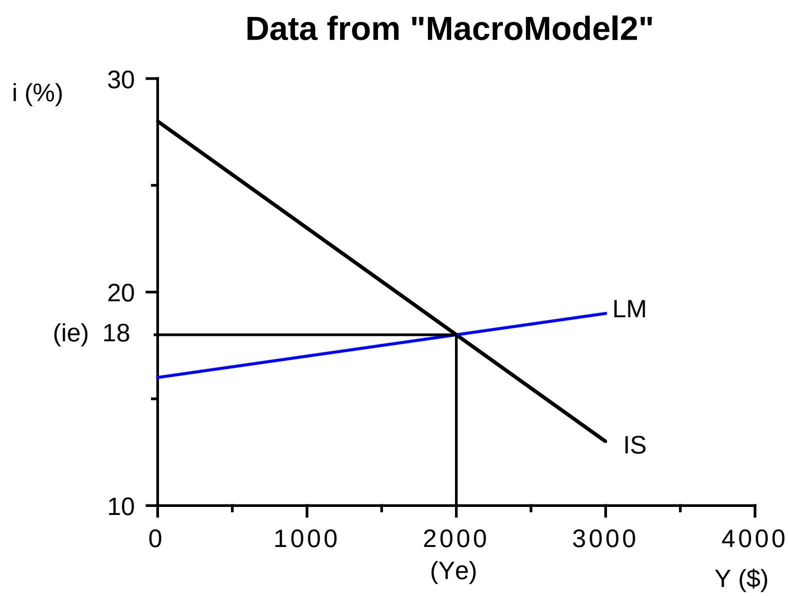


Figure 2.14: IS/LM Analysis of Example 3 Data

There should be no mystery or uncertainty surrounding the IS/LM analysis at this point. IS/LM curves are simply a short-cut to finding the equilibrium values for income and interest rate. There are two equations and two unknowns—what simpler strategy than to put them on one graph could be devised? The two unknowns, or endogenous variables, are on the axes; each equilibrium condition is represented by a curve (IS for goods market and LM for money market). The intersection shows the general equilibrium values for i and Y.

In another attempt to show the logic underlying this fundamental macroeconomic analysis, let's break down the IS/LM curves into their component parts—the money market, the investment demand function and the goods market. Figure 2.15 shows how the general equilibrium solution found by the IS/LM analysis would look in the partial equilibriumframework.

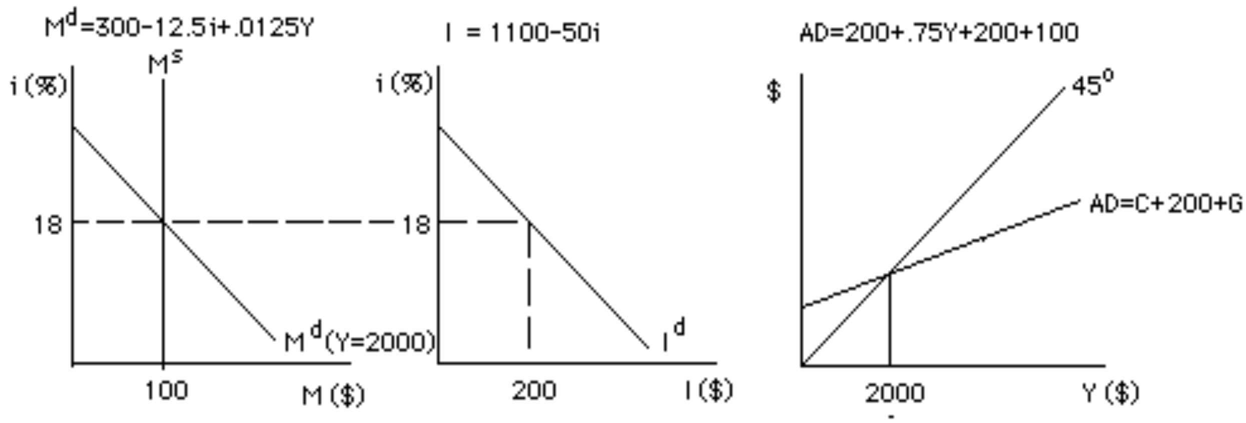


Figure 2.15: Example 3 Data in General Equilibrium

The key reason why we cannot, in general equilibrium analysis, use this framework lies in the money demand function. Since M^d is a function of Y, it would be extremely difficult to determine where i and Y will be mutually consistent—this is what the IS/LM analysis does so beautifully. This point can be illustrated as we turn to the first of our two fundamental questions—how does a given shock to the system affect the equilibrium values of the endogenous variables (i and Y)? We will examine a goods market shock (ΔG) and a money market shock (ΔM^s).

III) Comparative Statics

We return to the *raison d'etre* of macroeconomics—to find answers to the two fundamental questions. Because of the feedback mechanism, we now have two interrelated endogenous variables to deal with, Y and i. Perhaps these questions are more time consuming and complicated in the general equilibrium model; but you should begin to see, however, that no matter how complex, the core stays unchanged. Understand the fundamentals and you understand a great deal!

Question 1: Effect of a shock on Y_e?

Shock 1: An Increase in G:

Suppose that government spending rose by \$100. Using Figure 2.15, we know that AD will shift up by \$100. Since we know the slope of the AD curve is .75 (=.8(1-.0625)), the multiplier is 4 (=1/(1-MPC(1-t_0)). Thus, the partial equilibrium result is that Y_e increases by \$400—i.e., Y_{pe}=\$2400 and i_{pe}=18%. The equilibrium interest rate remains unchanged because money demand is not a function of income in the partial equilibrium model.[11]

General equilibrium, on the other hand, includes a "feedback mechanism." As Y increases, M^d will increase. The resulting increase in the equilibrium interest rate will lower investment, which in turn lowers AD which causes a decrease in Y_e. This crowding out phenomenon occurs because money demand depends on income, interest rates depend on money demand, and investment depends on interest rates. If this were not the case then changes in Y_e would not affect anything else in the system and the feedback loop would be broken. The chain reaction will continue until the i and Y variables settle down at mutually compatible, or general equilibrium, levels.

Other than a repetition of earlier ground, what have we gained? A greater appreciation for IS/LM analysis! We know from Figure 2.10 that the system will settle at a general equilibrium. But the solution cannot be found without IS/LM analysis. Perhaps that statement is too strong—it is possible, by trial and error, to continually try different values of Y and i until a mutually consistent pair are found. IS/LM, at the very least, allows us to avoid such a painful solution strategy.

We know that the general equilibrium Y_e and i_e will be somewhere between the initial and the partial equilibrium values of the endogenous variables. Let's use the IS/LM analysis to find the exact Y_e and i_e that we would observe in response to a $100 increase in G.

Mathematically, all we have to do is recalculate the Y_e Equation with the new value of G (G=200 instead of G=100).

$$Y_e = \frac{\dfrac{200 + 1100 + 200}{50} - \dfrac{300 - 100}{12.5}}{\dfrac{[1 - .8(1-.0625)]}{50} + \dfrac{.0125}{12.5}}$$

Y_e = $2333.33.

Substituting into the LM curve equation (the IS would work just as well):

---

[11]Any doubts here should send the reader scrambling back to Section 2: The Partial Equilibrium Keynesian Model.

$$i_e = \frac{300-100+(.0125*2333.33)}{12.5}$$

$$i_e = 18.33\%.$$

Graphically, we can examine the solution two different ways—the two sector and investment demand graph and the IS/LM analysis. Figure 2.16 shows the former:

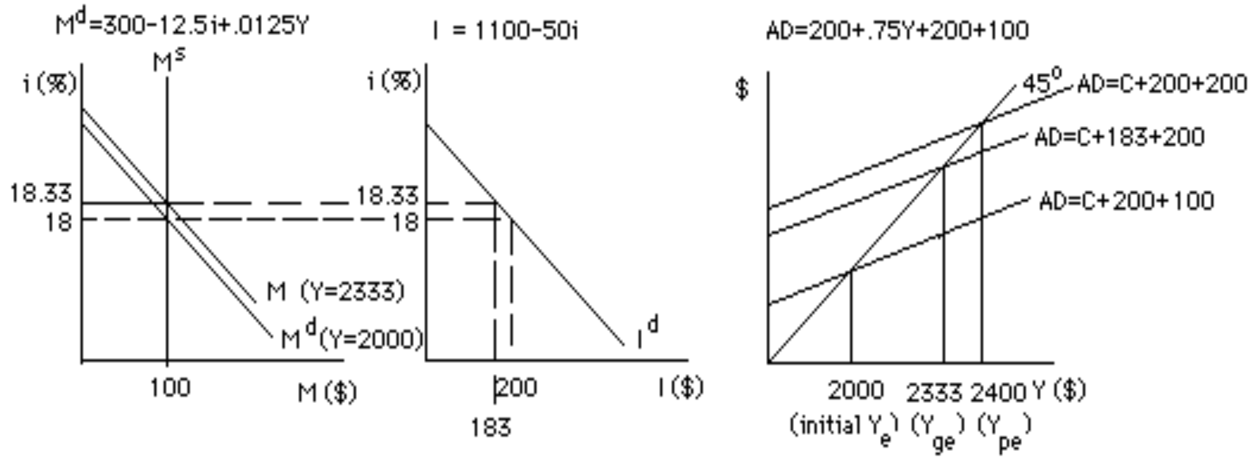


FIGURE 2.16: An Increase in G -- Partial vs. General Equilibrium

Note that the increase in G first raised Y_e to \$2400—this is the partial equilibrium result. However, this increase in income led to an increase in M^d which raised interest rates, which lowered investment, which lowered AD, which lowered Y. This fall in Y started the "chain reaction" again, this time culminating in an increase in Y. The chain of events eventually settled down to a general equilibrium at Y_e=\$2333 and i_e=18.33%. AD and Y_e are greater than their initial values, but smaller than their partial equilibrium counterparts. The amount \$667, the difference between Y_{pe} and Y_{ge}, is the crowding out effect caused by the .33% rise in the equilibrium interest rate.

We found the general equilibrium solution by applying the mathematics of the IS/LM analysis, then showed the result with the partial equilibrium model graph. We can also show the result using IS/LM curves. Since G does not appear in the LM curve equation, changes in G leave the LM unchanged. Thus, the LM curve is, as before,

$$i_e = \left(\frac{d_0 - M^{s0}}{d_1}\right) + \left(\frac{d_2}{d_1}\right)Y$$

Substituting the values in our current example,

$$i_e = 16 + .001Y.$$

The IS curve, on the other hand, does contain G. Changes in G will change the IS curve. We know they will change the intercept and not the slope because G only appears in the intercept. The general equation for the IS curve is:

$$i_e = \left(\frac{c_0 + e_0 + G_0}{e_1}\right) - \left(\frac{[1 - MPC(1-t_0)]}{e_1}\right)Y$$

When G_0=\$100, the IS curve was:

$$i_e = 28 - .005Y.$$

And we found Y_e=\$2000 and i_e=18% as our general equilibrium solution (see Figure 2.14).

Now, G has increased by \$100 to G=\$200. The IS curve is now:

$$i_e = \frac{200 + 1100 + 200}{50} - \frac{[1 - .8(1-.0625)]Y}{50}, \text{ or}$$

$$i_e = 30 - .005Y.$$

To find Y_e, we set the LM equal to the new IS curve (i.e., find the intersection):

$$16 + .001Y_e = 30 - .005Y_e$$

$$.006Y_e = 14$$

$$Y_e = \$2333.33$$

Substituting into the IS curve (using the LM would also work):

$$i_e = 30 - .005(2333.33)$$

$$i_e = 18.33\%.$$

Why is this solution the same as the Y_e Equation we used above? Because it's the same equation. The Y_e Equation is a general solution and our work here is the step by step solution. Figure 2.17 shows this solution in graphical terms:

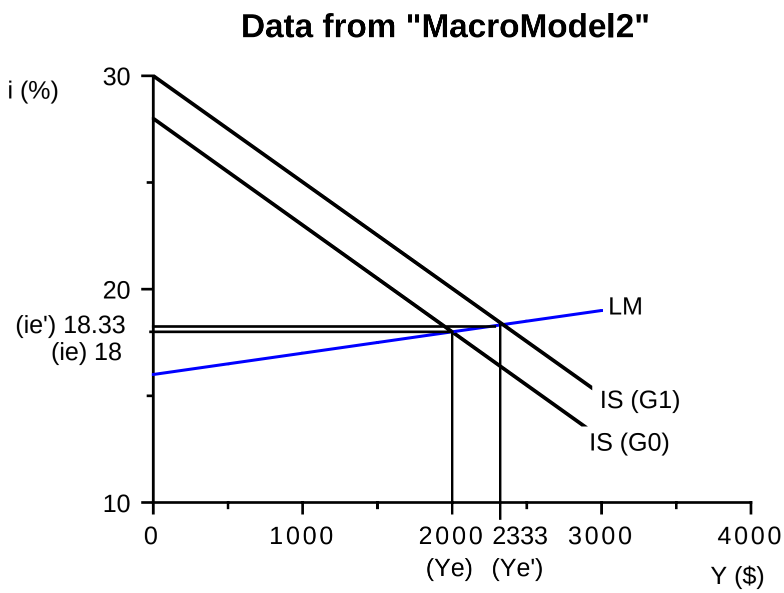


FIGURE 2.17: An Increase in G—IS/LM Analysis

The IS/LM framework allows us to see the partial v. general equilibrium solutions in a different light. It turns out that partial equilibrium is a special case of general equilibrium. Partial equilibrium does not allow a "feedback mechanism" through M^d. Thus, an increase in G increases Y_e and there is no crowding out because the interest rate remains unchanged. In the IS/LM framework, this simply means that the LM curve is horizontal! The Partial Equilibrium Model is a special case of the General Equilibrium Model. Using our example data, the Partial Equilibrium Model implies the LM curve is a horizontal line at i=18%. Thus, increasing G leads to a new IS curve

$$i_e = 30 - .005Y.$$

Setting the IS equal to LM and solving for Y_e yields:

$$18 = 30 - .005Y_e$$

$$Y_e = \$2400.$$

This is exactly the partial equilibrium result we obtained above!

Recall that we were able to find the new equilibrium value of national income in response to a given shock by using the multiplier instead of recalculating the new Y_e. We saw that this proved invaluable in solving our second fundamental question (the question dealing with policy prescriptions). Multiplier analysis can also be used in the general equilibrium model; but, as you may see intuitively, it is more complicated. Nevertheless, it may shed additional light on the general equilibrium model.

We want to know how much Y_e will change for a given change in G. A mathematician would say, "We want to know the derivative of Y_e with respect to G." This is the same work we did in previous models in our analysis of the multiplier—only a bit messier because of the feedback mechanism.

