

Understanding Equilibrium in the IS/LM Model

1995 version

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Introduction:

This brief work is designed to provide additional ammunition for the student in the ongoing war against IS/LM confusion and ignorance. The author has claimed in his *Notes on Macroeconomic Theory* (1995) that,

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? (p. 52)

The author still worries, however, that the student is memorizing the equilibrium condition, $IS=LM$ generates Y_e , without really understanding why the condition works. Most students are unable to explain why setting IS equal to LM generates the equilibrium level of output. I have, on rare occasion, heard a student give the following explanation: "Along the IS curve the goods market is in equilibrium; along the LM curve the money market is in equilibrium. Therefore, for both markets to be in equilibrium, the system must be on both curves. This only occurs at the intersection of the curves." That's pretty good, and it's the explanation I used in *Notes on Macroeconomic Theory*; but I still worry that there is too little understanding and too much memorization. I very much want to get across true, complete comprehension of this fundamental macro tool known as the IS/LM graph. To do this, I undertake a detailed analysis of the meaning of equilibrium in the IS/LM Model in the pages that follow.

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The Equilibration Process:

In struggling with the problem of teaching the student why the intersection of the IS and LM curves yields the general equilibrium solution to the interest rate and output variables, I wondered why students are able to understand quickly how a market equilibrates. The typical student knows that $D=S$ generates the P_e, Q_e combination that we seek. He also knows, however, the process by which such a solution is reached. From the first course in economics he is taught that any price above the equilibrium price generates a surplus which forces suppliers to cut prices in order to sell their inventories. On the other hand, a P below P_e results in a shortage and upward pressure on the price as consumers bid up the price. When asked why the intersection of S and D yields P_e , the typical student responds with this story. The student hasn't memorized that $S=D$ generates P_e , he has learned that there is an "equilibration process" at work.

The microeconomist's story of how equilibrium is attained provides the key to teaching the concept of equilibrium price in a single market. Note how the presentation proceeds: (1) define equilibrium as no tendency to change, (2) pick a value and see if it has a tendency to change, and, (3) if it does, describe the forces that lead to change and point out the direction of the change. This explanation is understood by the vast majority of students. Simply put, as a means to communicate an idea, it really works! When asked why $S=D$ generates the P_e , the typical response is built around the notion that forces are at work that will drive the price to a certain value. No attempt is made at repeating a memorized condition—as is usually the case when the question concerns equilibrium output in a macro model.

The next step is obvious: if it works for explaining the equilibration process in a single market, let's apply it to explain why $IS=LM$ yields Y_e . By following the three steps outlined above, we hope to get the same spectacular results in terms of understanding the IS/LM graph that we get in microeconomics. Let's do it!

Step(1): Defining equilibrium

As in microeconomics, equilibrium is defined as no tendency to change. In general, an endogenous variable (that is, a variable whose value is determined by forces within the system) can have an infinite possible range of values. In economics, most endogenous variables, such as output in a macro model, are usually constrained to be positive; but they can still take on any value from zero to positive infinity. The equilibrium value is one particular value—the one value where the variable has no tendency to change. Any other value is not a state of rest for there are forces within the model that will generate movement to a new value.

Step (2): Pick a value and see if it has a tendency to change

Figure 1 shows an initial value of i_0 and Y_0 that's on the IS curve, but not on the LM curve:

