Korea University
IIE 301 – Money & Banking

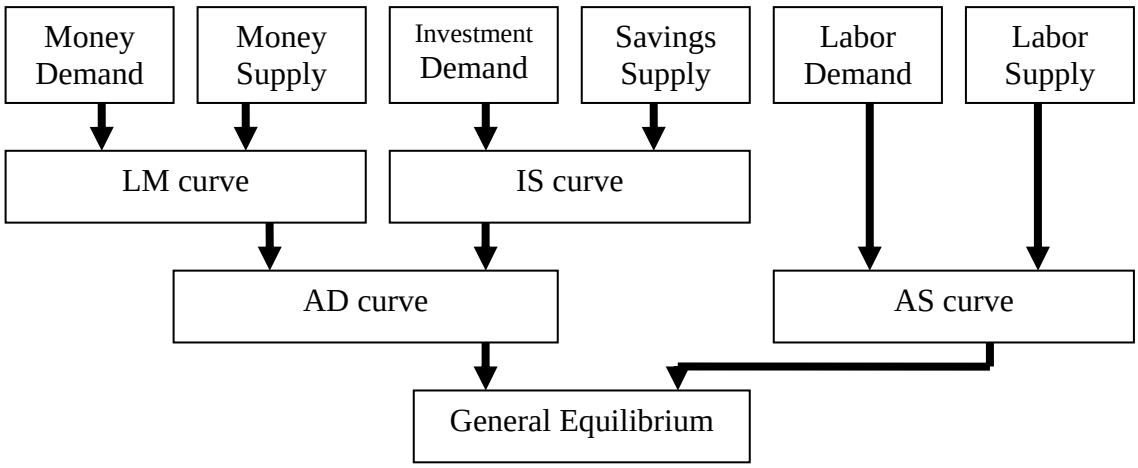
Building the IS-LM/AD-AS model

We are building a model that we can use to examine business cycle behavior and the response of macroeconomic variables to government policy. We will proceed by examining the behavior of three key markets: the money market, the investment-savings market, and the labor market. Our model economy also has a four market, the goods market, but we will invoke Walras Law and consider market clearing in only three of the four markets.

Walras Law – If there are N markets in an economy, and if N-1 of these markets clear, then the N^{th} market must also clear.

We will examine market clearing or other market behavior and use it to derive relations which we can plot on two dimensional diagrams. The money market and investment-savings markets will give us relations between aggregate real output (Y) and the real interest rate (r). We will call these two relations the LM and IS curves, respectively. The joint behavior in these two markets will give us a relation between Y and the general level of prices (P), which we will call an aggregate demand (AD) curve. Behavior in the labor market will also give us a relation between Y and P which we will call the aggregate supply (AS) curve. We will consider the long-run market clearing behavior of the labor market, as well as short-run disequilibrium behavior.

The diagram below illustrates the relation between these markets and curves.



The Money Market and the LM Curve

The demand for money is modeled as a demand for "real balances", that is as the demand for a certain level of real purchasing power or a certain amount of goods that one can purchase with one's money holdings. We will call this demand for money, "liquidity", and abbreviate it with an L. The demand for real money balances is assumed to be a function to two things, nominal interest rates (i), and real output (Y). A rise in interest rates will give households an incentive to hold less money, since money earns little or no interest, and hence, its opportunity cost has risen.

Also, as Y rises households and firms in the economy will increase purchases of goods and this will lead to an increase in the demand for real money balances to buy those goods.

The nominal interest rate can be decomposed using the Fisher equation into the real interest rate and the expected rate of inflation, $i = r + \pi^e$. This gives us the following money demand equation:

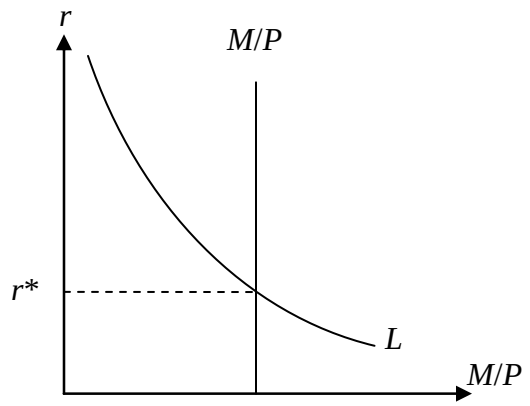
$$L = L(\underset{(-)}{r + \pi^e}, \underset{(+)}{Y})$$

The supply of money comes from the central bank or monetary authority and we will assume this is a given as part of monetary policy. Hence, we will not model this economically. The purchasing power of the money supply will be the nominal money supply (M) divided by the general level of prices (P).

This gives the following market-clearing condition for the money market.

$$\frac{M}{P} = L(r + \pi^e, Y)$$

And we can illustrate this with the following figure.



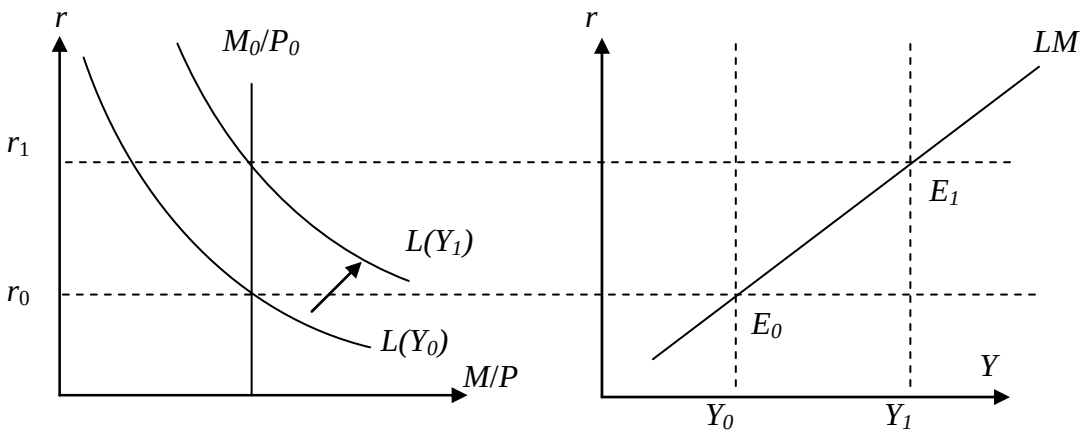
The market clears where supply equals demand. Since the real money supply is not sensitive to the interest rate, the quantity of money demanded is always M/P and the interest rate adjusts to ensure the market clears

An LM curve is defined as all combinations of output (Y) and real interest rate (r) that are consistent with clearing in the money market.