We proceed by finding, in the Y_e Equation, dY_e/dG. Although our task looks herculean, in fact, it is merely yet another application of the linear derivative rule we used above.

Y_e Equation:

$$Y_e = \frac{\dfrac{c_0 + e_0 + G_0}{e_1} - \dfrac{\left(d_0 - M^{s0}\right)}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}}$$

We can rewrite the Y_e Equation, isolating G, as follows:

$$Y_e = \frac{\dfrac{c_0 + e_0}{e_1} - \dfrac{\left(d_0 - M^{s0}\right)}{d_1}}{\left\{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}\right\}} + \frac{\dfrac{G}{e_1}}{\left\{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}\right\}}$$

Then,

$$\frac{dY_e}{dG} = + \frac{\dfrac{1}{e_1}}{\left(\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}\right)}$$

Substituting the values from our example 3 data:

$$\frac{dY_e}{dG} = + \frac{\frac{1}{50}}{\left(\frac{[1 - .8(1-.0625)]}{50} + \frac{.0125}{12.5}\right)}$$

$dY_e/dG = 3.3333.$

That is, for every $1 increase in G, there will be a corresponding $3.3333 increase in Y_e. Given that we increased government spending by $100, the equilibrium level of output will increase by $333.33 to Y_e=$2333.33. It is the same solution as before, but much less work to calculate.

Note that the general equilibrium multiplier for G (=3.33) is less than the partial equilibrium multiplier for G (=4—see Section 2). This is simply another manifestation of making M^d a function of Y. Increases in G increase Y in both general and partial equilibrium. The key difference, however, lies in the "feedback mechanism" found in the general equilibrium model. The increased Y leads to an increase in M^d which increases i which "short circuits" the expansionary effect of the initial increase in G by lowering I. Thus, the final increase in Y_e is less in the general than in the partial equilibrium model.

As usual, it will be only when we turn to the policy prescription question that the multiplier analysis shows its real power. At this stage, it serves merely to confirm our answers in finding the new Y_e for a given shock.

Shock 2: An Increase in M^s:

Before we turn to the second fundamental question, let's analyze the effect on Y_e of an increase in M^s. Suppose we start from the data given in Example 3:

$C = 200 + .8(Y - .0625Y)$

$I = 1100 - 50i$

$G = 100$

$M^d = 300 - 12.5i + .0125Y$

$M^s = 100$

First, we need to find the initial equilibrium values of Y and i. We apply the Y_e Equation derived above and plug in the appropriate values.

Y_e Equation:

$$Y_e = \frac{\dfrac{c_0 + e_0 + G_0}{e_1} - \dfrac{d_0 - M^{s0}}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}}$$

$$Y_e = \frac{\dfrac{200 + 1100 + 100}{50} - \dfrac{300 - 100}{12.5}}{\dfrac{[1 - .8(1-.0625)]}{50} + \dfrac{.0125}{12.5}}$$

$$Y_e = \$2000.$$

Then, we use the either the money market (LM) or goods market (IS) equilibrium to find i_e:

$$i_e = \left(\frac{d_0 - M^{s0}}{d_1}\right) + \left(\frac{d_2}{d_1}\right)Y$$

$$i_e = \frac{300 - 100 + (.0125*2000)}{12.5}$$

$$i_e = 18\%.$$

Now, the question is: How will an increase of \$100 in the money supply affect Y_e and i_e? At this point, we have two alternative solution strategies: (A) Find the money supply multiplier dY_e/dM^s or (B) Recalculate the Y_e equation with \$200 as the M^s. First, we will apply the multiplier method; then we will examine how the solution can be found by the first method.

(A) Finding the money supply multiplier:

From the Y_e equation, we find dY_e/dM^s. This gives the change in Y_e for a $1 increase in M^s; multiplying by 100 (the money supply increase) should give the increase in Y_e.

Y_e Equation:

$$Y_e = \frac{\dfrac{c_0 + e_0 + G_0}{e_1} - \dfrac{d_0 - M^{s0}}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}}$$

Rewriting so that M^s is isolated,

$$Y_e = \frac{\dfrac{c_0 + e_0 + G_0}{e_1} - \dfrac{d_0}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}} + \frac{\dfrac{M^s}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}}$$

Then,

$$\frac{dY_e}{dM^S} = + \frac{\dfrac{1}{d_1}}{\left\{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}\right\}}$$

Substituting the data from example 3,

$$\frac{dY_e}{dM^S} = + \frac{\dfrac{1}{12.5}}{\left\{\dfrac{[1 - .8(1-.0625)]}{50} + \dfrac{.0125}{12.5}\right\}}$$

$dY_e/dM^s = 13.33$

Since the increase in M^s = $100, the change in Y_e is

$dY_e = (100)(13.33)$

$dY_e = \$1333.33.$

Thus, the new Y_e = \$3333.33 and the new equilibrium interest rate is:

$$i_e = \left(\frac{d_0 - M^{s0}}{d_1}\right) + \left(\frac{d_2}{d_1}\right)Y$$

$$i_e = \frac{300 - 200 + (.0125*3333.33)}{12.5}$$

$$i_e = 11.33\%.$$

Recall that the money supply multiplier in the partial equilibrium model was 16. Once again, the reason why the multiplier is smaller in the general equilibrium model is because of the fact that money demand is a function of income. Increases in income lead to increases in M^d; the resulting increase in the interest rate drives down investment and this lowers Y_e (this is known as crowding out).

<u>(B) Recalculating:</u>

Recalculating the IS and LM curves has the advantage that shifts in the IS or LM curves can be captured graphically. We know that the IS curve is:

$$i_e = \left(\frac{c_0 + e_0 + G_0}{e_1}\right) - \left(\frac{[1 - MPC(1-t_0)]}{e_1}\right)Y$$

Substituting in the relevant values, we have:

$$i_e = 28 - .005Y.$$

Note that changes in M^s do not affect the IS curve because money supply does not appear in the function.

The LM curve is:

$$i_e = \left(\frac{d_0 - M^{s0}}{d_1}\right) + \left(\frac{d_2}{d_1}\right)Y$$

With M^s = \$100, the LM curve is:

$$i_e = 16 + .001Y.$$

Clearly, the increase in the money supply will shift the LM curve because M^s appears as a variable in the LM function—more specifically, M^s appears in the intercept. You should examine the variables in the LM curve and note that G and t do **not** appear. With M^s = \$200, the LM curve becomes:

$$i_e = \frac{300 - 200 + .0125Y}{12.5}$$

$$i_e = 8 + .001Y.$$

Setting the IS equal to the LM curve and solving, we get:

$28 - .005Y = 8 + .001Y$

$.006Y = 20$

$Y_e = \$3333.33.$

Substituting into the IS or LM curve will give us $i_e = 11.33\%$.

Figure 2.18 shows the effects of an increase in the M^s on the endogenous variables.

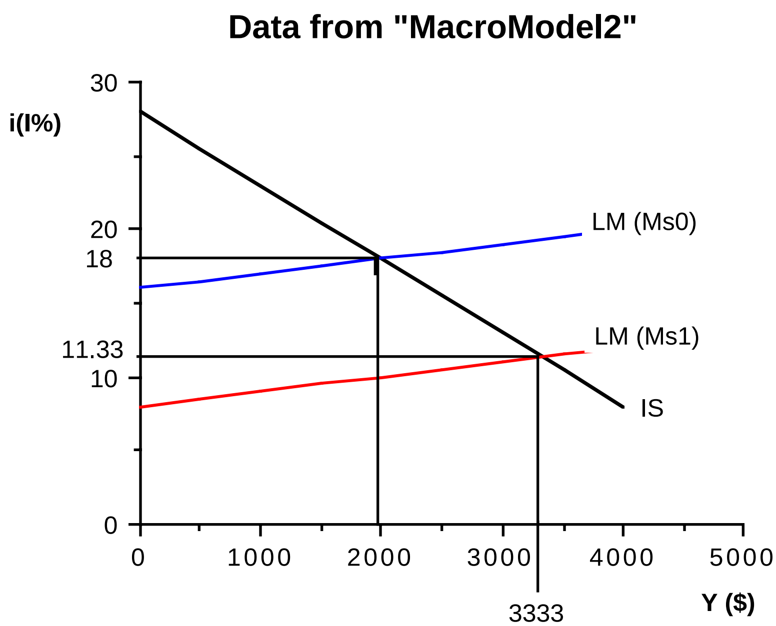


FIGURE 2.18: An Increase in M^s in the IS/LM Framework

Clearly, both approaches give the same results—the multiplier does it "all-at-once," while recalculating the IS/LM curves is step by step. Each solution strategy has its proper place—use the multiplier to quickly find dY_e if given an exogenous shock or to find the needed policy move if given a GNP Gap; use the recalculation method to draw a graph or to see clearly how curves are shifting.

Examining the IS and LM curves:

Before we turn to the second fundamental question, let's examine, for a moment, the IS and LM curves:

IS Curve:

$$i_e = \left(\frac{c_0 + e_0 + G_0}{e_1}\right) - \left(\frac{[1 - MPC(1-t_0)]}{e_1}\right)Y$$

LM Curve:

$$i_e = \left(\frac{d_0 - M^{s0}}{d_1}\right) + \left(\frac{d_2}{d_1}\right)Y$$

Only changes in c_0 (autonomous consumption), MPC, t_0 (the tax rate), e_0 (autonomous investment), G_0 (government spending) and e_1 (the slope of the investment demand function) affect (i.e., **shift**) the IS curve. Note, furthermore, that an increase in the tax rate shifts the IS left—the opposite of an increase in G.

Only changes in d_0, d_1, d_2, and M^s can shift or affect the LM curve. Note how an increase in M^s lowers the intercept, $(d_0 - M^s)/d_1$, and, therefore, shifts the LM curve down. An increase in d_0 would have the opposite effect. A change in d_2 would alter the slope, but leave the intercept unaffected; while a change in d_1 would change both the slope and the intercept of the line.

But the main point to remember is this: **changes in G and t shift the IS curve left/right and leave the LM unaffected; changes in M^s shift the LM curve**

up/down and leave the IS unaffected. Understanding why and how these shifts occur and the resulting implications is the rest of the story.

Question 2: Shock needed to generate desirable Y_e?

We are now in a position to turn to the second fundamental question: How can we use G, t, and/or M^s to solve the GNP Gap? Assume the economy of example 3; we know such an economy will converge to an equilibrium level of national income of $2000 and an equilibrium interest rate of 18%. If the full-employment level of national income is $2500, how can the policy making authorities eliminate this $500 GNP Gap?

The solution can take only two forms—(A) shift the IS curve right or (B) shift the LM curve down so that the intersection of the IS/LM curves occurs at Y=$2500.

Strategy (A) turns our attention quite naturally to G and t. As before, it is possible to envision government attempts to stimulate AD through c_0, MPC, e_0, or e_1; but the most obvious policy tools to shift the IS schedule are G and t. The first step we must take is to derive the multiplier. Much of this work has already been done and we can simply rewrite a few equations:

Y_e Equation:

$$Y_e = \frac{\dfrac{c_0 + e_0 + G_0}{e_1} - \dfrac{d_0 - M^{s0}}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}}$$

The G Multiplier:

$$\frac{dY_e}{dG} = + \frac{\dfrac{1}{e_1}}{\left(\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}\right)}$$

From the example 3 data,

$dY/dG = 3.3333.$

Now, given that we know we want to increase Y_e by \$500, we can solve for dG:

$\$500/dG = 3.3333$

$dG = \$150.$

That is, an increase in government spending of \$150 will increase Y_e by \$500 up to the full-employment level of \$2500. Note that this is a greater increase than what was needed in the partial equilibrium model (where dG=\$125). This occurs because we have to overcome the effects of a decrease in Y from a decrease in I, from an increase in i, from an increase in M^d—the crowding out effect.

At this point, government expenditures equal \$250 and revenues equal \$156.25($=t_0Y=.0625*2500$)—a deficit of \$93.75. The equilibrium interest rate is:

$$i_e = \frac{d_0 - M^{s0} + d_2Y}{d_1}$$

$$i_e = \frac{300 - 100 + (.0125*2500)}{12.5}$$

$$i_e = 18.5\%.$$

Figure 2.19 shows the Strategy (A) solution:

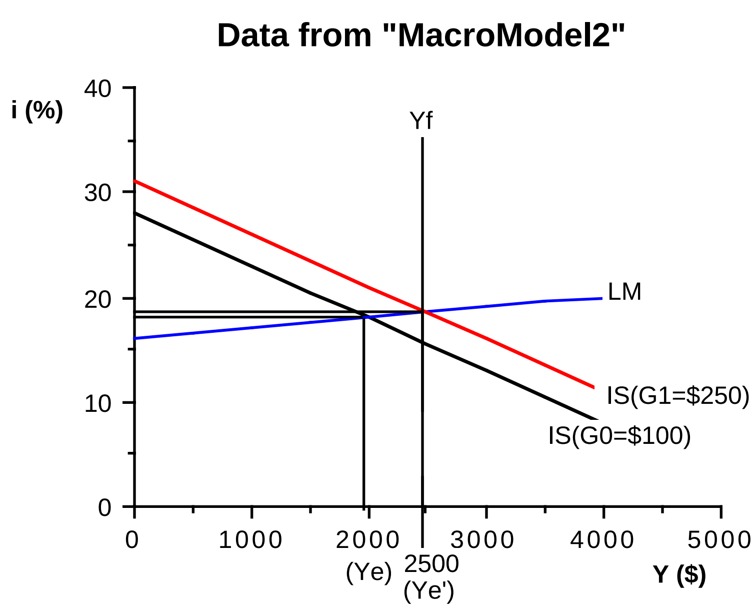


FIGURE 2.19: Shifting the IS Curve to Reach Y_f

Strategy (B), shifting the LM curve, is conceptually similar. We find the money supply multiplier and change M^s by the appropriate amount. The money supply multiplier is derived, as before, from the Y_e Equation.

Y_e Equation:

$$Y_e = \frac{\dfrac{c_0 + e_0 + G_0}{e_1} - \dfrac{d_0 - M^{s0}}{d_1}}{\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}}$$

The M^s Multiplier:

$$\frac{dY_e}{dM^s} = + \frac{\dfrac{1}{d_1}}{\left(\dfrac{[1 - MPC(1-t_0)]}{e_1} + \dfrac{d_2}{d_1}\right)}$$

From the example 3 data,

$$\frac{dY_e}{dM^s} = + \frac{\dfrac{1}{12.5}}{\left(\dfrac{[1 - .8(1-.0625)]}{50} + \dfrac{.0125}{12.5}\right)}$$

$dY_e/dM^s = 13.33.$

Clearly, in order to increase Y_e by \$500, we must increase the money supply by:

$\$500/dM^s = 13.33$

$dM^s = \$37.51.$

Note that this is a greater increase than was needed in the partial equilibrium model ($dM^s = \$31.25$). The reason, once again, is the need to overcome the crowding out effect.