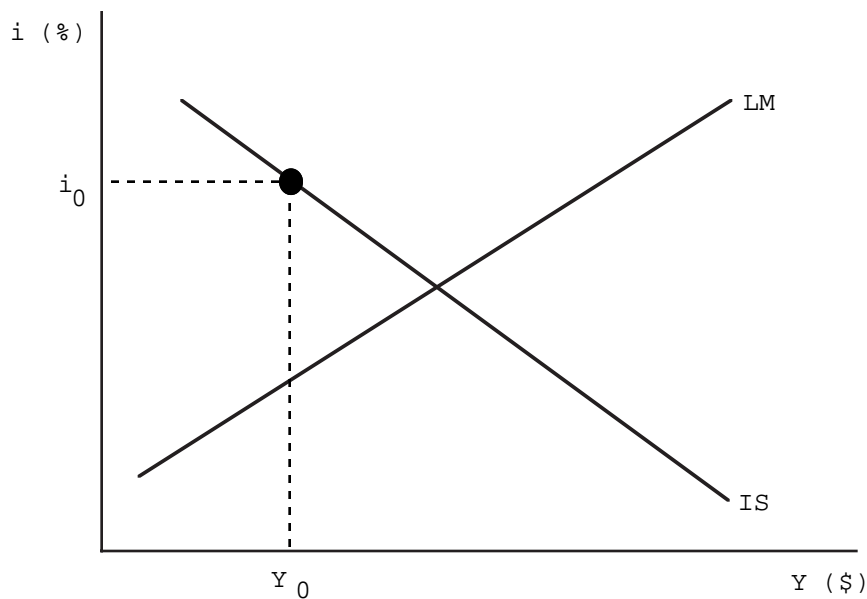


Figure 1: An Initial Disequilibrium

The student no doubt knows that the i, Y combination depicted in Figure 1 is not the equilibrium combination, but the crucial question is "Why?" To apply the "equilibration process" explanation to this question, we must show how and why the i_0, Y_0 pair has a tendency to change. In order to do this, we will bring to the front the set of graphs that *underlies* the IS/LM graph:

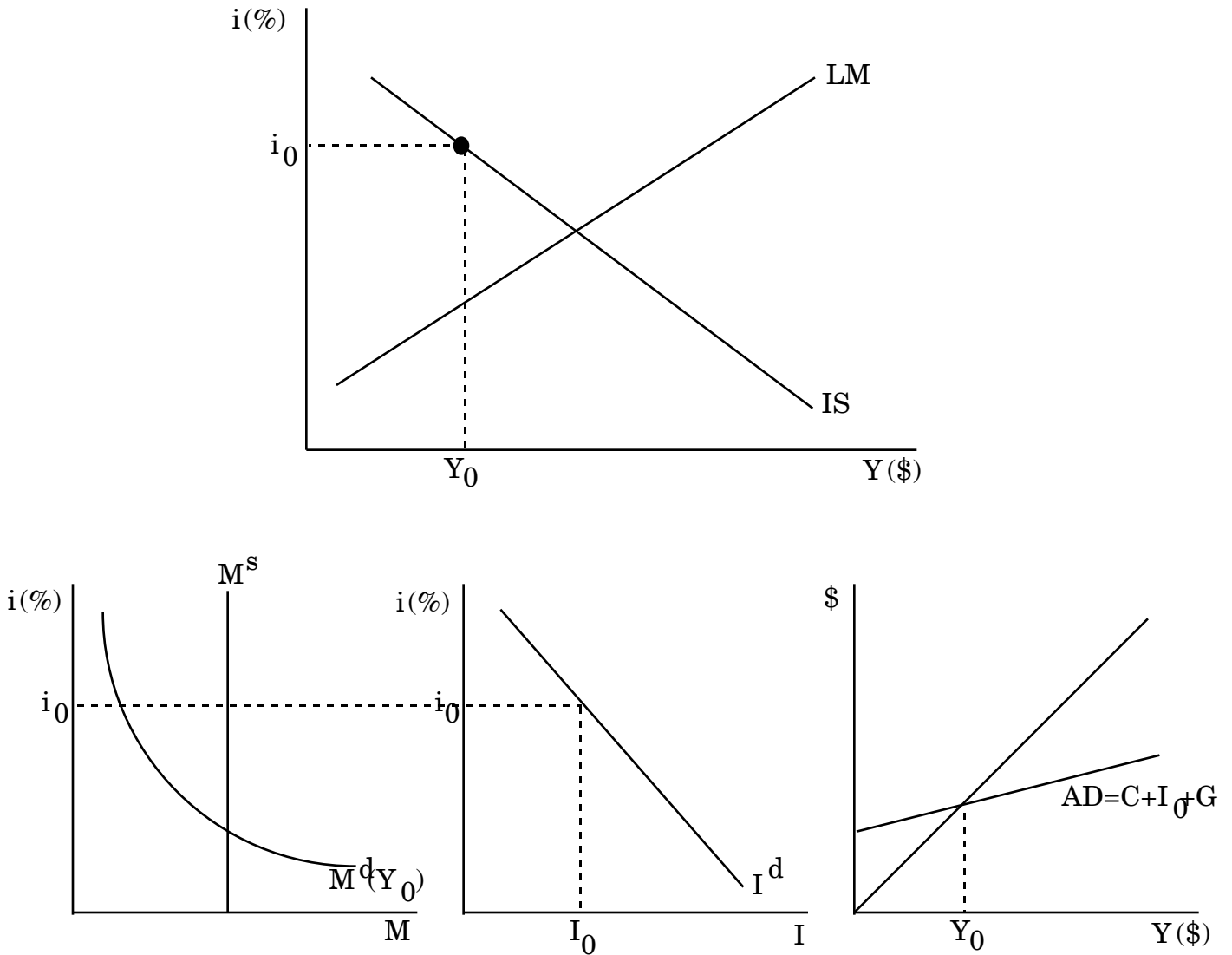


Figure 2: An Initial Disequilibrium -- The Whole Story

Look closely at the relationship between the IS/LM graph and the three graphs that compose the IS/LM graph. Being on the IS curve means that we are in equilibrium in the goods market; hence, I was careful to place Y_0 on the intersection of the AD and 45° line. However, being off the LM curve means that the money market is not in equilibrium; therefore, the existing interest rate is clearly above the equilibrium interest rate.