To see what this curve looks like consider the diagrams below. Imagine equilibrium with some initial level of output, Y_0. This gives us money demand curve, L_0. Given expected inflation of π_0, a current price level of P_0 and a money supply of M_0, the money market clears with real interest rate of r_0. This gives us point E_0 on the LM curve; a combination of Y_0 and r_0 is consistent with money market clearing.

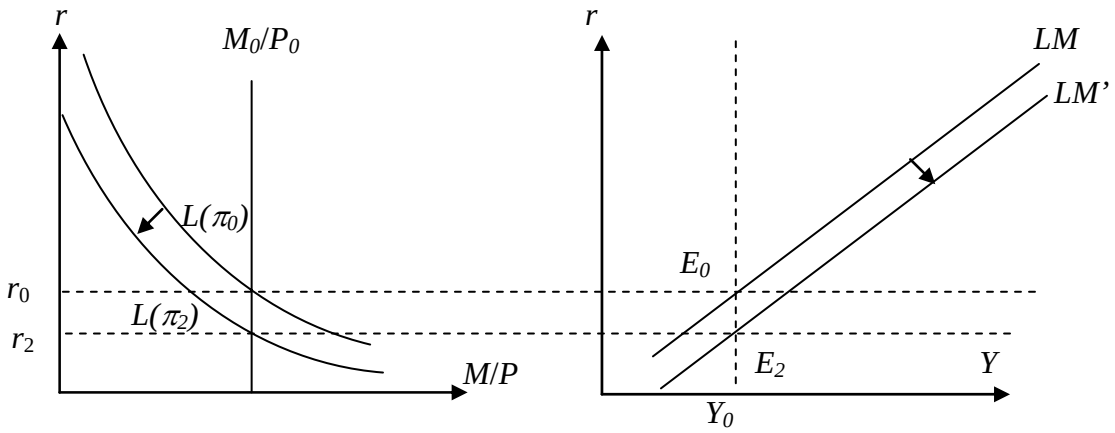
Now suppose output rises to Y_1. The L curve will shift to the right because higher output raises the demand for real money balances. If inflation, prices & money supplies remain unchanged, then the market now clears at the higher interest rate r_1. This gives us point E_1 on the LM curve, since a combination of Y_1 and r_1 is also consistent with money market clearing.

Considering every possible combination of Y and r gives us the entire LM curve, which slopes upward.



Now consider the things that might change the location of the LM curve.

If the expected inflation rate were to rise to π_2 the money demand curve would shift down even if output stayed constant at Y_0. This would give us a lower interest rate of r_2 and would correspond to point E_2 on the diagram below.



The LM curve shifts down if the expected interest rate rises.

Similar logic shows that if the money supply (M) were to rise, or the price level (P) were to fall, the real money supply would shift to the right driving the interest rate down and shifting the LM curve out also.

The following table summarizes these results:

Increase in	LM curve shifts to the
π^e	right
M	right
P	left

The Investment-Savings Market and the IS Curve

As a general rule, households collectively are net savers. Firms, on the other hand, want to borrow funds for investment purposes. The financial sector of the economy is devoted to matching up potential lenders with potential borrowers.

The supply of savings comes primarily from households and is driven by the consumption smoothing motive. That is, while incomes may vary a great deal over time, households wish to keep consumption levels roughly constant. The smoothing of consumption is facilitated varying the household's level of savings appropriately. When incomes are high, households will save. When incomes are low they will borrow, or dissave. Unexpected increases in income will also have effects on savings. If income increases and the increase is know to be temporary, then households will respond by saving most of the increase, in order to consume the additional income in all future periods. If income stays constant today, but households believe that income in the future will be higher than previously expected, they will respond by borrowing more or saving less in order to consume more today. Permanent changes in income, where income rises both now and is expected to rise in the future will have smaller effects on savings because consumption will rise in conjunction with output.

In addition, changes in interest rates will change savings behavior. The interest rate is the opportunity cost of consuming today. If a household consumes a dollar's worth of goods today, it foregoes the opportunity of consuming (1+i) dollars' worth of goods next year. Hence, as interest rates rise, households will consume less and save more.

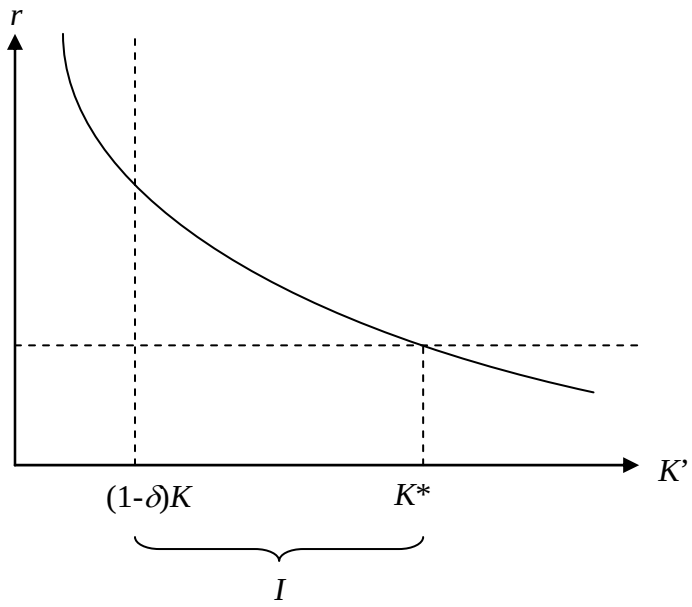
This allows us to write the savings supply function as:

$S = S(\underset{(+)}{r}, \underset{(+)}{X}, \underset{(-)}{X^e})$; where X is the household's current income, and X^e is its expected future income.