The new equilibrium interest rate is:

$$i_e = \frac{d_0 - M^{s0} + d_2 Y}{d_1}$$

$$i_e = \frac{300 - 137.51 + (.0125*2500)}{12.5}$$

$$i_e = 15.5\%.$$

Figure 2.20 shows the Strategy (B) solution:

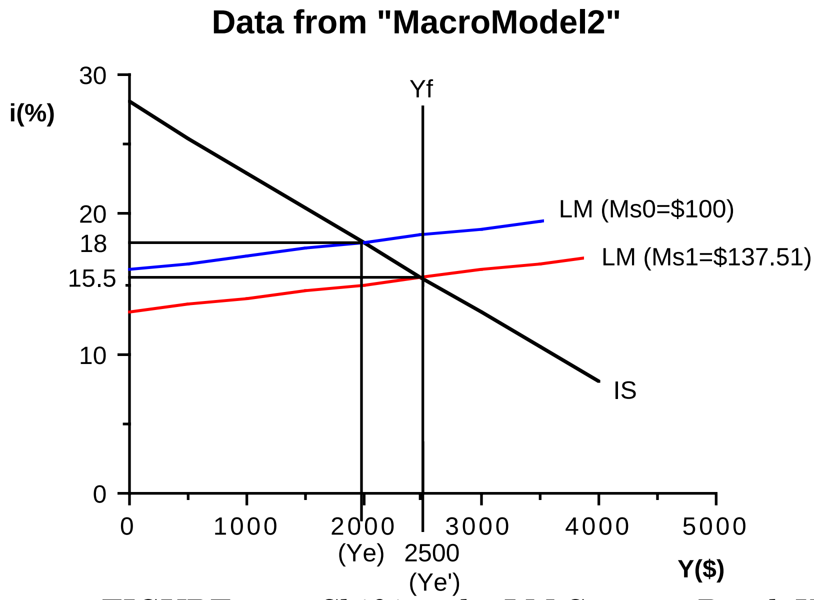


FIGURE 2.20: Shifting the LM Curve to Reach Y_f

Note that, although we did not examine the needed change in the tax rate, it should be clear that a decrease in t_0 would be needed in order to eliminate the GNP Gap. Such a move would shift the IS curve up and increase Y_e and i_e.

"So, should we use G / t or M^s?

Finally, the question of appropriate policy goals needs to be discussed. Many students believe that M^s is to be preferred over G and t because shifting the IS curve up increases income, but raises the interest rate; while shifting the LM curve down increases Y and lowers i. Furthermore, G and t are thought to be inferior as policy tools to M^s because fiscal policy tools generate deficits, while the money supply does not.

These considerations may be important in a more sophisticated model, but for now the only macroeconomic policy goal we have is to reach full-employment. In general, the goals of macroeconomic policy are to maintain full-employment and a stable price level. Worries about deficits or interest rates, in and of themselves, are irrelevant.

These issues become important only when, through some feedback mechanism, they affect future output or the rate of change of prices. Clearly, our model has no mechanism through which this can take place—deficits do not affect Y_e and we have implicitly assumed fixed prices.

<u>Summary:</u>

In this section, we examined the General Equilibrium Keynesian Model. We expanded the partial equilibrium model by making a small, but crucial change—money demand is now a function of national income. This made our analysis of the two fundamental questions (how will a shock affect Y_e and how can we force Y_e=Y_f) more difficult because of the crowding out effect. Any change in an exogenous variable will now have a series of "second order" effects that were not considered in the partial equilibrium model.

These secondary effects or reverberations are captured by the IS/LM analysis. The IS and LM curves represent equilibrium in the goods and money markets, respectively. The intersection of these two curves implies, therefore, simultaneous equilibrium in both markets—a condition that must hold if we are to have a general equilibrium. IS/LM is, therefore, seen as a convenient graphical device that enables a quick, easy determination of the two crucial endogenous variables, output and interest rate.

The macro-reasoning that we discussed earlier was very much in evidence in this model. It is absolutely essential that the student of macroeconomics be able to think sequentially and logically. Chains such as "increased Y --> increased M^d --> increased i --> decreased I --> decreased AD --> decreased Y" must come naturally at this point.

Finally, I urge you to concentrate on the graphical analysis of the IS/LM theory. There are only two fundamental questions, that can be asked:

(1) Given an exogenous shock, what happens to Y_e?

(2) What should we do to eliminate the GNP Gap?

These types of qualitative problems can be most easily solved graphically. For the first type, isolate which curve the variable affects, then shift it accordingly and find the new Y_e. For the second, remember that M^s can only affect LM and fiscal policy tools (G and t) can only affect the IS curve. Use the appropriate policy tool to shift a curve such that the new intersection point is at full-employment.

To Review:

Previous definitions and concepts all hold—equilibrium, money market and the Fed have the same meanings as in the partial equilibrium model.

Partial v. General Equilibrium: For a given shock, partial equilibrium only considers the "first order" effect. Increase G leads, through the multiplier to an increase in Y_e—case closed. General equilibrium, on the other hand, is a more sophisticated analysis of a given shock. It examines **all** effects from a particular shock. Increasing G does lead, at first, to an increase in Y_e; but we know that the resulting increase in M^d will lead to a series of subsequent effects. At some point, the economy will settle into a new, mutually consistent pair of Y and i values. These general equilibrium values will be between the initial and the partial equilibrium values (see Figure 2.10).

IS/LM: Surprising as it may seem, IS/LM curves are merely a short-cut to the general equilibrium solution. Each curve represents a set of equilibrium combinations and the intersection is the general equilibrium point—the only point where both markets are simultaneously in equilibrium. IS curves slope downward because to get more equilibrium Y a lower i is needed (to stimulate higher I). LM curves slope upwards because more Y leads to higher M^d which leads, in turn, to higher equilibrium i.

Comparative Statics: The multiplier is the same conceptually as before, but it is more complicated. In particular, multipliers have a smaller value than before because the feedback mechanism in the general equilibrium model serves to mitigate the effects of any given shock. Mathematically, multipliers have extra terms because of the feedback mechanism. Always remember that G and t can only affect the IS curve; while M^s can only affect the LM curve.

NOTE:

Because I continue to worry that the typical student does NOT truly understand the IS/LM model, I have written *Understanding Equilibrium in the IS/LM Model* and included it at the end of these Macro Notes. There is little doubt that a complete mastery of the IS/LM model is required to understand modern macroeconomic theory. Don't "wave your hands" or remain content with a superficial grasp of IS and LM curves. Examine these notes and your textbook carefully. Ask questions. The model may or may not have applicability to the real world, but it is certainly an excellent example of the equilibrium version of the Economic Approach.

Section 4: A Comparison of the Three Short Run, Fixed Price Keynesian Models

At this point, we have covered quite a bit of ground. In an effort to organize thoughts and help in understanding macroeconomics, a review and comparison of the three models we have considered thus far will be undertaken. We will analyze each model (the simple, partial equilibrium and general equilibrium models) with respect to a particular criterion in an attempt to underscore the fundamental differences. Bear in mind that, of the three, the general equilibrium model is the most complete and is the one which we will use to build from in the next chapter.

You are urged to make comparisons of your own as you read through this section. Return to the previous sections if necessary—be an active and attentive reader.

Criterion 1: The Model

Simple	Partial	General
$Y = C + I + G$	$Y = C + I + G$	$Y = C + I + G$
$C=c_0+MPC(Y-t_0Y)$	$C=c_0+MPC(Y-t_0Y)$	$C=c_0+MPC(Y-t_0Y)$
$I=I_0$	$I = e_0 - e_1 i$	$I = e_0 - e_1 i$
$G=G_0$	$G=G_0$	$G=G_0$
	$M^d = M^s$	$M^d = M^s$
	$M^d = d_0 - d_1 i$	$M^d = d_0 - d_1 i + d_2 Y$
	$M^s = M^{s0}$	$M^s = M^{s0}$

Notes:

(1) The simple model has no money market; investment is given and is not a function of the interest rate.

(2) The key, and only, difference between the partial and general equilibrium models is that money demand is a function of income in the latter.

Criterion 2: An Example Model

Simple	Partial	General
Y = C + I + G	Y = C + I + G	Y = C + I + G
C=200+.8(Y-.0625Y)	C=200+.8(Y-.0625Y)	C=200+.8(Y-.0625Y)
I=200	I = 1100 - 50i	I = 1100 - 50i
G=100	G=100	G=100
	$M^d = M^s$	$M^d = M^s$
	$M^d = 325 - 12.5i$	$M^d = 300 - 12.5i + .0125Y$
	$M^s = 100$	$M^s = 100$

Notes:

(1) Data come from examples 1, 2 and 3 respectively.

Criterion 3: A Mathematical Analysis of Equilibrium

Simple

Equation 1:

$$Y_e = \frac{c_0 + I_0 + G_0}{[1 - MPC(1 - t_0)]}$$

Partial

Equation 2:

$$Y_e = \frac{c_0 + e_0 - e_1\left(\frac{d_0 - M^{s0}}{d_1}\right) + G_0}{1 - MPC(1 - t_0)}$$

General

The Y_e Equation:

$$Y_e = \frac{\frac{c_0 + e_0 + G_0}{e_1} - \frac{(d_0 - M^{s0})}{d_1}}{\left\{\frac{[1 - MPC(1 - t_0)]}{e_1} + \frac{d_2}{d_1}\right\}}$$

Notes:

(1) Partial is the same as simple except for a messier investment term.

(2) General is the same as partial except that d_1 and d_2 have made an appearance in the denominator. This is why the multiplier is smaller in the general equilibrium case (i.e., a larger denominator). This is why crowding out occurs in the generalequilibriummodel.

Criterion 4: Example Equilibrium

Simple

$$Y_e = \frac{200 + 200 + 100}{1 - .8(1 - .0625)}$$

Y_e = \$2000

Partial

$$Y = \frac{200 + 1100 - 50 \frac{325 - 100}{12.5} + 100}{1 - .8(1 - .0625)}$$

Y_e = \$2000

i_e = 18% (from $M^d = M^s$)

General

$$Y_e = \frac{\frac{200 + 1100 + 100}{50} - \frac{300 - 100}{12.5}}{\frac{[1 - .8(1 - .0625)]}{50} + \frac{.0125}{12.5}}$$

Y_e = \$2000

i_e = 18% (from either IS or LM)

Notes: (1) The examples were constructed so that each model starts from the same equilibrium position.

Criterion 5: A Graphical Analysis of Equilibrium

Simple

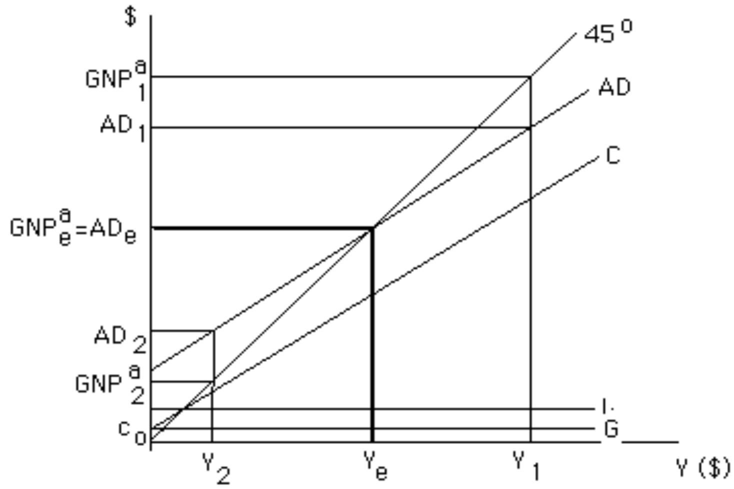


FIGURE 2.1: The Keynesian Cross: Equilibrium Income Determination

Partial

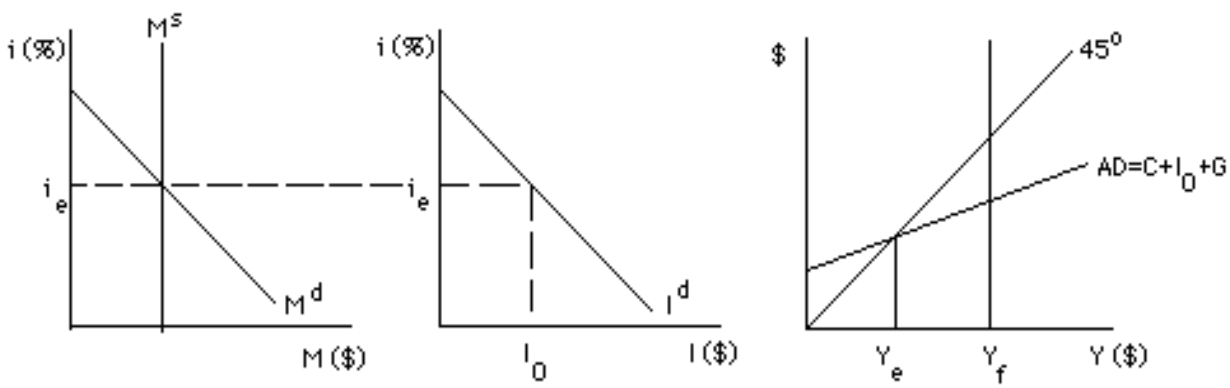


FIGURE 2.7: The Partial Equilibrium Model

General

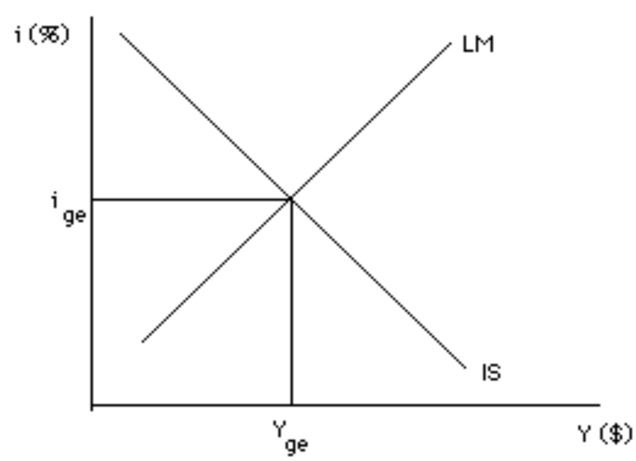


FIGURE 2.13: IS/LM to get the General Equilibrium Solution

We now turn to a comparison of the first fundamental question: How does Y_e change in response to an exogenous shock? We will consider two shocks—ΔG and ΔM^s.