The student should see that the existing values of i and Y will have a tendency to change. The interest rate will fall because there is a shortage of bonds and as the price of bonds rises to drive the bond market to equilibrium, the interest rate will fall. The equilibrium interest rate, of course, will be found at the intersection of the M^s and M^d schedules. Output will increase because a falling interest rate will trigger higher investment expenditures by firms. The increased I will increase AD and, therefore, Y_e will increase. But then the higher income will shift money demand up, which will increase the equilibrium interest rate, and the same chain will be triggered leading to a decrease in the equilibrium level of output. The student undoubtedly knows that, eventually, after running through a series of converging loops, the system will settle into a mutually compatible, or general equilibrium, combination of i and Y .

If you think the iteration process is a messy and cumbersome means of calculating the general equilibrium, or final, resting place of i and Y , you should applaud the use of the IS/LM graph. In one quick graph, we can immediately and easily see the system's general equilibrium solution. From our initial i_0, Y_0 combination, the IS/LM graph allows us to instantly see the final solution and to predict a decrease in interest rates and increase in output. However, a drawback is that it does not show how or why these effects will take place. In other words, the IS/LM graph's primary virtue is its ability to quickly and easily show the final solution. This, unfortunately, is not costless. In order to gain the benefits of the IS/LM graph, we must hide the equilibrium process that drives the system to equilibrium. Hence, most (all?) macro expositions of the IS/LM Model present a graphical analysis such as Figure 1 (the IS/LM graph alone). Presenting the underlying money and goods market graphs is seen as repetitive or confusing. Of

course, here we are more interested in showing how and why the endogenous variables, i and Y , will change. For this reason, the underlying money and goods market graphs will be highlighted.

Step (3): A Description of the Forces that Lead to Changes in i and Y and the Direction of those Changes:

From Figure 2 and Step 2 we know that both the i and Y variables are out of equilibrium and, therefore, that they will have a tendency to change. What we must determine is how and why that change will take place. Unfortunately, here it gets messy. Unlike microeconomics, where one basic equilibration process is taught ($P < P_e \rightarrow$ higher P ; $P > P_e \rightarrow$ lower P), the IS/LM Model has several possible equilibration processes. Different equilibration processes arise when different assumptions regarding the speed and order in which the variables reach equilibrium are made. In this work, we will show the student three of the many possibilities.

Equilibration 1: Cobweb Equilibration:

Suppose that we assume that markets equilibrate in sequential order. First one market clears, then another, then the first clears in response to changes from the second market, and so on. Such a process would result in a cobweb equilibrium. In other words, we know that at i_0 and Y_0 in Figure 2 that the interest rate is out of general equilibrium (because there is a shortage of bonds) and that the level of output is out of equilibrium (because the disequilibrium interest rate is determining a "wrong" level of investment). Suppose we assume that the money market clears first, generating an equilibrium interest rate. The new level of investment (resulting from the changed i) leads to a new AD and we assume that the goods market then clears. The new Y_e will change M^d and new i_e will result. The new i_e will lead to a new I and, through a changed AD, a new Y_e . Eventually, these i and y will settle down at their general, or mutually compatible, equilibrium levels. This is given, of course, by the intersection of the IS and LM curves!

Graphically, cobweb equilibration looks like the following:

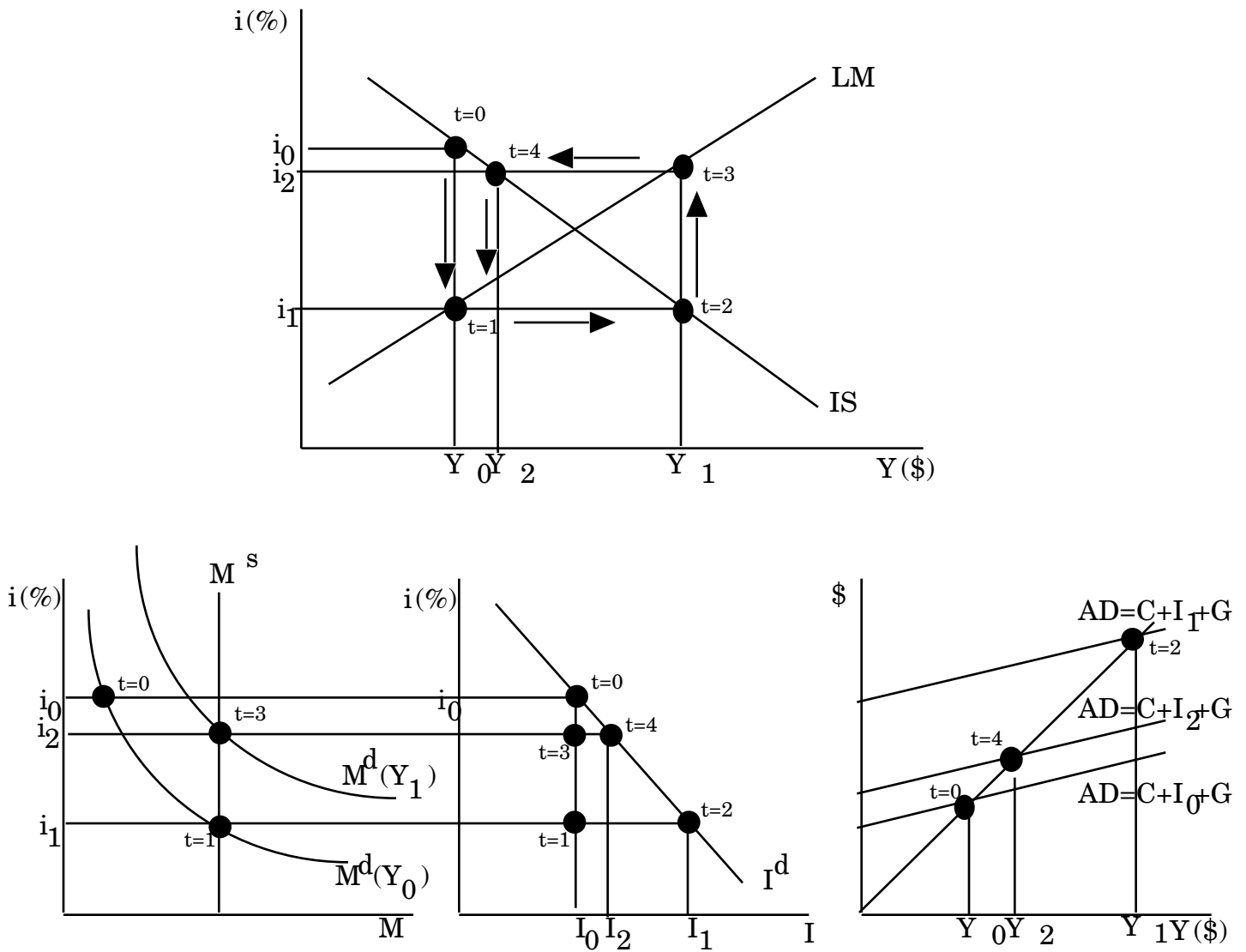


Figure 3: Cobweb Equilibration

In explaining the Cobweb equilibrium process, the student is urged to follow the text carefully and match up the written description with the information provided in the graph.

In time period zero, $t=0$, there is disequilibrium. Clearly, being off the LM curve means that the money market is not in equilibrium. We know we will end up at the intersection of the IS and LM curves because that has been drummed repeatedly into our brains, but do we understand the process by which this system will reach equilibrium? The Cobweb Equilibration explanation that follows is based on the assumption that markets clear sequentially.

As mentioned above, we start at $t=0$, with the interest rate above the equilibrium interest rate and the goods market in equilibrium for the given interest rate, i_0 . In the next period, $t=1$, suppose the bond market clears so that the interest rate equals the equilibrium interest rate. In Figure 3, this means that the interest rate falls to i_1 in the IS/LM graph and in the money market graph. Note that equilibrium in the money market (for the given Y) means that we are on the LM curve. Of course, now we are off the IS curve! In time period $t=1$, the low interest rate, i_1 , does not correspond with the low level of investment, I_0 . Therefore, AD is "wrong" and so is the ruling level of output, Y_0 .

Going in sequential order, we allow the goods market to go to equilibrium. In time period $t=2$, we allow the lower interest rate, i_1 , to increase investment expenditures to I_1 . This, in turn, increases AD and yields an equilibrium level of output of Y_1 . On the IS/LM graph, we have moved back on the IS curve because the goods market is once again in equilibrium. However, in time period $t=2$ we are off the LM curve because the higher level of income, Y_1 , will increase M^d and this will require a higher equilibrium interest rate.