The demand for investment funds depends on the behavior of firms. We assume that firms maximize profits. Intuitively, this means firms will equate marginal revenues to marginal costs. Marginal revenue is the price of the good times the marginal product of capital. If we measure everything in units of production goods, rather than in money, then the price of the good is always 1 and marginal revenue is the same as marginal product. A firm will therefore desire to purchase capital until the marginal unit of capital yields output that sells for the marginal cost of that capital. The marginal cost being the interest rate. This marginal condition can be written as:

$MPK(K') = r$; where K' is next period's capital stock

The solution to this condition is the optimal or desired level of capital next period. We assume that the marginal product of capital falls as the amount of capital rises, so knowing the interest rate allows us to find the unique level of K', denoted K^*. The level of investment that occurs will depend on how much capital the firm already owns and how much of it remains undepreciated. The formula for determining this is $I = K^* - (1-\delta)K$. This is illustrated below.



If the expected level of technology tomorrow rises, then the MPK of capital will rise and the desired level of capital, *K**, will be higher

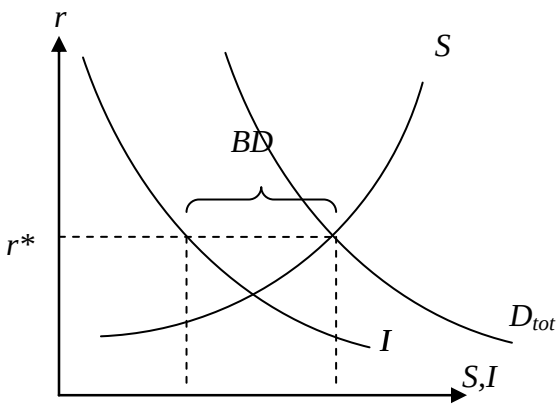
This allows us to write the investment demand function as:

$I = I(\underset{(-)}{r}, \underset{(+)}{A^e}, \underset{(-)}{K})$; where A^e is the expected level of future technology

Finally, there is a third source of supply or demand in the market coming from the government. We will not attempt to model government savings or borrowing. Instead we will treat it as a policy that is just give by some government policy-making process. The amount the government chooses to borrow is the budget deficit, which we will denote *BD*. If the government runs a surplus we will show this by giving *BD* a negative value. Hence, equilibrium in the investment-savings market (assuming a closed economy) is given by:

$S(r, X, X^e) = I(r, A^e, K\} + BD$

This is illustrated by the following figure:



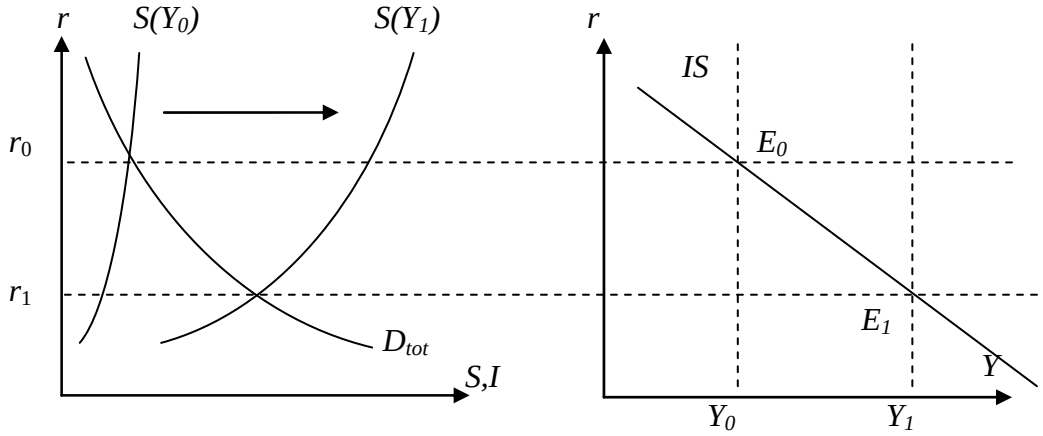
The market clears where savings supply equals total demand, i.e. private investment plus government borrowing.

An IS curve is defined as all combinations of output (*Y*) and real interest rate (*r*) that are consistent with clearing in the investment-savings market.

To see what this curve looks like consider the diagrams below. Imagine equilibrium with some initial level of output, Y_0. This gives us savings supply curve, $S(Y_0)$. Given expected future output and technology, current capital stock, and budget deficit, the market clears with real interest rate of r_0. This gives us point E_0 on the IS curve; a combination of Y_0 and r_0 is consistent with investment-savings market clearing.

Now suppose output rises to Y_1. The S curve will shift to the right because higher output raises the supply of savings. If everything else remains unchanged, then the market now clears at the lower interest rate r_1. This gives us point E_1 on the IS curve, since a combination of Y_1 and r_1 is also consistent with investment-savings market clearing.