Criterion 6A: The Effects of an Increase in G

Simple

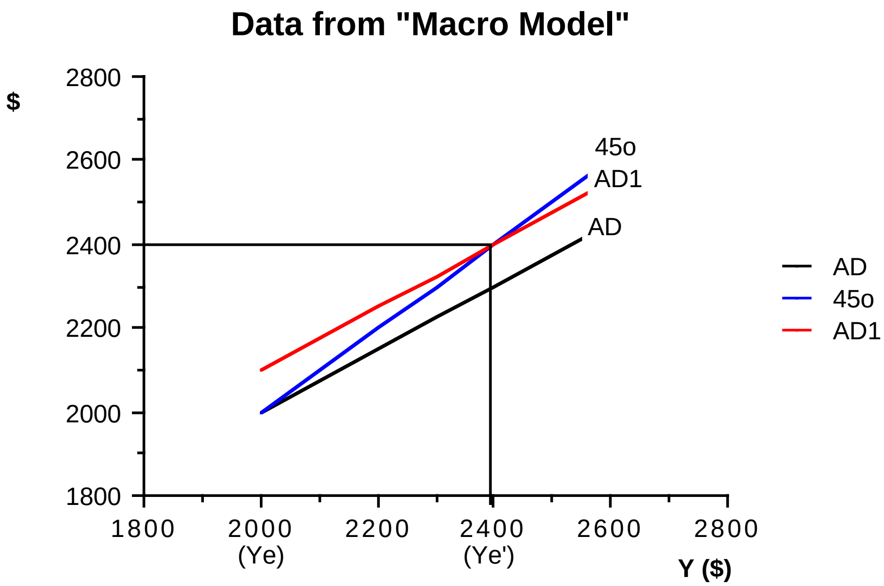


FIGURE 2.2: The Effect on Y_e from an Increase in G

Partial

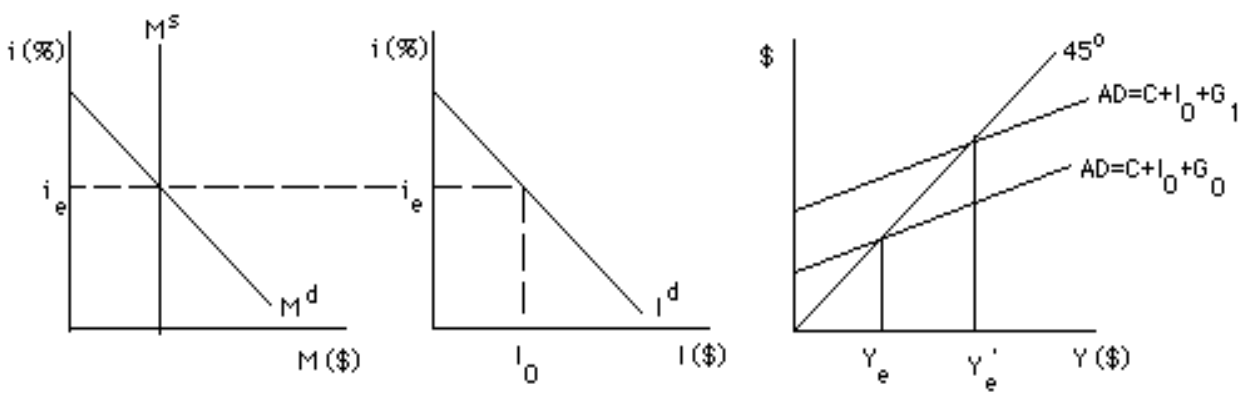


FIGURE 2.21: An Increase in G in the Partial Equilibrium Model

General

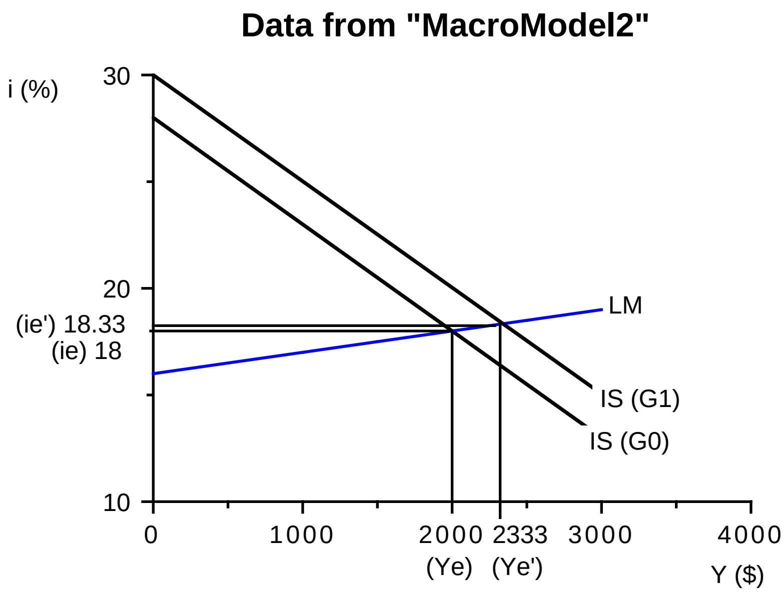


FIGURE 2.17: An Increase in G—IS/LM Analysis

Notes:

(1) Figure 2.16 in Section 3 clearly shows the difference between the partial and general equilibrium models with respect to a change in G.

(2) There is no difference between the simple and partial equilibrium models with respect to a change in G. This equivalence holds because neither model has a feedback mechanism (the simple model has no monetary sector and the partial model's money demand is not a function of income).

(3) It is the feedback mechanism, M^d =f(i and ***Y***), that generates the difference between the partial and general equilibrium models. Anything that increases Y will increase M^d and, hence, interest rates. This will lower investment demand, in turn, lowering aggregate demand, which lowers Y—lessening the initial increase in Y.

Criterion 6B: The Effects of an Increase in M^s

Simple

There is no monetary sector so there is no way for the money supply to affect Y_e.

Partial

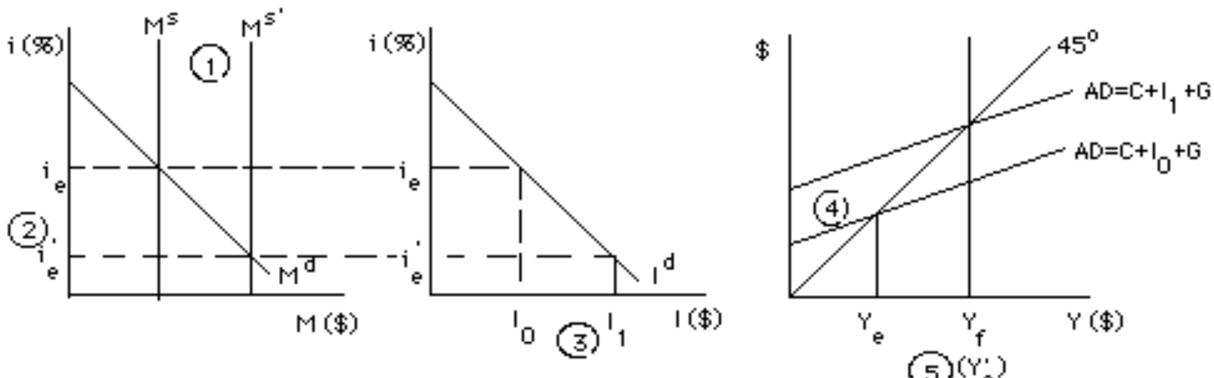


FIGURE 2.8: The Effect of an Increase in M^S on Y_e

General

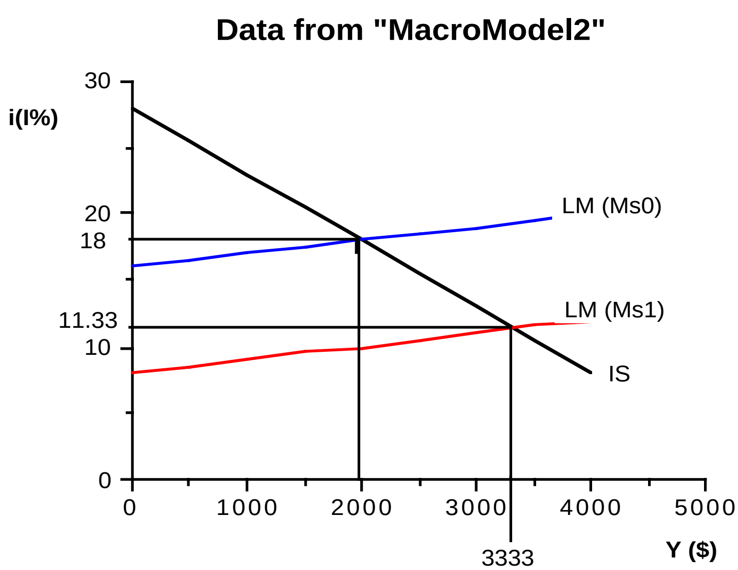


FIGURE 2.18: An Increase in M^s in the IS/LM Framework

Notes:

(1) Once again, the presence of the feedback mechanism makes the effect of a shock (in this case, an increase in the money supply) smaller in the general equilibriummodel.

Finally, we turn our attention to the second fundamental question: How can policy makers use the tools at their disposal to ensure that the equilibrium equals the full-employment level of national income?

Criterion 7: Solving the GNP Gap

Simple

In the simple model, policy makers can only use fiscal policy tools (G and t) to eliminate the GNP Gap. If $Y_e < Y_f$, increasing G or decreasing t will increase AD and, consequently, Y. To determine the exact amount of the needed increase in G, we can use the G multiplier.

Partial

In the partial equilibrium model, policy makers have the fiscal policy tools they had in the simple model plus the money supply. The addition of a monetary sector allows the Fed to increase M^s which lowers i, which increases I, which increases AD, which increases Y_e. The exact amount of the needed increase can be found by deriving the M^s multiplier.

General

In the general equilibrium model, policy makers have the same tools they had in the partial model (G, t, and M^s), but they must take into consideration the feedback mechanism. A shock which increases Y will, through the increase in M^d and resulting chain of events, decrease Y. The system will settle into a general equilibrium between the initial and partial equilibrium, or "first-round", value of Y. This can be seen by the fact that the multipliers in the general model are always smaller than the multipliers in the partial model—indicating that a given shock will not have as great an effect when considered from a general equilibrium point of view. Thus, policy makers must take this into account when they are deciding on the magnitude of a particular policy. Calculating the G or M^s multiplier when using G or M^s, respectively, will ensure that the proper shock is administered. Graphically, proper policy requires that changes be made to shift appropriate curves such that the new intersection is at full-employment. The money supply shifts the LM curve and fiscal policy tools (G and t) shift the IS curve.

<u>Summary:</u>

The fundamentals of the three models analyzed in this chapter are remarkably similar—equilibrium, comparative statics (or the two fundamental questions) and multipliers are all used the same way. We began by building the simplest possible model of the economy, the Simple Keynesian Model, and slowly added complexities. The Partial Equilibrium Model enabled us to incorporate the monetary sector and investment demand function. No longer is investment exogenous, it is determined by the interest rate which, in turn, is determined by equilibrating forces in the bond market. The General Equilibrium, or IS/LM, Model brought us the "feedback mechanism" through which changes in Y_e affected M^d and led, eventually, to further changes in Y_e.

At this point, we have a model that predicts values of the interest rate and level of output given values for the exogenous variables. We know, however, that the two objectives facing policy makers are to maintain full-employment and price stability. By implicitly holding prices constant, we are unable, with the IS/LM Model alone, to provide any insight into the second macro policy goal. Our next challenge, therefore, is to drop the assumption of fixed prices and allow that variable to be determined, as are income and the interest rate, endogenously.

<u>Note on Additional Readings:</u>

Chapter 3 of these notes should be read in conjunction with the selections from Dornbusch and Fischer, <u>Macroeconomics</u>, 5th Edition, on reserve at the library (which I'll henceforth call D&F). The order of topics and readings is as follows:

<u>Introduction to Aggregate Demand and Aggregate Supply</u>

- D&F, Ch. 7, Introduction and Sections 7-1 to 7-4 (pp. 219-241; ignore Box 7-1 on p. 230) and Section 7-8 (Summary), items 1.-8, p. 256

<u>Derivation of the Aggregate Demand curve and the AS/AD Model in the Short Run</u>

- Chapter 3 of these notes
  (Box 7-1 on D&F, p. 230 derives the Aggregate Demand curve in very terse, mathematical language)

<u>Aggregate Supply</u>

- D&F, Ch. 13
- D&F, Ch. 7, Sections 7 and 8

<u>Dynamic Aggregate Supply and Aggregate Demand (putting inflation into the model)</u>

- D&F, Ch. 14

Chapter 3: Short Run, Flexible (to Varying Degree) Price Models

Section 1: The "Conventional" IS/LM—AD/AS Keynesian Model

In this chapter, we drop the assumption of fixed prices and allow prices to vary. Therefore, the determination of the price level becomes a third variable that must be explained by the model. This has several immediate and important consequences—(1) we will need another equilibrium condition since we now have three endogenous variables (Y, i and P); (2) we will have another "feedback mechanism" which, conceptually, operates much like the M^d=f(Y) feedback mechanism; and, finally, (3) we will be able to discuss macroeconomic policy in terms of the desire for full-employment and price stability. These often incompatible objectives and the three tools available to policy makers form the basis of the macro policy debate.

Although the model is different because of the relaxation of the fixed prices assumption, much remains the same—equilibrium; comparative statics; multipliers; IS/LM; and G, t, or M^s as policy tools. It is assumed, in this section, that the reader is well versed in these concepts and can quickly manipulate the General Equilibrium Keynesian Model. Macroeconomics is a structure very much "built from the bottom up"—the reader who misses a floor will find herself on shaky footing indeed. Do not continue until you are confident of your understanding of the general equilibrium model—especially the derivation of the IS/LM graph and the notion of a "feedback mechanism." With that caveat, we plow forward into the IS/LM—AD/AS "Conventional" Keynesian Model.

After reviewing the assumptions, we turn to the analysis of the model. Since a crucial component of the model is the derivation of the AD curve, we devote a section to a careful, rigorous analysis of the AD curve. We then combine the verbal and graphical analyses to highlight the major features of the model. A review of the comparative statics properties of the model and a summary compose the rest of this section. Since the mathematics of this model are more complicated than the general equilibrium model (mainly because AD is nonlinear), the mathematical exposition is not presented here.