In time period $t=3$, we return to the money market and drive the interest rate to its new equilibrium position. The higher money demand (because of the Y increase to Y_1) establishes a new equilibrium interest rate of i_2 . In the IS/LM graph, we are now back on the LM curve because the money market is in equilibrium; but we are off the IS curve because the goods market is in disequilibrium—the higher interest rate at i_2 will change the level of investment which will change AD and Y .

In time period $t=4$, we return to the goods market in order to allow the forces in the model to determine the equilibrium level of output. The higher interest rate, i_2 , determines a lower level of investment, I_2 , which leads, through AD, to lower

equilibrium level of output, Y_2 . In the IS/LM graph, the economy is now at i_2 and Y_1 —in goods market equilibrium, but in money market disequilibrium.

This process will continue, of course, until the economy reaches a state of rest at i_e, Y_e in time period $t=n$ in Figure 4:

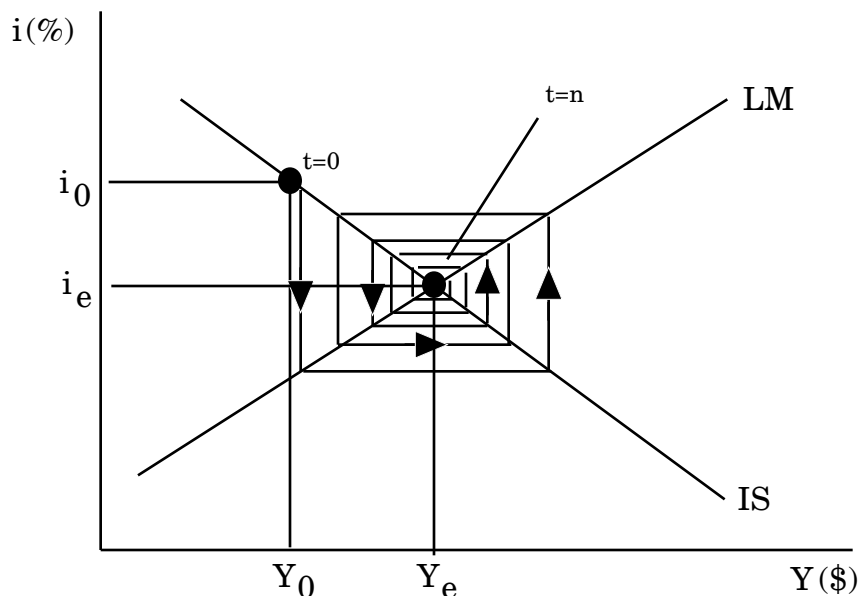


Figure 4: The Cobweb Model in General Form

The student should clearly see two points, one minor and the other major. First, the minor point: the equilibrium path looks like a cobweb, hence the name "Cobweb Equilibration." Much more important, however, is the second point: the intersection of the IS and LM curves give equilibrium solutions for i and Y **because there are forces that drive these variables to equilibrium.** It's exactly analogous to the micro S and D yielding P_e story in the sense that values that are not equilibrium values are driven to equilibrium by forces from within the model. Although the IS/LM Cobweb equilibration process may be more difficult to

understand than the micro supply and demand equilibrium process, it is conceptually identical.²

The Cobweb equilibration process is not, however, widely accepted. Most economists feel that the sequential market clearing assumption is incorrect. After all, there is no reason why the money and goods market must clear in alternating order. Furthermore, the model generates a pattern for the endogenous variables that is not observed. From an initial equilibrium, as shown in Figure 3, an increase in the money supply in time period $t=0$ would generate the following changes: a large decrease in i , while Y remained constant (in $t=1$); then a large increase in Y , while i remained constant (in $t=2$); then a large increase in i , while Y remained constant (in $t=3$); then a large decrease in Y , while i remained constant (in $t=4$); and so on. Such a pattern in i and Y is not empirically observed.

Although not widely accepted, the Cobweb equilibration process is a theoretical possibility. From a pedagogical perspective, it helps the student understand the IS/LM graph and explains a possible rationale for why $IS=LM$ generates the i_e, Y_e combination. To a second possible equilibration process, we now turn.

Equilibration 2: Asset Market Equilibration:

Many macroeconomists believe that asset markets inherently clear faster than goods markets. In response to an increase in money supply for example, it can be assumed that the bond market (which is now experiencing a shortage) will quickly clear and that the equilibrium interest rate will be quickly reestablished. In fact, a strong version of this story would have the asset market always in equilibrium because it is assumed that the asset market can immediately adjust itself to a given shock. We name such a view the Asset Market Equilibration Process.