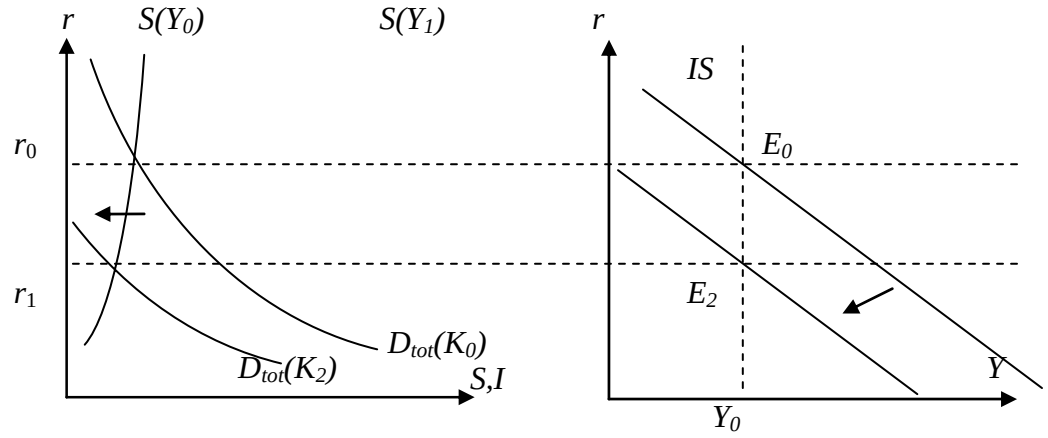
Considering every possible combination of *Y* and *r* gives us the entire IS curve, which slopes downward.



Now consider the things that might change the location of the IS curve.

If the current capital stock, *K*, were to rise, then the demand for private investment would fall, even though output stayed constant at Y_0.

This would give us a lower interest rate of r_2 and would correspond to point E_2 on the diagram below.



The IS curve shifts down if the current capital stock rises.

Similar logic shows that if the future income (Y^e) were to rise, or the budget deficit (*BD*) or expected future technology (A^e) were to fall, the IS curve would shift down or to the left also.

Note that there is a relation between the household's endowment of goods and the firm's investment decision. The firm's dividends in the first period are the same as the household's income, $X = Y + (1-\delta)K - K'$. The firm's dividends in the future are the same as the household's future income, $X^e = A^e F(K') + (1-\delta)K'$. Hence, increases in A^e will cause Y^e to rise also. Economists cannot measure Y^e very well, but we do measure a closely related variable known as consumer confidence (*CC*). *CC* is constructed from surveys of households and measures their expectations of their own future economic circumstances. Increases in *CC* are arguably highly correlated with increases households' expected future income. We will view *CC* as given by households and determined in a non-economic way. John Maynard Keynes called this unpredictable behavior, "animal spirits". We can view Y^e as a positive function of both A^e and *CC*.

Thus, when Ae rises, the investment demand curve shifts to the right while savings supply shifts to the left. Both these effects cause the interest rate to rise, meaning the IS curve has shifted up or to the right.

The following table summarizes these results:

Increase in	IS curve shifts to the
CC	right
A^e	right
K	left
BD	right

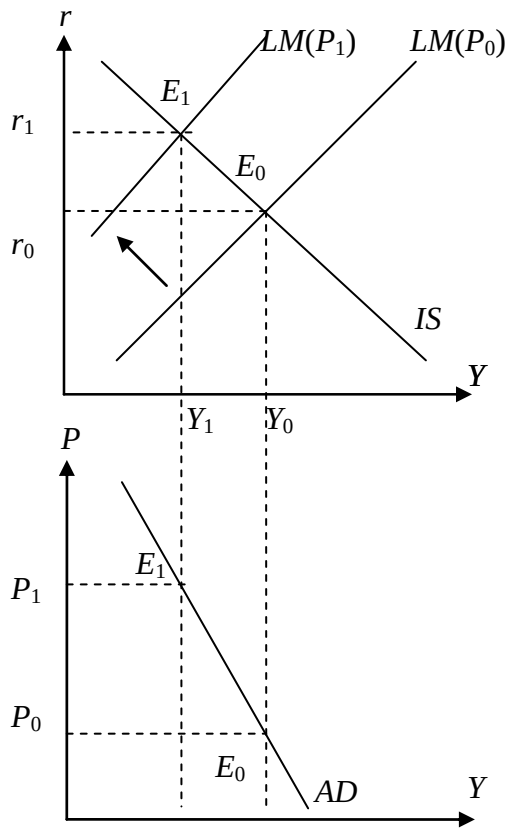
All of the analysis above applies to a closed economy. A small open economy will face a fixed world interest rate. Since the country is small, no amount of excess savings or investment will affect the world interest rate. In this case the IS curve is always a horizontal line and does not shift in response to any of the changes listed above. Instead, the countries net exports of goods

adjust. If the current capital stock, *K*, were to rise as above, there would be greater investment, but no change in savings and the country would either export fewer goods or import more goods as a way of acquiring the additional capital it wants.

The IS & LM Curves and the AD Curve

If prices were to remain unchanged we could use the IS & LM curves to describe the behavior of the economy. Old Keynesian models often assumed that prices were slow to move in the short run and did exactly this.

We can use the IS and LM curves to derive an aggregate demand (AD) curve. **An AD curve is defined as all combinations of output (*Y*) and general level of prices (*P*) that are consistent with clearing in the investment-savings and money markets.**