But before we begin our work, two quick notes regarding terminology are needed. First, we will soon be making reference to "price-income space" or, for the IS/LM graph, "i-Y space." Although economists are certainly guilty as charged when it comes to the liberal use of confusing jargon, this is most certainly not another example of needless "economic-ese." As emphasized above, the model analyzed in this section has three endogenous variables. Thus, the exposition requires two graphs—one to describe the interest rate and output combination and another for the price and output combination.[12] It becomes important to distinguish the x and y axes of the graph under discussion. For example, AD in P-Y space is different from AD in the Keynesian cross diagram.[13] The latter has dollars per year ($) on the y axis, while AD in P-Y space has the price level (P), in index form, on the y axis.[14]

Secondly, in an attempt to ensure that the reader is aware of what variables affect a particular schedule, we will change our notation in the graphs to the following:

$IS(c_0, MPC, t_0, e_0, e_1, G_0)$,

or $IS(G, t)$,

where the variables in the parentheses represent variables that shift, in this example, the IS curve. Thus, the notation is read by saying, for IS(G, t), "The IS curve is a function of the level of government spending and the tax rate." Changes in either of these variables will cause a shift of the entire IS curve in i-Y space.

---

[12]Note that output is repeated since there are three endogenous variables to be determined, but four axes (two on each graph). It should not be surprising that the output solution is identical in each graph (after all, consistency is a fundamental attribute of static, orthodox economics models); nor that economists take advantage of this duplication by stacking the graphs on top of each other with output on the x axis.

[13] This terminology is certainly confusing! Although some textbooks label AD in the Keynesian cross graph "Aggregate Expenditure" ("AE"), most use the same name, aggregate demand (AD) for these two different concepts.

[14]Note that the price axis is not denominated in dollars, but in terms of some price index of all the goods and services in the economy (the CPI, although only a representative market basket of goods, would be an obvious candidate). There is no one single good that is being produced, but many goods and services. Therefore, it is impossible to refer to price as "$/unit" of a single good and a price index must be generated. The reader is urged to refer to his lecture notes and/or textbook to review the uses and derivations of price indices.

Assumptions:

We have the same model as the general equilibrium model—aggregate demand is composed of consumer (consumption function), firm (investment function) and government (government spending) demands. The money market has a money demand (which is a function of the interest rate and income) and a money supply.

(1) However, here we find our first change. The money supply is defined as the **real** (as opposed to the nominal) stock of money. That is, the money supply is the nominal, or current, dollar amount of money adjusted for the price level. Mathematically, we write

$$\text{real } M^S = \frac{M^S}{P}$$

(2) The second "assumption" is more a change in definition. Because the price level is allowed to fluctuate, GNP depends on both quantity produced and the price level. Therefore, Y will now represent real output and real national income. That is, output (or income) will always be expressed in constant dollars in order to remove the effects of changes in prices.

(3) Now, as mentioned in the introduction to this chapter, the introduction of a third endogenous variable requires a third equilibrium condition. This forces a major change from the general equilibrium model. More precisely, we are going to need another required relationship between equations in order to determine the price level. This "required relationship" is the AD/AS part of the IS/LM—AD/AS "Conventional" KeynesianModel.

For now, we simply assume the existence of an **aggregate supply curve.** The discussion of the AS curve will be temporarily postponed. From a pedagogical point of view, it is easier to merely assume the existence of an upward sloping curve to solve the model, then explain how differences in AS lead to differences in results. Thus, in sections 2 and 3 of this chapter, the reader will see how differences with respect to the shape of the AS curve lead to different "schools" of macroeconomics.

The AS curve plays a crucial role in this model—when combined with the relevant AD curve, we can determine the equilibrium level of prices and income. In essence, AS is needed in order that P may be determined endogenously.

Mathematically, we assume that AS is linear with some positive y-axis intercept (g_0) and a positive slope (g_1):

The AS Curve:

$$Y = g_0 + g_1P$$

Once again, discussion of the variables that affect g_0 and g_1 will be deferred until a full understanding of the workings of the model is gained. At that point, the differing views of macroeconomists will be highlighted.

<u>Deriving the AD Curve:</u>

Our first task on the way to understanding the IS/LM—AD/AS Model is to explain the equilibrium condition that will be used to determine the price level. We have simply assumed the existence of an upward sloping, linear AS curve, but have said nothing about its counterpart—the AD curve. Of course, it is the intersection of the AD and AS curves that determine the price level, so it is imperative that we derive the AD curve.

It is important that the student understand that the AD curve in P-Y space is neither the AD curve in the Keynesian cross diagram nor is it similar to a "micro" demand curve. AD in Keynesian cross diagram is composed of the sum of consumers' (C), firms' (I), and the government's (G) demands for output. A micro demand curve is derived from the theory of consumer behavior—the consumer allocates a budget (i.e., he's given product prices and income) across products such that utility is maximized. By changing the price of product, *ceteris paribus*, and recording the optimal quantity at each given price, a demand curve can be depicted in P-Q space. It must be clearly and strongly stated that the macro AD curve in P-Y space has nothing whatsoever to do with this logic. Do not say, "AD in P-Y space is downward sloping because when the price goes down, agents want to buy more." This is completely erroneous.

If it's not the sum of C+I+G, nor a "micro" demand curve, then where does the AD curve in P-Y space come from? Simply put, it is derived from the necessary equilibrium conditions in the goods (IS curve) and money (LM curve) markets. The first footnote in this chapter pointed out that there are three endogenous variables (i, Y and P), but four axes (since there are two graphs) in the IS/LM—AD/AS model. One of these axes, then, must be duplicated. (Of course, the x axes, showing the level of output, are the ones repeated). Using this same logic, note that there are also four relationships, (1) IS curve, (2) LM curve, (3) AD curve, and (4) AS curve, being graphed. Since there are only three endogenous variables, one of these must be a derivative of the others. The IS curve shows the goods market equilibrium in i-Y space—for a given interest rate, a level of investment is determined that, in turn, determines aggregate demand and, thus, Y_e. The LM curve depicts the locus of points at which the money market is in equilibrium in i-Y space—for a given level of income, the M^d curve is fixed which, in conjunction with M^s, determines i_e. The AS curve, at this point, has been assumed to be a linear, upward sloping relationship between P and Y. Thus, there are three independent relationships and three endogenous variables; by default, the AD curve in P-Y space must be a dependent or derivative relationship. It must be a restatement or different presentation of information already available.

Simply put, the AD curve in P-Y space shows, given a price level, what the compatible level of equilibrium output must be. A given price level determines the real money supply (since real $M^s = M^s/P$) which, in turn, sets the LM curve in i-Y space. By combining the IS and LM curves, the equilibrium level of output is determined. When the price level changes, the LM curve shifts and a new Y_e is determined. By tracing out the P-Y_e paired values, the AD curve in P-Y space is derived. Figure 3.1 shows how the AD curve in P-Y space is constructed:

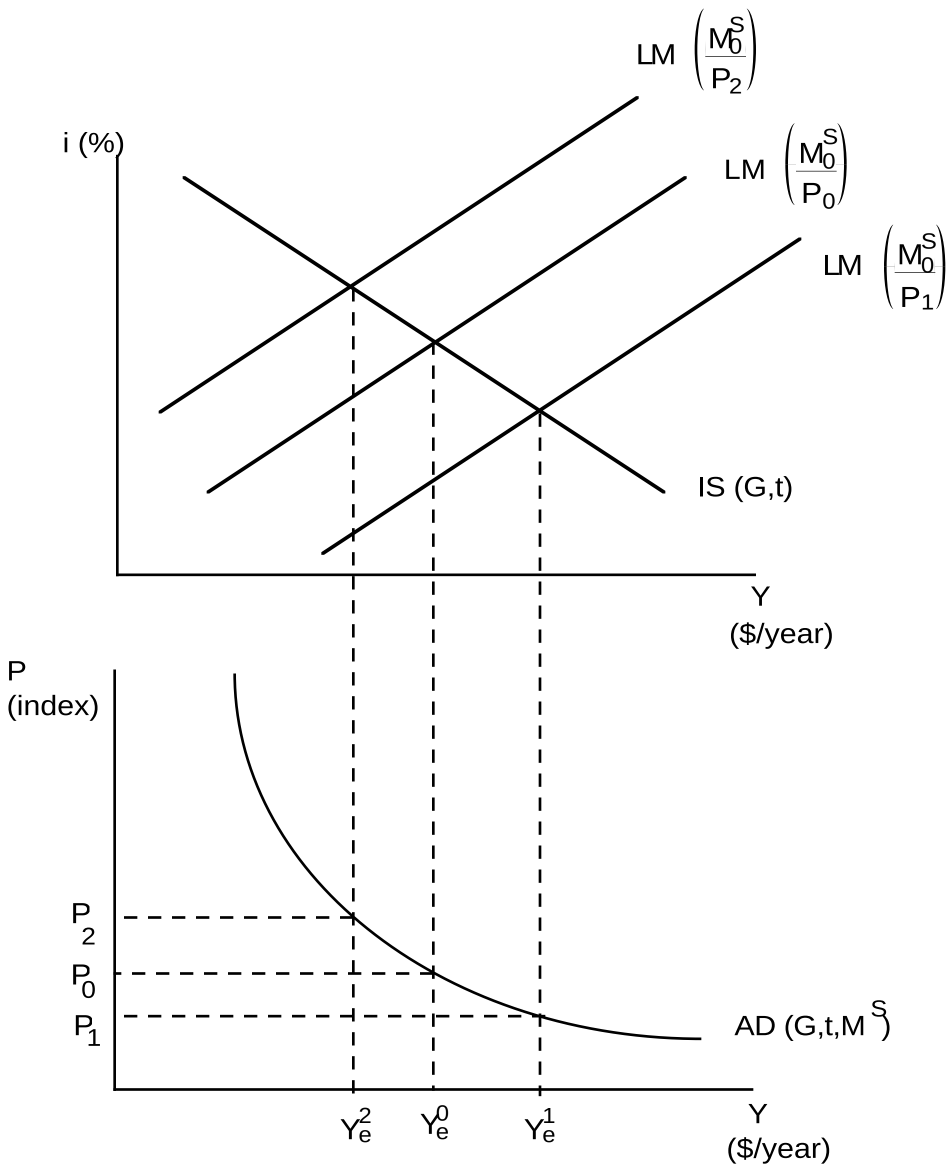


Figure 3.1: Constructing the AD Curve

The graph emphasizes that AD in P-Y space is not an independent piece of the model, but a necessary relationship between price and output given equilibrium in the goods and money markets. The subscripts, as usual, are crucial. A price level P_0 sets the LM curve at a place where its intersection with the IS curve determines an equilibrium output level of Y_e^0. Changing the price and finding the Y_e which is compatible to the new price exposes the necessary relationship between price and output that is called the AD curve. For example, raising the price moves the economy up the AD curve in P-Y space, meaning less output is demanded, not because output is more expensive, but because the higher price triggers the following chain:

increase P -> decrease real M^s -> increase i -> decrease I -> decrease AD[15] -> decrease Y_e -> decrease M^d -> decrease i . . . [ultimately] increase i_e, decrease Y_e.

This messy chain, as the reader must now appreciate, is quickly and easily captured by the IS/LM graph. Raising the price level shifts the LM curve up, while holding the IS curve constant (since IS is not a function of P in this model). The resulting general equilibrium solution must be a higher equilibrium interest rate and a lower equilibrium level of output (and national income).[16]

"Derivation," the word used in the title of this subsection, of the AD curve in P-Y space should include not only an explanation of where the AD comes from, but also what variables shift the AD curve. A mathematical derivation of the AD curve will reinforce the point that the AD in P-Y space is a residual relationship while easily showing how G, t, and M^s shift the AD curve.

Suppose the economy is depicted by the following IS and LM curves (in linear form):

IS curve: $i = a_0(G) - a_1(t)Y$[17]

LM curve: $i = (b_0 - d_1 \frac{M^s}{P}) + b_1 Y$

15This AD is with respect to the Keynesian cross, not to the AD curve in P-Y space!

16 The following statement says the same thing: "AD slopes downward because a lower price level produces a larger real money stock, which lowers interest rates and therefore stimulates investment demand, which through the multiplier produces an even larger boost in the income level."

17The notation "$a_0(G)$" means that the intercept, a_0, is a function of a series of exogenous variables, including G.

Mathematically, the AD curve is P-Y space is derived by setting the IS=LM curve and solving for P as a function of Y:

$$a_0(G) - a_1(t)Y = (b_0 - \frac{M^s}{d_1 P}) + b_1 Y$$ [18]

$$\frac{M^s}{d_1 P} = b_0 + b_1 Y - a_0(G) + a_1(t)Y$$

AD curve: $$P = \frac{M^s}{d_1\{b_0 - a_0(G) + (a_1(t) + b_1)Y\}}$$

It should be immediately apparent why AD is truly a non-linear relationship, and why it is a function of G, t, and M^s. As long as real money supply is defined as M^s/P, the AD curve will be non-linear in Y because P and Y will always be reciprocal. As to the variables underlying the AD curve, they all come from the IS and LM curves. Since G, t, and M^s are exogenous variables in the IS/LM graph, they must be also be exogenous variables in the AD curve—a curve that is derived from the IS/LM relationship.

How do changes in these shock variables affect the AD curve? You should answer this question yourself by showing graphically how the AD curve would shift when G, t, and M^s increase or decrease. DO IT!!!

<u>The Verbal and Graphical Expositions of the IS/LM—AD/AS Model:</u>

I) Setting Up the Model

Let's take a look at the model. Money supply is now the real money supply and we have an AS curve and a third equilibrium condition:

Equilibriumconditions:

$Y = C + I + G$

$M^d = M^s$

$AS = AD$

---

[18]Where the parenthesis indicate "is a function of." In other words, a careful derivation of the IS curve would show that the intercept is composed of several terms, including government spending; while the slope contained the tax rate.

Components of AD (in $-$ space, i.e., the Keynesian cross):

$$C = c_0 + MPC(Y - t_0 Y)$$

$$I = e_0 - e_1 i$$

$$G = G_0$$

Money market components:

$$M^d = d_0 - d_1 i + d_2 Y$$

$$M^s = M^{s0}/P$$

AS curve:

$$Y = g_0 + g_1 P$$

Explicit consideration of the equations in the model should highlight the expositional problem faced by the macroeconomist. No longer will a single, two dimensional graph show the solution to the model because there are three endogenous variables (i, Y and P). Macroeconomists have solved this problem by going to two graphs stacked on top of each other. The Y variable is the tie between the two graphs—it must always have the same equilibrium value.[19] The IS/LM graph is composed of two independent equilibrium conditions; while the AD/AS graph is built on an independent AS curve and an endogenously derived (from the IS/LM conditions) AD curve.