Returning to the initial disequilibrium of Figure 2, we must work out how the Asset Market equilibration process will drive i and Y to its final resting place on the intersection of the IS and LM curves. Equilibration over time is given by Figure 5:

²In fact, there are cobweb equilibrium micro models for certain markets — especially agricultural markets where there are lags between production and consumption decisions.

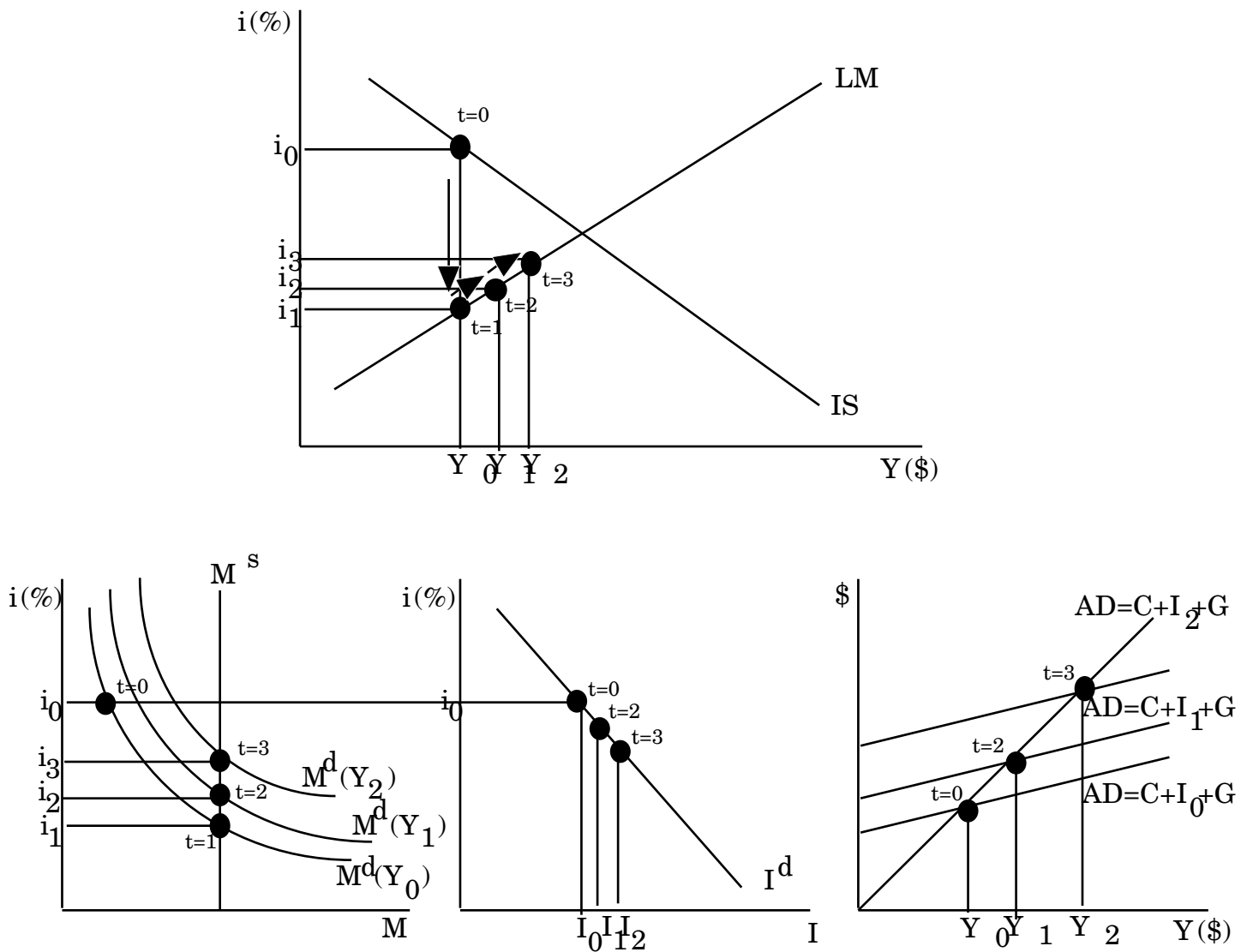


Figure 5: Asset Market Equilibration

Once again, in explaining the Asset Market equilibrium process, the student is urged to follow the text carefully and match up the written description with the information provided in the graph.