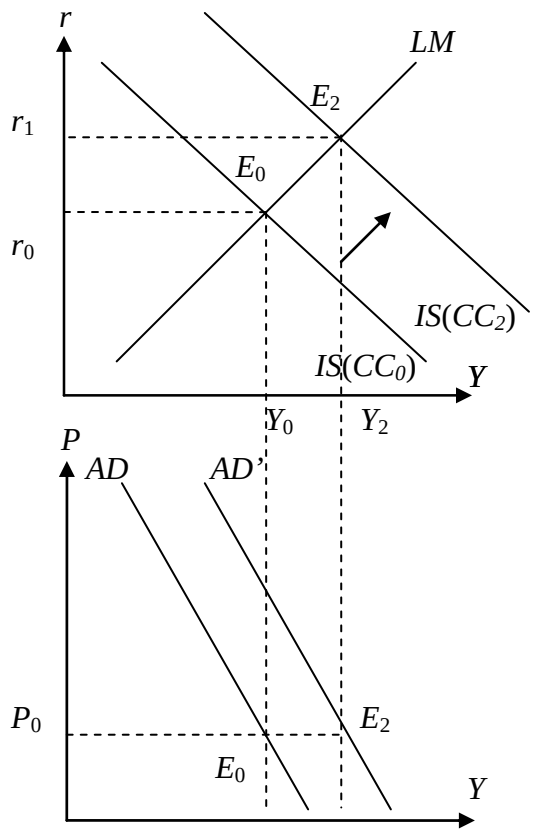
First, let's derive the AD curve by considering an equilibrium with prices held constant. This is done by looking for the intersection of the IS and LM curves. Since we need both markets to clear, we must be simultaneously on both the IS and LM curves. Since the IS curve slopes down and the LM curve slopes down, there is only one unique intersection point. At this point we find the unique values of Y and r that are consistent with clearing in both the money and investment-savings markets. In mathematical jargon, we say that both Y & r are endogenous variable. That is, they are determined inside the model and not just given by assumption. Y & r are function of exogenous variables, those given by assumption and, hence, outside the model. These exogenous variables include: π^e, M, P, K, CC, A^e, and BD. Since P is exogenous and Y is endogenous, we have one combination on the AD curve. This is illustrated by point E_0 on the diagram below with endogenous values of r_0 and Y_0 for the exogenous value of P_0.

Suppose now that prices were to rise exogenously (as we will see below, ultimately prices are endogenous just like Y & r, but suppose they weren't)

As we saw above an increase in P will shift the LM curve to the left. Hence the endogenous value of r rises to r_1 and the endogenous value of Y falls to Y_1. Considering every possible combination of exogenous P and the resulting endogenous Y gives us the entire AD curve, which slopes downward.

Anything that disturbs the IS or LM curve, other than a change in P, will cause the AD curve to shift. This will come from a change in any of the remaining exogenous variables: π^e, M, K, CC, A^e, and BD.

Consider a change in CC as illustrated below.



A increase in *CC* shifts the IS curve to the right and the endogenous values of *Y* and *r* rise to Y2 and r2, respectively.

Since *P* has not changed, this means the AD curve has shifted out or to the right.

Changes in A^e, *K* and *BD* will have similar effects by shifting the IS curve.

Changes in π^e and *M* will shift the LM curve, and hence, also shift the AD curve.

The following table summarizes these results:

Increase in	AD curve shifts to the
π^e	right
M	right
K	left
CC	right
A^e	right
BD	right

The Labor Market and the AS Curve

The final market to consider is the labor market. Labor demand comes from firms and is directly related to the marginal product of labor. Labor supply comes from households and is related to expected lifetime income.

We will distinguish between long-run and short-run behavior in the labor market. With the investment-savings market and the money market, prices adjust quickly to establish equilibrium. There are institutional details that make the labor market clear much more slowly. Hence we will distinguish between the long-run where the labor market ultimately clear and the short-run where there is either excess supply or excess demand for labor.

Consider first the supply of labor from households. Households view labor as lost leisure time. Every household is endowed with a fixed amount of time which they may either consume in the form of leisure or supply to the market in exchange for wages. Hence real wages, the number of goods per units of labor, are the opportunity cost of leisure. As real wages rise, households will choose to consume less leisure, because it is more expensive and hence will supply more labor to the market. Thus, the labor supply is upward sloping.

In addition, as a household's lifetime income rises, either through more income now or in the future, the household will chose to consume more of all goods, including leisure. So as lifetime income rises the labor supply curve shifts to the left.

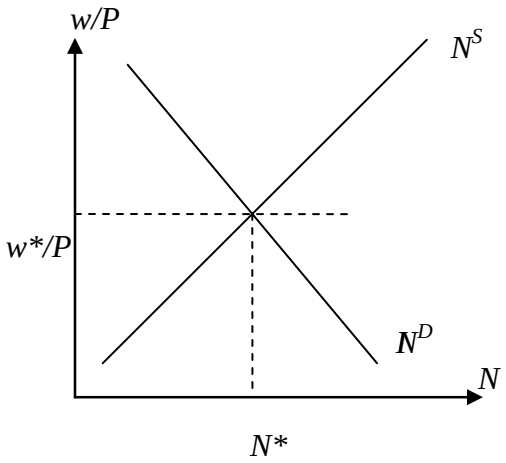
This gives us the following labor supply function:

$N = N^S(\underset{(+)}{w/P}, \underset{(-)}{W^e})$; where N is labor, w is the nominal wage (\$ per unit of labor) and W^e is expected lifetime income. The real wage (goods per unit of labor) is w/P.

Labor demand comes from profit maximizing firms. The firm equates the value of the marginal product of labor with the nominal cost of a unit of labor, so that $P \cdot MPL(\underset{(-)}{N}, \underset{(+)}{K}, \underset{(+)}{A}) = w$, where A is the level of technology today and K is today's capital stock. We can solve this equation for the optimal level of labor as a function of K, A and w/P to get the labor demand function:

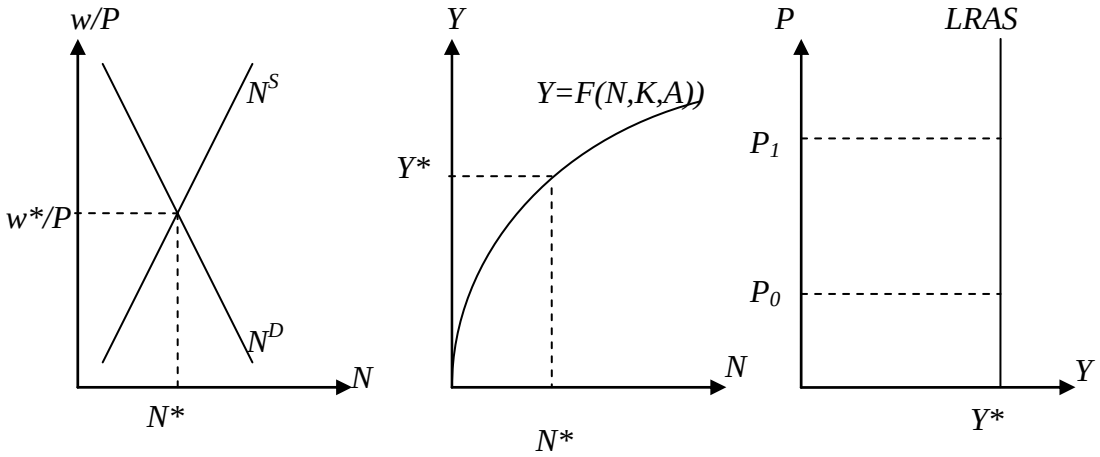
$N = N^D(\underset{(-)}{w/P}, \underset{(+)}{A}, \underset{(+)}{K})$

Equilibrium is given by labor supply equaling labor demand as illustrated below:



An AS curve is defined as all combinations of output (*Y*) and general level of prices (*P*) that are consistent with the behavior of the labor market.

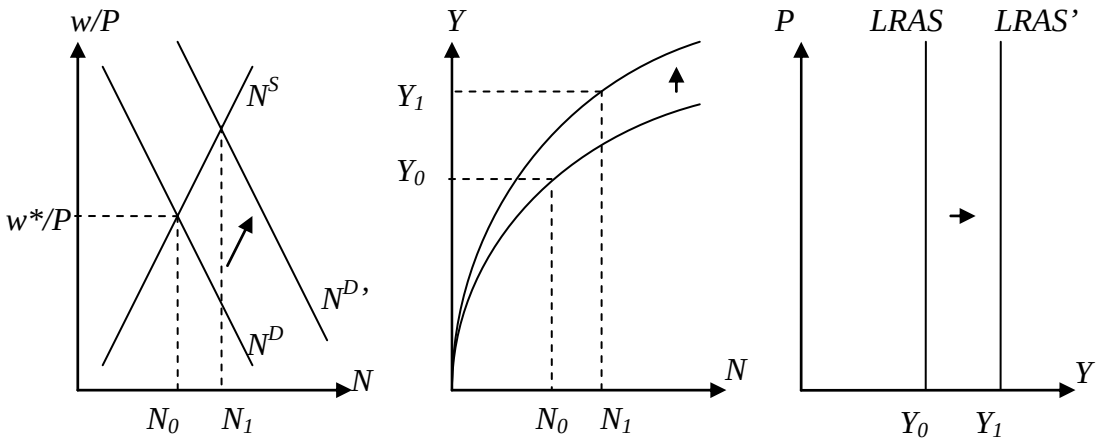
In the long run the labor market clears. Once again let us suppose the price level were exogenously given. The diagrams below illustrate how an long-run aggregate supply curve (LRAS) is derived.



Suppose the price level is initially at P_0. In the labor market w adjusts to ensure that w/P0 is the market clearing wage. A level of employment, *N**, is the result. The second graph shows the aggregate production function where the current levels of technology and capital are fixed, but labor may vary. If *N** is the amount of labor hired, then *Y** is produced.

If the price level rises to P_1, the nominal wage will also rise so that the real wage remains the same. We will still hire *N** and produce *Y**. Hence, the LRAS is a vertical line with a level of output equal to *Y**.

Anything that changes the equilibrium level of employment will shift the LRAS curve. For example, suppose that either the current level of capital or the level of technology rose.



Both of these will increase the demand for labor and cause the real wage to rise. The level of employment also rises which means output rises for two reasons: 1) there is more capital or better technology and 2) there is more labor hired. As a result the LRAS shifts to the right.

An increase in W^e, expected lifetime income, will also shift the LRAS by shifting the labor supply curve to the left, raising the real wage, lowering employment and yielding a lower level of output so that the LRAS shifts to the left.

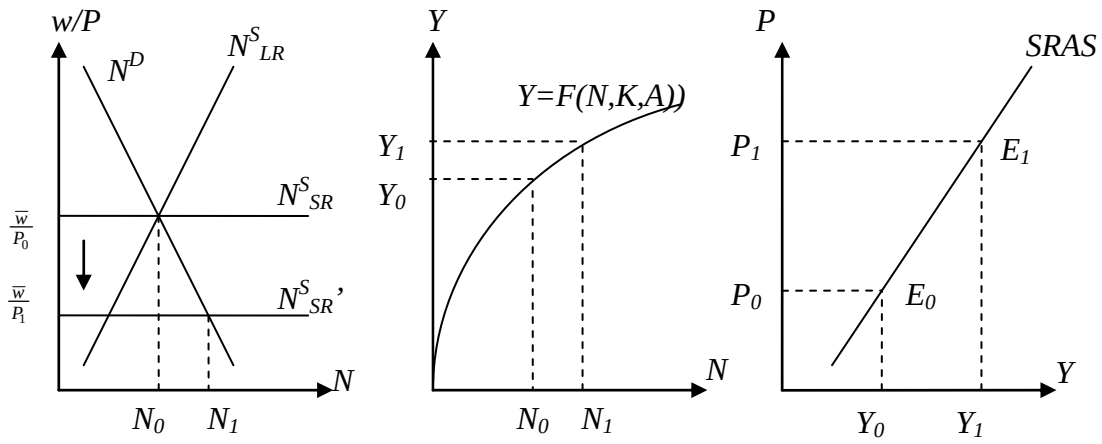
The following table summarizes these results:

Increase in	LRAS curve shifts to the
W^e	left
K	right
A	right

In the short run the labor market may not clear. This could be due to a variety of reasons. We will assume that this is because of nominal wage contracting. Firms and workers contract well in advance how much labor will be supplied at various wages. The nature of the contract we envision is one were workers agree to supply any amount of labor to the firm at a fixed nominal wage, $\overline{w}$, for the short run. In the long run these contracts will be renegotiated to clear the market, but if there is an unexpected shock in the short run, workers may end up working more or less than they expected when they signed the labor contract.