II) Finding the Equilibrium Solution

Once these issues are understood, the graphical exposition is straightforward—the IS/LM graph shows the equilibrium interest rate and equilibrium output solutions; while the AD/AS graph depicts the equilibrium values of the price level and output. The pieces are carefully, tightly intertwined—IS/LM is used to derive the AD curve which is, in turn,

---

[19]The perceptive reader will notice that we now have two different ways of determining the equilibrium level of output—the IS/LM analysis and the AD/AS analysis. Can these be contradictory or inconsistent? No—finding Y_e, the equilibrium level of real GNP (or real national income), through IS/LM will always yield the same Y_e, the equilibrium level of output in index or composite good form, found by the AD/AS framework. Naylor and Schmutte believe showing different equilibrium output levels on the IS/LM and AD/AS output axes is an egregious error that shows a fundamental misunderstanding of this macroeconomic model.

needed in the AD/AS graph to determine the price level which is then used to set the LM curve in i-Y space.[20] Figure 3.2 below shows a general equilibrium for the IS/LM—AD/AS model:

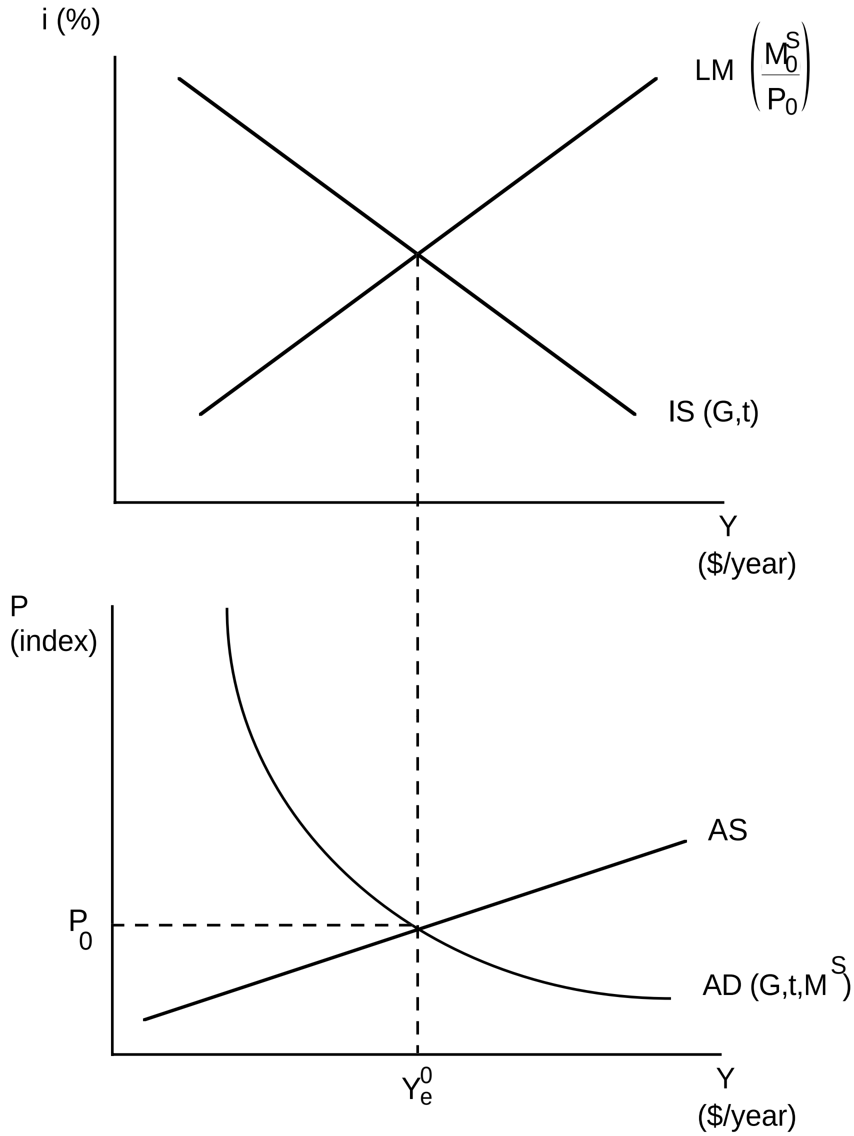


Figure 3.2: The IS/LM — AD/AS Graphical Exposition

[20]The reader should note that this tight interrelationship also implies that any comparative static analysis will require shifting of curves in both the IS/LM and AD/AS graphs; and, once again, that the equilibrium values of the endogenous variables must be mutually consistent.

Note the work done by each piece of the model:

- The IS curve gives us the goods market equilibrium. At each interest rate (i), it shows the equilibrium level of output (Y_e) that will correspond to that interest rate (through the i-I and AD=C+I+G relationships).
- The LM curve gives the money market equilibrium. At each level of income (Y), it shows the equilibrium interest rate (i_e) that will correspond to that level of income (through the Y-M^d and M^d=M^s to determine i_e relationships). Note, however, that the relaxation of the fixed price assumption has left the LM curve dangling, so to speak. Unless we know the price level, we can't set the M^s curve (since the real M^s = M^s/P) which means we can't determine i_e and, hence, we can't position the LM curve in i-Y space. Of course, the AD/AS graph is used to determine P_e and that allows the LM curve to be fixed!
- The AD curve is derived from the IS and LM curves. Given a price, the LM curve is determined and the IS/LM intersection can then yield the Y_e that corresponds to that price. The AD curve in P-Y space, then, simply conveys all the possible equilibrium combinations of price and output.
- The AS curve is built by assumption. Its role is to determine, by finding the intersection of AD and AS, the equilibrium price level. (See your Economics 4 notes and Dornbusch and Fischer, Macroeconomics, Chs. 13 and 14 for a discussion of where the AS curve comes from.)

III) Comparative Statics

The IS/LM—AD/AS Model is powerful because it quickly and easily shows the equilibrium values of output (Y), interest rate (i), and the price level (P) for a given set of exogenous variables. Of course, macroeconomists are interested in more than simply grinding out a trio of values for the endogenous variables. The fundamental goal of orthodox macro analysis is to do comparative statics—i.e., in macro, to provide answers to the two fundamental questions: (1) Given a shock, what are the new equilibrium values of the endogenous variables? and (2) What shock is needed to push the endogenous variables (with special emphasis on Y and P) to particular levels? It is because of its ability to depict and explain the answers to these two questions that the IS/LM—AD/AS Model is so often used. To the first of these questions, we now turn.

Q1: Effect of a shock on Y_e, P_e?

Imagine an economy described by the equations given in the IS/LM—AD/AS Model and assume, furthermore, that the system is in some initial equilibrium. What would happen if government spending suddenly increased?

Clearly, the initial equilibrium position could no longer be the equilibrium level of national income and the interest rate. At the initial Y_e, AD (in the Keynesian cross graph) must now be greater than actual GNP. We know that such a situation will induce firms to produce more and, thus, cannot be an equilibrium situation.

The Simple Keynesian and Partial Equilibrium Models would predict that the new intersection of $AD(G_1)$ and the 45^o line would yield the new Y_e. The IS/LM Model would include the "second-order" effects of the shock and predict the new Y_e would be at some point between the initial and partial equilibrium values. Y_e would be lower than in the partial equilibrium model because money demand would increase when Y_e increased, raising interest rates; and the resulting crowding out effect would lower Y_e relative to its partial equilibrium value. The new Y_e could be determined by locating the intersection of the new IS curve, $IS(G_1)$, and the LM curve.

The IS/LM—AD/AS Model catches an additional effect emanating from the initial ΔG shock. The increase in G, along with effects mentioned thus far, will:

(1) increase AD in P-Y space, which will

(2) increase prices, which will

(3) lower the real money supply, which will

trigger the "chain reaction" we've studied so carefully:

decrease M^s-->increase i-->decrease I-->decrease AD-->decrease Y-->

decrease M^d -->decrease i-->increase I-->increase AD-->increase Y-->

.

.

.

The final resting place can be captured by the IS/LM analysis as:

(4) an upward shift in the LM curve, which will

(5) decrease Y_e and increase i_e relative to the IS/LM Model.[21]

Let's analyze each step in turn:

(1) The AD curve in P-Y space shifts to the right because G has increased. The G increase will shift the IS curve to the right. Thus, when the AD curve is derived from the IS/LM graph, it will be shifted to the right.

(2) The price level will increase because the intersection of the new AD and initial AS curves will be to the northeast.

(3) Since the money supply is now defined as the real money supply (i.e., adjusted for the price level), it is clear that an increase in price level will lower the money supply.

(4) A decrease in real M^s shifts up the LM curve for the opposite reasons that an increase in the money supply lowers the money market equilibrium schedule. With a decrease in the money supply, a higher equilibrium interest rate will be associated with any given level of equilibrium income.

(5) With the IS/LM analysis, it is easy to see that an upward shift in the LM curve will lower Y_e and increase i_e because the new intersection point of the IS and LM curves will be higher and to the left of the initial intersection.

---

[21]To be sure there is no confusion, perhaps a review of the nomenclature would be helpful. The IS/LM Model is a fixed price model; while the IS/LM—AD/AS Model allows price to vary. The IS/LM Model has two endogenous variables (i and Y) and one feedback mechanism ($M^d = f(Y)$). The IS/LM—AD/AS Model has three endogenous variables (i, Y, and P) and two feedback mechanisms ($M^d = f(Y)$ and real $M^s = f(P)$).

The important change in this model lies with the price level and aggregate supply. The increase in G now has two channels by which it affects Y_e and i_e. The first is through the shift in the IS curve—a straightforward application of the increase in G increasing AD in the Keynesian cross diagram. But, now, the increase in G also affects AD in P-Y (or AD/AS) space. This increases prices and, through the real money supply, or second, feedback mechanism, this shifts the LM curve up. The second feedback mechanism further mitigates the effect of an increase in G on Y_e and i_e.

From an initial equilibrium, an increase in G has its greatest effect on Y_e in the Simple Keynesian and Partial Equilibrium Models. The feedback mechanism of M^d lessens the impact of a shock somewhat in the IS/LM Model. And now we see, through an increase in P and the M^s feedback mechanism, that the IS/LM—AD/AS model lessens the effect even more.

Once again, the question of timing is of critical importance here. And, as before, we can only report that there is no consensus among macroeconomists as to the speed with which the "feedback mechanisms" operate. In fact, disagreement over the speed of adjustment is often an important distinguishing feature between economists of different schools of thought. (See Dornbusch and Fischer.)

Let's examine the graphical solution to an increase in G in the IS/LM—AD/AS model. We will proceed by systematically showing the shifts and changes that occur from an increase in government spending. The shifts in curves and explanations of changes in variables are arranged in a sequential order for pedagogical purposes. The equations in the model, in reality, operate simultaneously.

SHOCK: Increase government spending from G to G_1.

EFFECTS: **Step 1**: The shock will, initially, have two effects—IS and therefore AD will shift. Let's analyze each shift in turn, focusing on Figure 3.3 and noting that each step is labelled carefully:

1A: The IS curve will shift up because AD=C+I+G has increased.

1B: The AD curve in P-Y space will shift to the right because the IS curve shifted to the right.

Step 2: The increase in AD will affect P and Y in the AD/AS graph:

2A: Increase in the price level to P_e^1.

2B: Increase in output to Y_e^1.

The increase in the IS curve will affect i and Y in the IS/LM graph:

2C: Raise the interest rate to i_e^a.

2D: Increase in output to Y_e^a.

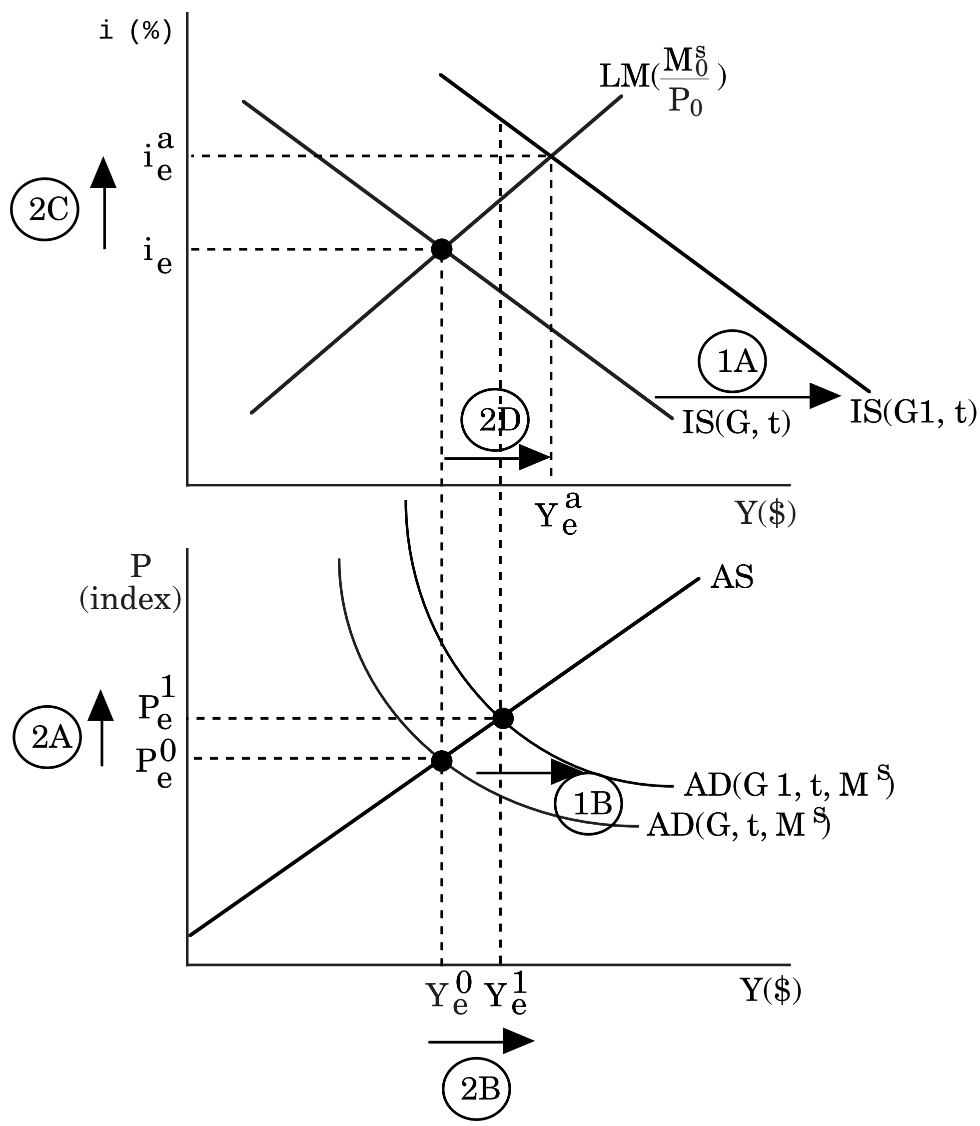


Figure 3.3: The Effect of an Increase in G -- The Intermediate Solution

It is clear from Figure 3.3 that the increase in the equilibrium level of output is different in the AD/AS graph (Y_e^1) from the IS/LM graph (Y_e^a). We know this cannot be true. This difference arises not because this macroeconomic model is inconsistent, but because we have yet to fully work through the effects of the increase in G in the IS/LM graph. We have only considered the first ($M^d = f(Y)$) of the two feedback mechanisms in the IS/LM—AD/AS model.