In time period zero, $t=0$, there is disequilibrium. Let's suppose that the monetary authorities have increased the money supply. The LM curve used to pass through the point (Y_0, i_0) , but the shock has shifted it to present position. As before, being off the LM curve means that the money market is not in equilibrium.

We know we will end up at the intersection of the IS and LM curves because that's what we've memorized, but do we understand the process by which this system will reach equilibrium? The Asset Market Equilibration explanation that follows is based on the assumption that the asset market is always in equilibrium.

As mentioned above, we start at $t=0$, with the interest rate above the equilibrium interest rate (since the money supply has just been increased) and the goods market in equilibrium for the given (or old equilibrium) interest rate, i_0 . In the next period, $t=1$, we know that the bond market will clear so that the interest rate equals the equilibrium interest rate. In Figure 5, this means that the interest rate falls to i_1 in the IS/LM graph and in the money market graph. Note that equilibrium in the money market (for the given Y) means that we are on the LM curve. Of course, now we are off the IS curve! In time period $t=1$, the low interest rate, i_1 , does not correspond with the low level of investment, I_0 . Therefore, AD is "wrong" and so is the ruling level of output, Y_0 .

In the next time period, $t=2$, firms **begin** to increase their investment expenditures. As investment is slowly increased to I_1 , AD increases and output increases to Y_1 . Note that output does not increase enough to clear the goods market because I does not correspond to the i_1 interest rate. Hence, we are still off the IS curve. In the same time period $t=2$, the Y increase is transmitted to M^d which results in an upward shift. Immediately, the interest rate responds and rises to its new equilibrium level, i_2 . Graphically, this means we stay on the LM curve. The movement in time period $t=2$ is a direct manifestation of the Asset Market equilibration assumption that asset markets are always in equilibrium, while the goods market takes longer to equilibrate. We will never be off the LM curve because the interest rate will always instantly adjust to any shock (including shifts in money demand).

We are still off the IS curve in $t=2$ because the equilibrium interest rate, i_2 still does not correspond to the level of investment. Consequently, in time period $t=3$, investment will increase a bit more, triggering the same process as in the previous period— Y will increase and this will shift up M^d which will force an increase in the interest rate to i_3 . This process will continue until the economy reaches a state of rest at i_e, Y_e in time period $t=n$ in Figure 6:

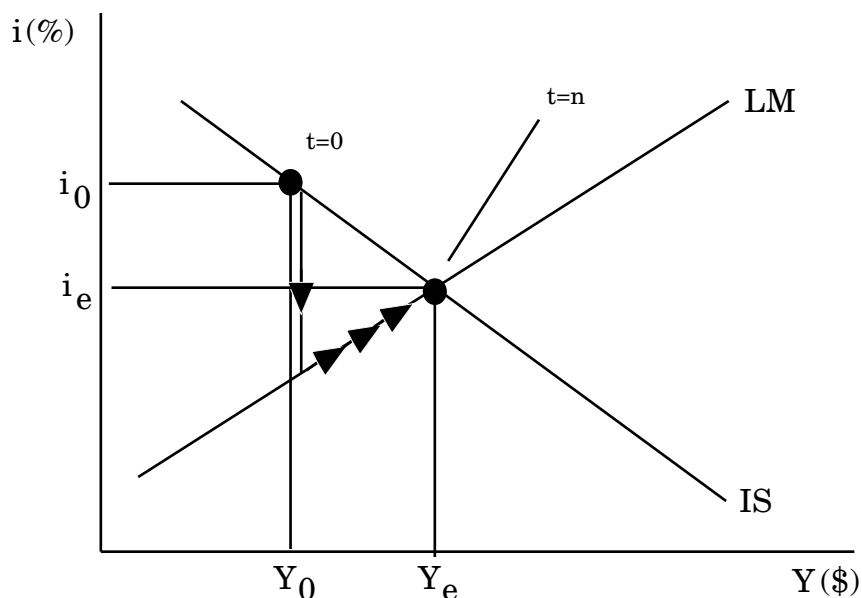


Figure 6: The Asset Market Equilibration Model in General Form

The Asset Market equilibration process emphasizes rapid adjustment in asset markets and slow adjustment in the goods market. In the IS/LM graph, this means that we will move quickly and vertically from any point in i - Y space to the LM curve then approach the intersection by moving along the LM curve. It must be emphasized, however that the fundamental point is still the fact that **there are forces that drive the system to equilibrium.**

Equilibration 3: Asset and Goods Market Equilibration:

The final equilibration process we will consider is a hybrid. It will be used to show that we can order the steps in the equilibrating process however we want. Different assumptions will generate different equilibrium process time paths.