Consider how the short-run aggregate labor supply (SRAS) is derived under these conditions. The nature of the contract (supplying any amount the firm wants at a fixed nominal wage) makes the labor supply curve in the short run perfectly elastic, or a horizontal line at $\overline{w}/P$. Any change in P will now effect labor supply and the SRAS will not be vertical.

The nominal wage will initially be set to clear the labor market at the initial price, P_0. This gives a level of output, Y_0 and corresponds to point E_0 on the graphs below. If the price rises to P_1, the real wage will fall and firms will hire more labor. Workers are not happy with this, but it is a cost of the security from a wage contract. More labor means more output and we move to point E_1. If we plotted every combination of P and Y we would get the SRAS curve, which slopes upward.



Again, anything that shifts the demand for labor will shift the SRAS curve. However, since the short-run labor supply does not shift for any reason other than a change in price, changes in W^e will NOT shift the SRAS.

The following table summarizes these results:

Increase in	SRAS curve shifts to the
K	right
A	right

Explaining Business Cycles using the IS/LM & AD/AS Model

Business cycles can be explained by any model which offers two key explanations: 1) a credible source of economic shocks, and 2) a realistic transmission mechanism. This rules out many explanations. For example, output in the US is positively correlated with the political party of the president. Hence we have a source of shocks. However, there is no realistic economics model that would allow a change in the party of the president to effect GDP. In other words, there is no realistic transmission mechanism.

We will focus on two competing models.

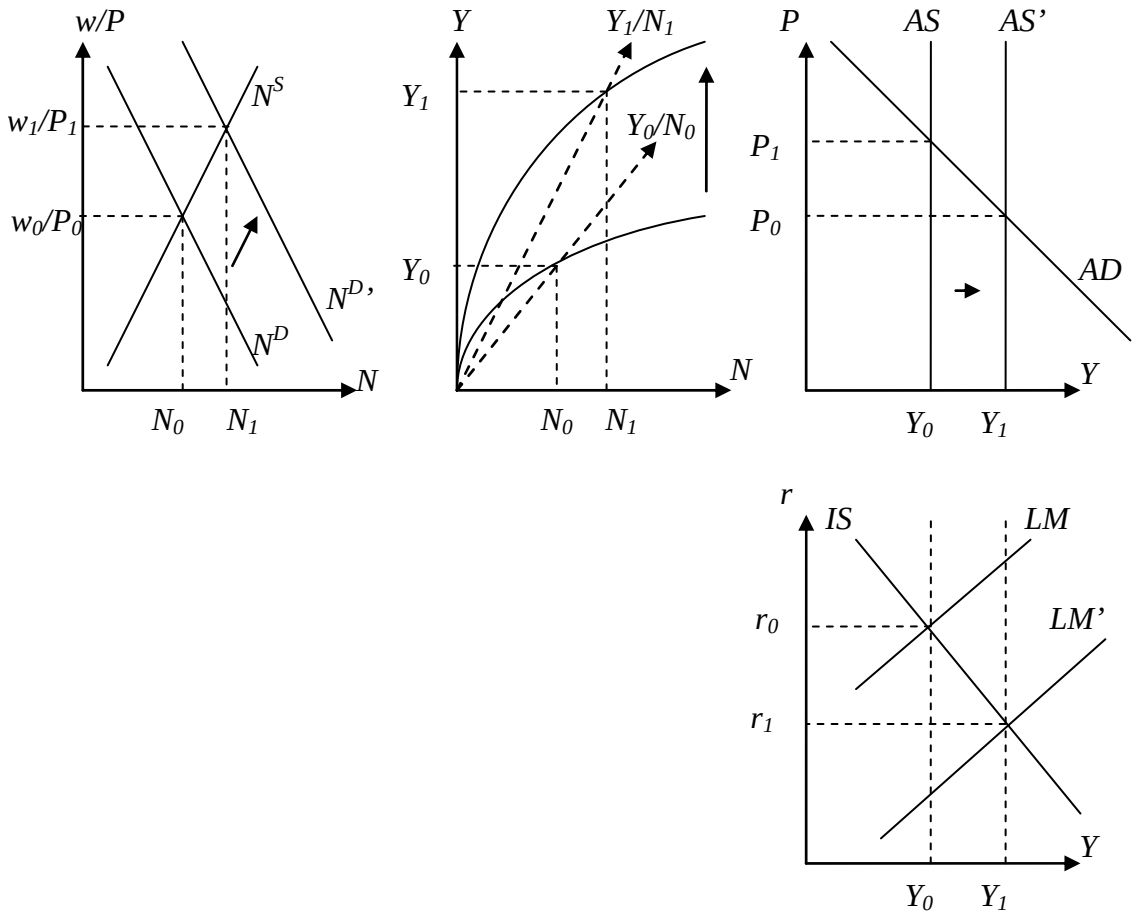
The first is the neoclassical model which says the source of shocks is fluctuations in technology. The transmission mechanism is a direct one; better technology leads to higher output. Neoclassical models assume that the labor market clears always so there is no SRAS. We are always on the LRAS. The neoclassical model is therefore useful even to those who disagree with its short run assumptions, since they agree they are good explanations of the economy in the long run.

The second model is the Keynesian model which focuses on movements in consumer confidence as the source of shock, and stickiness of either goods prices or wages as a transmission mechanism. We will use sticky wages via wage contracting as explained above. Shocks to consumer confidence will shift the AD curve and the SRAS curve's slope will lead to movement is equilibrium GDP levels.