Were we to be using the IS/LM Model of the previous section, the increase in G would shift IS curve to the right and result in an equilibrium level of income and interest rate at Y_e^a and i_e^a, respectively. In the IS/LM—AD/AS model, however, we must consider the second, or price level-money supply, feedback mechanism. Figure 3.3 clearly shows that the LM curve is a function of the real money supply, M^s/P. Since the price level has increased, the real money supply must have fallen. This means the LM curve must shift back and a new Y_e, i_e combination will result. (See next page.)

In other words, the complete solution requires working through the money supply feedback mechanism ($M^s = f(P)$) in i-Y space. Remembering that the increase in G initially has two effects (**Step 1:** Shift IS and AD and **Step 2:** Increase P and Y), we complete the effects that flow from an increase in G:

Step 3: The increase in the price level raises the LM curve (see 3 in Figure 3.4) because, for every given level of income, the equilibrium interest rate will be higher with a lower money supply.[22]

Step 4: The equilibrium level of output will decrease (relative to the IS/LM(M^s/P_e^0)) intersection to Y_e^1 (see 4A in Figure 3.4) and the equilibrium interest rate will increase to i_e^1 (see 4B in Figure 3.4).

[22]The reader may wish to refer to the previous chapter, especially Figure 2.12, to refresh his memory concerning shifts in the LM curve with respect to changes in the money supply.

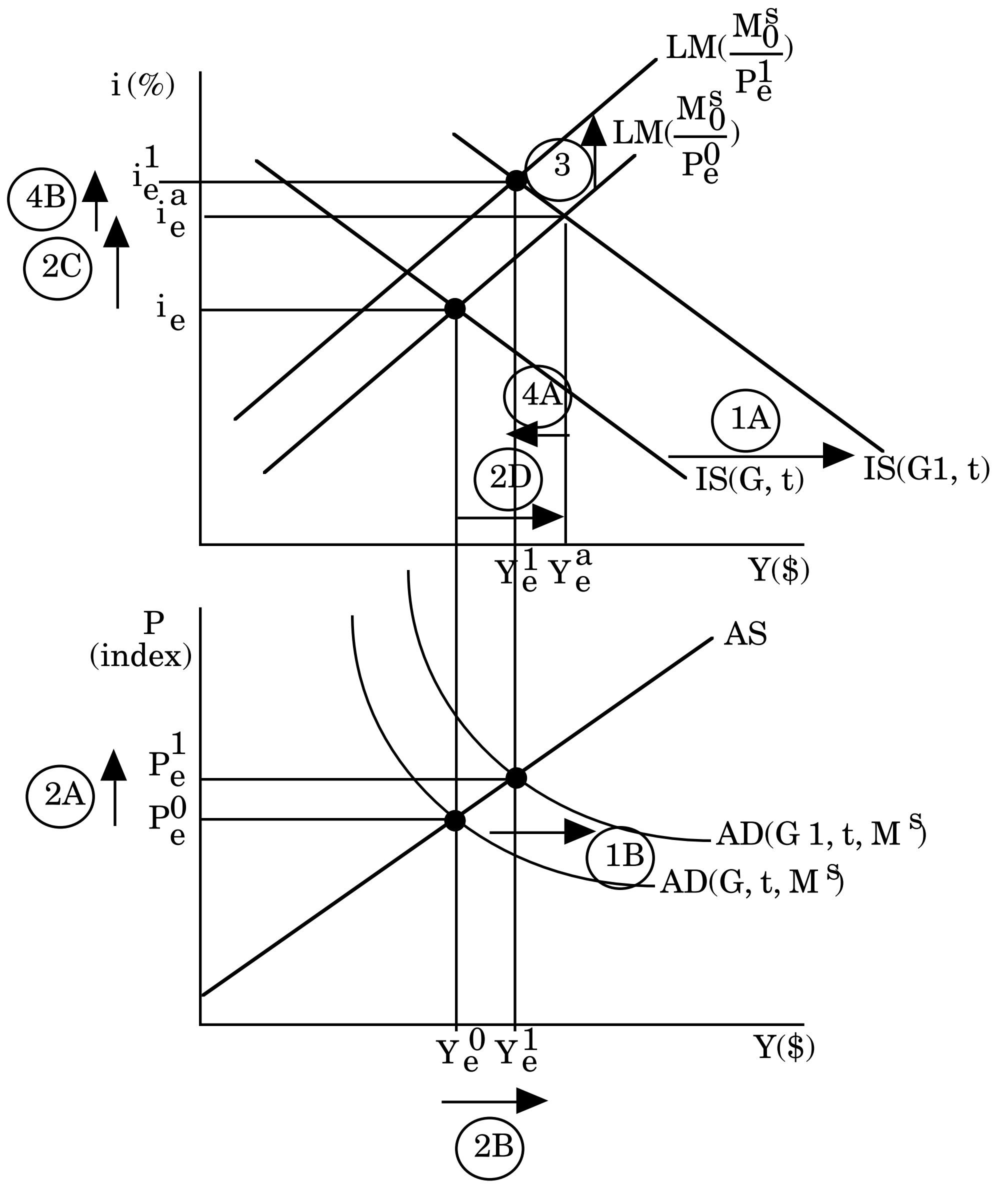


Figure 3.4: The Effect of an Increase in G -- The Complete Solution

Now that the full effects of the shock (including: (1) the direct effect of an increase in G, (2) the money demand feedback mechanism, and (3) the money supply feedback mechanism) have been incorporated into the IS/LM framework, it is clear that the two alternative methods of determining Y_e (IS/LM and AD/AS) yield the same result. The values of the endogenous variables change to Y_e^1, i_e^1, and P_e^1; or, in other words, equilibrium output, interest rate, and price level all increase. There is, however, an important difference between the two methods. The price level is an endogenous variable in the AD/AS framework, but an exogenous variable in the IS/LM model. Once we know how what the new price level is, we can find the new levels of the interest rate and output using the IS/LM approach, but that approach alone cannot give us the new price level.

Once again, note the comparison between the IS/LM Model solution for equilibrium output with one feedback mechanism (i.e., money demand a function of income), Y_e^a, and the IS/LM—AD/AS Model solution with two feedback mechanisms (M^d=f(Y) and M^s=f(P)), Y_e^1. As in the case when the model was expanded to allow for the first feedback mechanism, addition of a second feedback mechanism has mitigated the effects on output of the shock—there is a smaller equilibrium increase in output under the IS/LM—AD/AS Model than under the IS/LM Model.

Furthermore, note that it was much easier to find the equilibrium level of national income using the AD/AS analysis—it required only one shift, while the IS/LM required two. Does this make the IS/LM obsolete? No, the IS/LM analysis is still needed for the determination of the equilibrium interest rate and for the derivation of the AD curve. It may also serve as a check for the AD/AS solution.

Before considering the second type of fundamental question, it may be instructive to quickly present the graphical analysis of an increase in the money supply in the IS/LM—AD/AS model. Figure 3.5 shows the shifts and final equilibrium results. (See next page.)

With reference to Figure 3.5, the increase in the money supply (from M_0^s to M_1^s) increases AD (see 1A) in P-Y space and shifts down the LM curve (see 1B) in i-Y space. The equilibrium level of income and the price level are immediately determined in the AD/AS analysis (see 2A and 2B). The equilibrium level of income and the interest rate in the IS/LM framework at this point, are incorrect (see Y_e^a, i_e^a and movements 2C and 2D). Importantly, the IS/LM graph is incomplete—we have yet to include the feedback mechanism of the price change shifting the LM curve. As P increases, the real money supply falls and the LM curve shifts up (see 3). This leads to changes in the equilibrium interest rate (see 4A) and level of output (see 4B) and the final solution is given by the Y_e^1, i_e^1 combination.

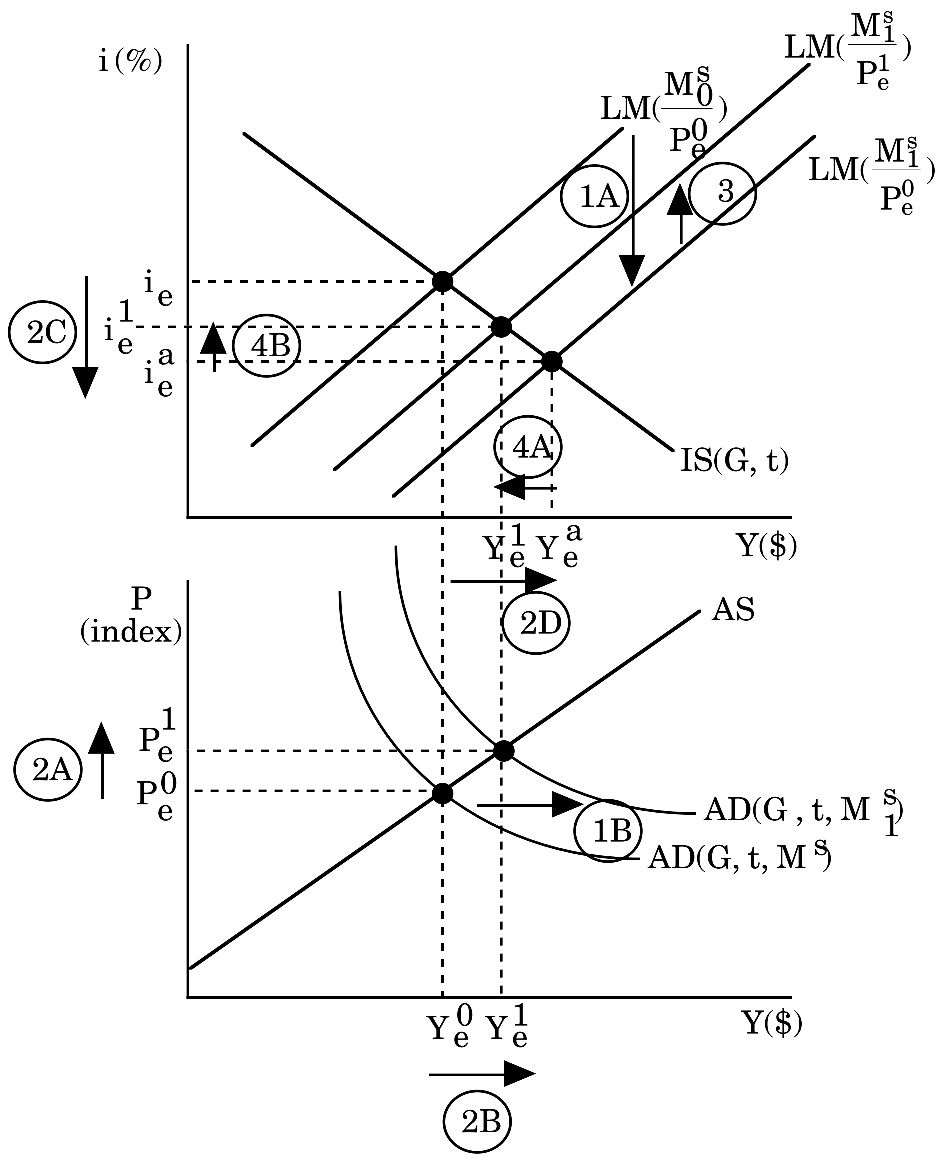


Figure 3.5: The Effect of an Increase in M^S -- The Complete Solution

Thus, we conclude that an increase in the money supply leads to an increase in equilibrium income and the price level, but a decrease in the equilibrium interest rate.

However, the changes in Y_e and i_e are not as great as they were in the general equilibrium model of Chapter 2 (Y_e^a and i_e^a in Figure 3.5)—because the money supply feedback mechanism was not present in that model. Finally, we note that the IS/LM and AD/AS graphs, when correctly applied, yield the same new equilibrium level of output in response to an increase in M^s.

<u>Question 2: Shock needed to generate desired Y_e?</u>

In considering the second fundamental question, we begin by noting that policy makers still have three tools with which they can influence macroeconomic variables. The fiscal policy variables, G and t, and the monetary policy variable, M^s, can be manipulated to achieve desired results. It is these "desired results," however, that have changed in the IS/LM—AD/AS model. In the general equilibrium model, the only goal was to reach full-employment; in the IS/LM—AD/AS general equilibrium model, policy makers try to maintain full-employment *and* a stable price level.

The authorities can close a positive GNP Gap by increasing G, decreasing t, and/or increasing M^s. Importantly, we know that the problem of maintaining Y_e=Y_f is now more difficult because of the second feedback mechanism. However, graphically, closing the GNP Gap is still a simple matter of shifting the AD curve such that Y_e=Y_f at the intersection of the new AD and the AS. We know that two shifts will occur in the IS/LM analysis and the final Y_e will be identical to that from the AD/AS solution. The IS/LM analysis will determine the equilibrium interest rate corresponding to the new, full-employment, equilibrium level of output. Thus, although empirically and quantitatively more difficult, the solution to the GNP Gap is qualitatively similar to previous work (force the intersection to occur at Y_f) and can be presented graphically.

Policy makers in this model, however, have the additional burden of worrying about price stability. Unfortunately, there is a tradeoff between inflation and unemployment—policies that mitigate unemployment (increase G, lower t, and/or increase M^s) increase prices; while moves to control inflation (lower G, increase t, and/or decrease M^s), increase unemployment. Obviously, the level of unemployment can be lowered through increases in AD; while inflation is dampened by decreases in AD. Clearly, no policy maker can accomplish both of these objectives simultaneously.

The expository device used by macroeconomists to capture the unemployment-inflation trade-off is the Phillips Curve. By showing the possible combinations of the rate of inflation and the level of unemployment, the Phillips Curve purports to present the policy maker with a menu of choices. The student is urged to review his notes and/or textbook on the Phillips Curve.