Suppose you believe that asset markets do tend to clear faster but that the goods market also has strong equilibrium forces. In other words, the dominance of asset over goods market with respect to speed toward equilibrium is not so great. In this case, the equilibration process might look like the following:

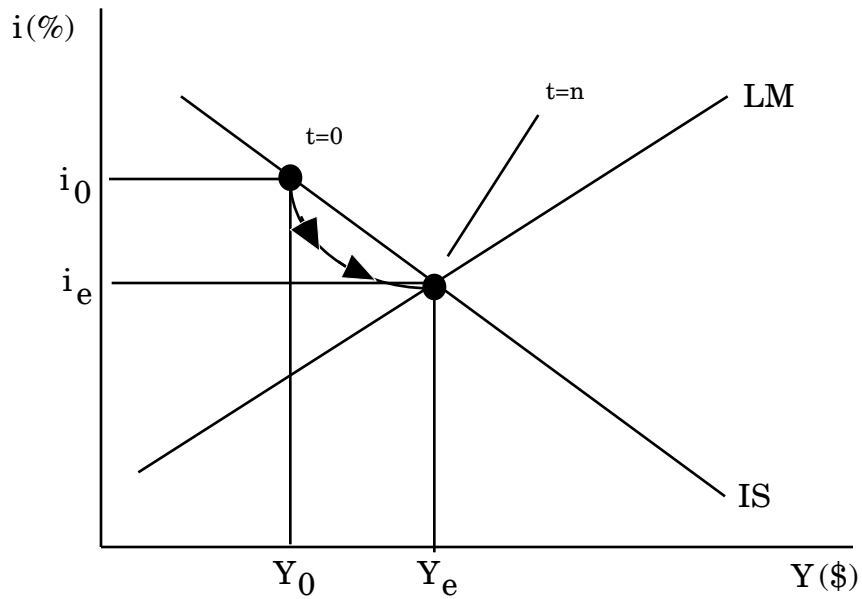


Figure 7: The Asset and Goods Market Equilibration Model in General Form

Instead of jumping immediately down to the LM curve as the asset market clears while the goods market stays fixed, Figure 7 depicts an equilibration process where both markets clear simultaneously. As i falls in the money market, I increases and Y increases. The Y increases serve as a brake on the i decreases and the system glides into the familiar equilibrium at the intersection of the IS and LM curves.

Some economists argue that this is the process that best matches empirical reality. In other words, a money supply increase will be followed, over time, by a simultaneous decrease in i and increase in Y . This is in direct opposition to the predictions made by the previous two equilibrating processes. Here, of course, is where the work of the econometrician becomes crucial. Difficulties with data and the problems caused by incessant buffeting of the model make empirical testing, to say the least, quite formidable.

Summary:

This paper has been one professor's attempt to remedy what he perceives to be a serious problem—namely, confusion concerning the explanation of equilibrium in the IS/LM model. The student should clearly understand and be able to explain why the intersection of the IS and LM curves yields the equilibrium values for interest rate and output. Most macroeconomists are interested in these values because they believe that is where the economy will be at any point in time.³ If the equilibrium values are of such crucial importance, then we must make sure that we understand how and why equilibrium is attained.

The heart of the explanation, of course, is analogous to the single market equilibrium process. Any values of i and Y that are not equilibrium values will be pushed toward their equilibrium values. The three graphs that underlie the IS/LM graph can be used to easily show why a value is a disequilibrium value and how forces within the system will move it toward its equilibrium value. By explicitly showing the relationship between the IS/LM graph and the underlying graphs (the money market, I^d , and goods market graphs), the student is made aware of the equilibrium forces that are suppressed when the IS/LM graph is presented in isolation.

By considering three alternative equilibration processes, the student gains several additional insights. First, it becomes clear that there is no one equilibration process. One's choice depends on what one believes about an individual market's speed toward equilibrium and empirical observation. Secondly, the mathematically inclined student should realize that alternative equilibration processes can be modeled by alternative systems of differential equations. Finally, an awareness of the difficulties faced in doing macroeconomics correctly can be easily gained when one begins asking questions about how the system moves toward equilibrium.

As usual, there are no "real world" answers here. It is to be hoped, however, that the student has gained a better understanding of the IS/LM Model and can now answer questions regarding the intersection of the IS and LM curves!

³I say "most" because there are some who focus on disequilibrium macro analysis. These economists believe that we are never in equilibrium and, therefore, should not concern ourselves with the equilibrium values of the endogenous variables.