The Neoclassical Model

This model is often referred to as the Real Business Cycle model because it focuses on real, rather than monetary, causes of economic fluctuations. Output and price movements are caused by movements in the aggregate supply curve. The neoclassical model assumes that the labor market always clears, even in the short-run. So there is no difference between the LRAS and the SRAS curves, both are vertical.

Consider the effects of a permanent increase in the level of technology as illustrated on the next page. The increase shifts the AS curve to the right. As a result, output rises and prices fall. In the labor market, both employment and the real wage rate rise. Output per worker, a measure of labor productivity that is given by the slope of a ray from the origin of the 2nd graph to the production point on the production function, rise. Since there has been a movement along the AD curve, the IS curve remained constant, while the LM curve shifted to the right, so interest rates fall.



The observed behavior of these variables in most economies is that prices are close to acyclical, though some researchers find them to be countercyclical. Interest rates are acyclical. Labor productivity and employment are strongly procyclical. Real wages are mildly procyclical.

The predicted and observed behavior of these variables is summarized below:

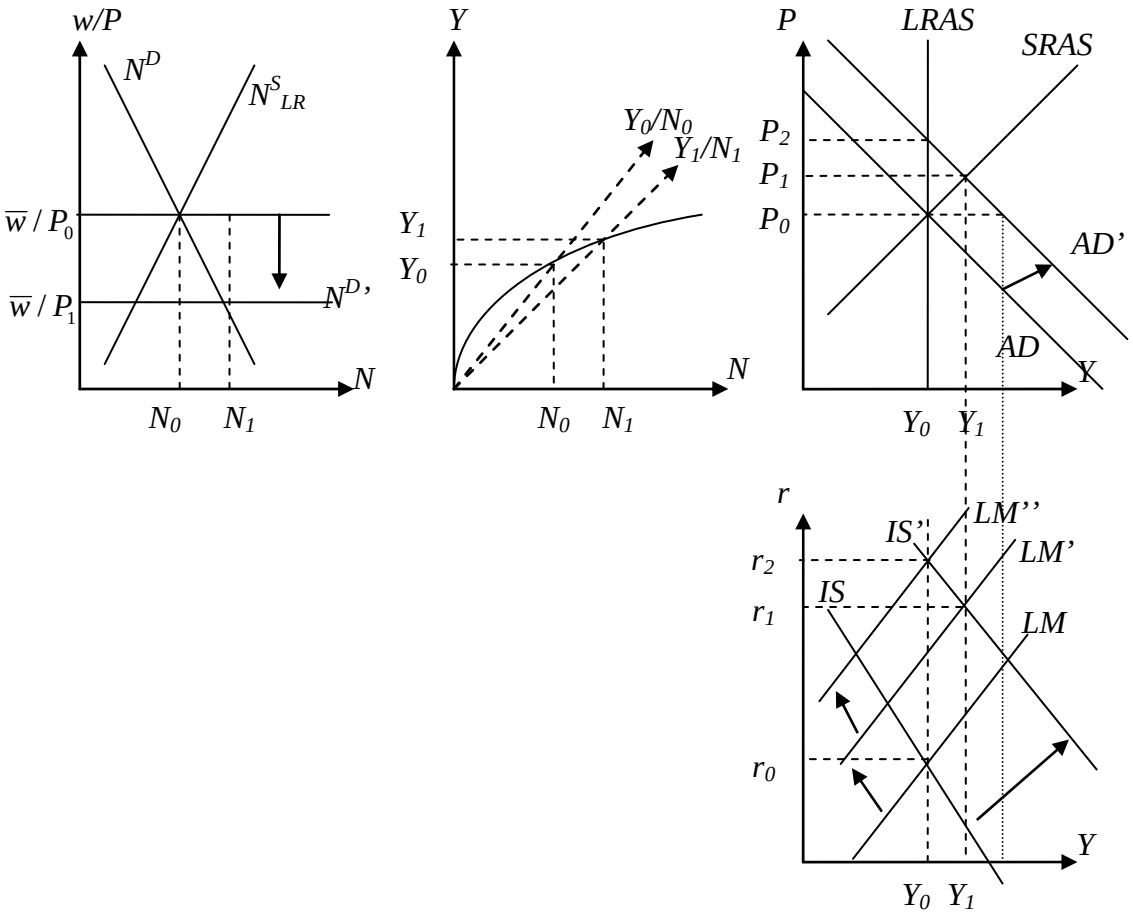
	Predicted	Observed	Fit of the Model
Prices	countercyclical	acyclical	fair or poor
Real wage	procyclical	mildly procyclical	fair
Employment	procyclical	procyclical	good
Labor productivity	procyclical	procyclical	good
Interest rates	countercyclical	acyclical	poor

The Keyenesian Model

This model stresses the role of consumer confidence shocks. An increase in consumer confidence shifts the IS curve to the right, which also shifts the AD curve to the right. Here we must distinguish between the short run and the long run.

In the short run, output and prices rise. The increase in price lowers the short-run labor supply curve and firms hire more workers. Labor productivity decreases due to diminishing marginal product of labor. The increase in prices also shifts the LM curve to the left. Interest rates rise.

In the long run, output returns to its original level, while prices rise even further. The nominal wage is readjusted so that real wages are the same as they were to begin with and employment also returns to its original level. The further increase in price shifts the LM curve to the left even more and interest rates rise further.



The predicted and observed short-run behavior of key macroeconomic variables is summarized below:

	Predicted	Observed	Fit of the Model
Prices	procyclical	acyclical	poor
Real wage	countercyclical	mildly procyclical	poor
Employment	procyclical	procyclical	good
Labor productivity	countercyclical	procyclical	poor
Interest rates	procyclical	acyclical	poor