We will not analyze the issue of using policy tools to hit the twin goals of full-employment and price stability in depth. We simply note that policy makers have dual objectives when the fixed price assumption is relaxed. We also note in passing that it is not the absolute level of prices per se which is important, but the rate of change of the price level. A slowly changing price level hovering around P=1000 is much preferred to doubling and tripling prices even if these are in the neighborhood of P=20. If, in order to maintain full-employment, AD must be increasingly increased, the resulting inflation is deemed undesirable and the goal of full-employment may have to be temporarily abandoned (most economists believe that this was Paul Volcker's position during the 1982 recession).

<u>Summary:</u>

In this section, we analyzed the "Conventional" IS/LM—AD/AS Keynesian Model—a flexible price model. By allowing prices to be determined endogenously, we created three changes in this model: (1) the introduction of the AS curve, (2) the need for a third equilibrium condition (AS=AD in P-Y space), and (3) the explicit consideration of the real money supply (M^s/P) as the money stock variable.

The last of these can be thought of as a "second feedback mechanism." Changes in exogenous variables will now affect Y_e and i_e in the IS/LM analysis through changes in prices because ΔP will shift the LM curve. Thus, an increase in G, for example, will initially shift only the IS curve, but will eventually, through its effect on P, also shift the LM curve.

But the IS/LM—AD/AS model is, although an extension of previous models, the application of already learned theory. We already know how a feedback mechanism works in a general equilibrium model—all we've done is added another feedback mechanism. IS/LM—AD/AS is only superficially more complicated than the general equilibrium model, fundamentally it is very similar.

In terms of exposition, a noteworthy change occurred—we abandoned the mathematical approach. The mathematical analogue to the verbal and graphical presentations is there, it's just rather messy. The reader should concentrate, therefore, on developing facility in manipulating the IS/LM—AD/AS graphs. The fundamental questions are the same—the reader should be able to offer graphical solutions and verbal reasoning for said solutions.

To Review:

Previous definitions and concepts all hold.

<u>General equilibrium model v. IS/LM—AD/AS:</u> The IS/LM—AD/AS model is a general equilibrium model; it is an extension of the general equilibrium model of the previous chapter. By allowing prices to vary, the answers to the two fundamental questions change. The second feedback mechanism serves to choke off the effect of a particular exogenous shock. Increases in Y_e and i_e as a result of an increase in G will not be as great in the IS/LM—AD/AS model as they would in the "simple" IS/LM model.

<u>Comparative Statics:</u> The answers to the two fundamental questions change because of the introduction of the AS curve and the second feedback mechanism. We now have the price level as an endogenous variable—one that affects the other two endogenous variables. The answers to type 1 fundamental questions (i.e., analysis of a given shock) must have two shifts in the IS/LM graph (as long as AS is upward sloping)[23]—(1) the initial shock and (2) the shift in the LM curve due to the change in the price level. For type 2 fundamental questions (that is, policy questions), the solution must include the effects of the second feedback mechanism. Furthermore, policy makers now must deal with two possibly conflicting goals—full-employment and price stability.

---

[23] Suggested footnote from Prof. Frank Howland: Why did I have to include this caveat, gentle reader?

In the "Conventional" IS/LM—AD/AS model presented in this section, AS was **assumed** to be upward sloping and the parameters, g_0 and g_1 were posited without explanation. It turns out that the shape or, more precisely, the slope of both the short run and long run AS curve and their components (i.e., their shift variables) play a crucial role in the determination of Y_e and P_e. (See the recommended readings in Dornbusch and Fischer's Macroeconomics for further discussion of these issues.)

Section 2: A Historical Digression

The time has come to explain the strange title of this chapter—"Short Run, Flexible (to Varying Degree) Price Models." In particular, we need to focus on the "flexible (to varying degree) price" terminology (of course by "price" we include wages as the price of labor). This section will explain what this means and, along the way, show three types of IS/LM—AD/AS models.

The bottom line is this: *Depending on the assumption made about price flexibility, it is possible to have three different IS / LM — AD / AS models*, including:

(1) the general equilibrium model of Chapter 2, Section 3 which assumed fixed prices everywhere (or complete price *in*flexibility); and, hence, a horizontal AS curve;

(2) the conventional IS/LM—AD/AS model of Chapter 3, Section 1 which assumed some, but not complete price flexibility; and, thus, an upward sloping AS curve; and

(3) the classical model contained in this Chapter 3, Section 2 which assumed complete price flexibility and, therefore, a vertical AS curve.

Figure 3.6 shows the three possibilities:

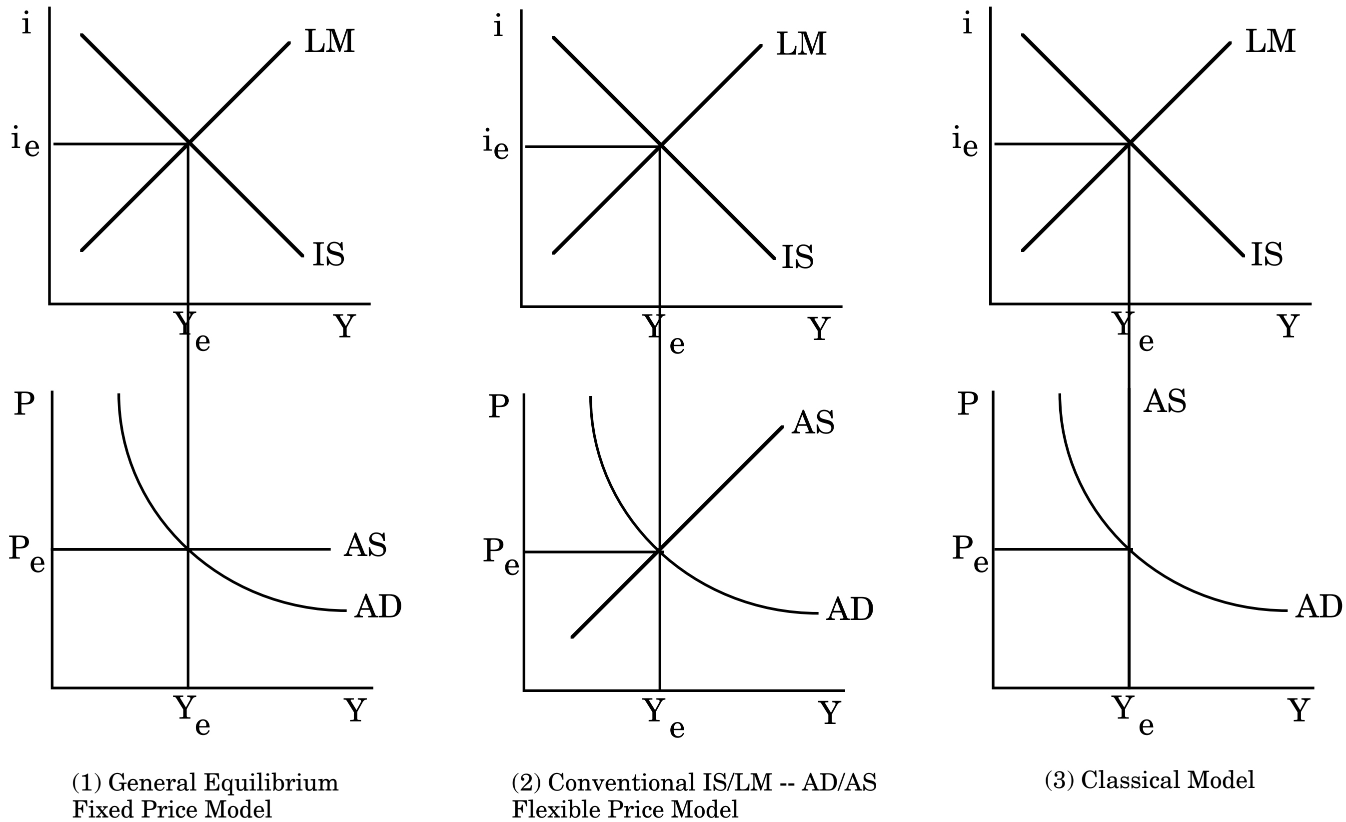


Figure 3.6: Short Run, Flexible (to Varying Degree) Price Models

Note that the we never presented the General Equilibrium Model (IS/LM alone) with its corresponding AD/AS graph. That's because AS does nothing in the determination of Y_e. In other words, the second feedback mechanism is not in operation because increases in AD do not change P. In this model, P is given and fixed by the position of the AS curve. P is not an endogenous variable and shocks to AD will not affect LM (through M^s/P) as they do in the other two, flexible price, general equilibrium models.

In 1936, John Maynard Keynes wrote a classic work titled, The General Theory of Employment, Interest and Money, known more simply as "The General Theory." Keynes argued it was a "general theory" because it was between two extremes—on the one hand a fixed price/horizontal AS model and on the other a perfectly flexible price/vertical AS model.

Keynes witnessed the Great Depression and argued that the classical model was wrong because there were no market forces driving Western economies back to full employment. He argued that the classical model was a "special case" (or "limiting point of the possible positions of equilibrium" [Keynes, GT, p. 3]) and that, usually, labor markets do not instantaneously clear. A more "general theory" would have AS be upward sloping and only in special circumstances would the extremes (vertical or horizontal AS) be observed.

Of course, Keynes had many other important insights into macroeconomic theory, but perhaps the most significant contribution of The General Theory was the framework with which to analyze macro problems. Today, many economists fall between the two extreme models—the most left-wing Keynesian does not believe in completely fixed prices/permanent disequilibrium in the labor market (the horizontal AS), but neither does the most reactionary classical economist believe in perfectly flexible prices/instantaneous labor market adjustment (the vertical AS). A Keynesian might argue, however, that "prices are slow to adjust" or "markets are slow to clear"—meaning, of course, that the AS is relatively price elastic. Her classical counterpart might believe, on the other hand, that "prices adjust rather quickly" and "markets clear reasonably fast"—these phrases express his belief that AS is relatively price inelastic.

Clearly, the Keynesian would be much more supportive of active demand management policies—since the AS curve is relatively flat, an increase in AD will tend to increase Y_e a lot and P_e a little. The classical economist would oppose such attempts to manipulate AD—given a steep AS curve, any increase in AD will lead to a small increase in Y_e and a large increase in P_e.

Who's right? Who knows? The question can only be settled by empirical analysis; but at least we now have a common paradigm and vocabulary with which to settle the debate. We also have, it is hoped, a clearer understanding of the differing views within macroeconomics.

Summary:

This section showed that the "Conventional" IS/LM—AD/AS Keynesian Model is, in a sense, a middle-of-the-road model because it lies between the General Equilibrium Model (with only $M^d = f(Y)$ as a feedback mechanism and prices fixed) and the Classical Model (where prices adjust so rapidly that no government policy can alter the level of output). The crucial difference among these three models concerns their assumption about the clearing properties of markets. In particular, perfectly flexible prices (including wages as the price of labor) in the labor market and perfect information will ensure that the AS curve is vertical. Fixed prices, on the other hand, lead to a horizontal AS curve. In between these two extreme positions lies an upward sloping AS curve of varying steepness. As prices get stickier and stickier and reaching equilibrium in markets takes longer and longer, the AS curve gets flatter and flatter. The actual empirical price elasticity of the AS curve is the subject of a tremendous amount of disagreement and debate. The reader is urged to see the relevant chapters in Dornbusch and Fischer.

Chapter 4: Conclusion

At this point, we conclude our examination into the fundamentals of macroeconomic theory. The reader should be able to manipulate the IS/LM—AD/AS model in both the short and long runs. It should be clear that IS/LM is an extension of the simple "Keynesian cross" (which assumes a fixed, exogenous interest rate) and that IS/LM—AD/AS is an extension of IS/LM (which assumes a fixed, exogenous price level). Furthermore, given a question—which we now know must be one of two types—the reader should be able to show graphically the effects on IS, LM, AD, and /or AS and the final effects on the endogenous variables (Y, i and P).

The reader should see how macro—and all orthodox economics—is built around comparative statics and the resulting two fundamental questions: (1) Given a shock, what is the new equilibrium value of the endogenous variable? and (2) What shock must be administered in order to move the endogenous variable to a desired level. Questions may come in many different guises, including: numerical calculation, a "story" or data to be analyzed[24], or a graph to be interpreted; but they all have the same root—comparative statics. The key to understanding modern day macroeconomics is the IS/LM—AD/AS Model. These notes were designed to communicate as clearly and completely as possible the mechanics and workings of this model.[25]

However, these Notes have covered only a portion of the basics of modern macroeconomic theory. The rest of the story concerns the derivation of the aggregate supply curve and—a closely related topic—dynamics, which is the study of how

---

24 This is a particularly popular macro question, in general, and one that has appeared, in various forms, on the last five year's written comps. Given a story, say an oil price shock or stock market crash, the student must analyze the effects of the shock on i, P and Y; and, furthermore, must discuss appropriate policy moves.

25 The student may also be interested in examining *Understanding Equilibrium in the IS/LM Model* by Humberto Barreto (included at the end of this notebook). Too much emphasis cannot be placed on the importance of comprehending and being able to manipulate the fundamental tool called the IS/LM—AD/AS Model.

macroeconomic variables change over time. You should read your macro textbook (or Dornbusch and Fischer, Chs. 7, 13, and 14) to learn this part of the story. An understanding of the underpinnings of the aggregate supply curve enables one to appreciate the impact of "supply shocks" (such as the OPEC-induced increases in oil prices) on the economy. Furthermore, a study of the different theories economists have given for the construction of the aggregate supply curve allows one to better understand the current debate between different schools of macroeconomic theory.[26]

Three crucial aspects of dynamic models are (1) the recognition that in the long run output must return to its full employment level, (2) the emphasis on the paths followed over time by output, prices, and interest rates, and, (3) the incorporation of expectations about future inflation into the model. The first point says that, unlike the implication of the short-run story told in Chapter 3 (and summarized in Figs. 3.4 and 3.5), it is not possible for the government to permanently increase output above the full-employment level. (Another way of putting this is that in the long run, the Classical view is correct.) The second point highlights the fact that different policy choices will produce different levels of unemployment and inflation during the transition to a new equilibrium, even if the equilibrium level of output and, possibly, prices is ultimately the same. The third point allows us to determine the impact of policies and macroeconomic shocks on the inflation rate, which is often what we are interested in (rather than the impact on the price level; recall that inflation is the rate of change in prices).

Macroeconomics is not easy, but neither is it impossible. For a student to immediately turn to a figure such as Figure 3.5 or an equation deriving the multiplier would be disastrous. Understanding has to be gained slowly, step by step. It is hoped that reader will **patiently** work his way through these notes and that such work will prove useful. Remember, there is a *pattern* to these Keynesian macroeconomic models, look hard enough and you *will* find it.

---

[26] Chapter 18 of Dornbusch and Fischer gives a valuable overview of current state debates in macroeconomic theory.