CHAPTER 1
ECONOMIC MODELS

Economic modeling is at the heart of economic theory. Modeling provides a logical, abstract template to help organize the analyst's thoughts. The model helps the economist logically isolate and sort out complicated chains of cause and effect and influence between the numerous interacting elements in an economy. Through the use of a model, the economist can experiment, at least logically, producing different scenarios, attempting to evaluate the effect of alternative policy options, or weighing the logical integrity of arguments presented in prose.

Certain types of models are extremely useful for presenting visually the essence of economic arguments. No student of economics has sat through a class for very long before a picture is drawn on a chalkboard. The visual appeal of a model clarifies the exposition.

In this text, four primary models will be presented; the **Aggregate Supply - Aggregate Demand (AS/AD) Model**, the **Loanable Funds Model**, an **HMCMacroSim** simulation model, and the **IS/LM Model**. All but the Loanable Funds model are inclusive models of the national economy. The **Loanable Funds Model** is a model of the finance markets and is used to discuss interest rate determination theory.

Types of Models

There are four types of models used in economic analysis, visual models, mathematical models, empirical models, and simulation models. Their primary features and differences are discussed below.

Visual Models

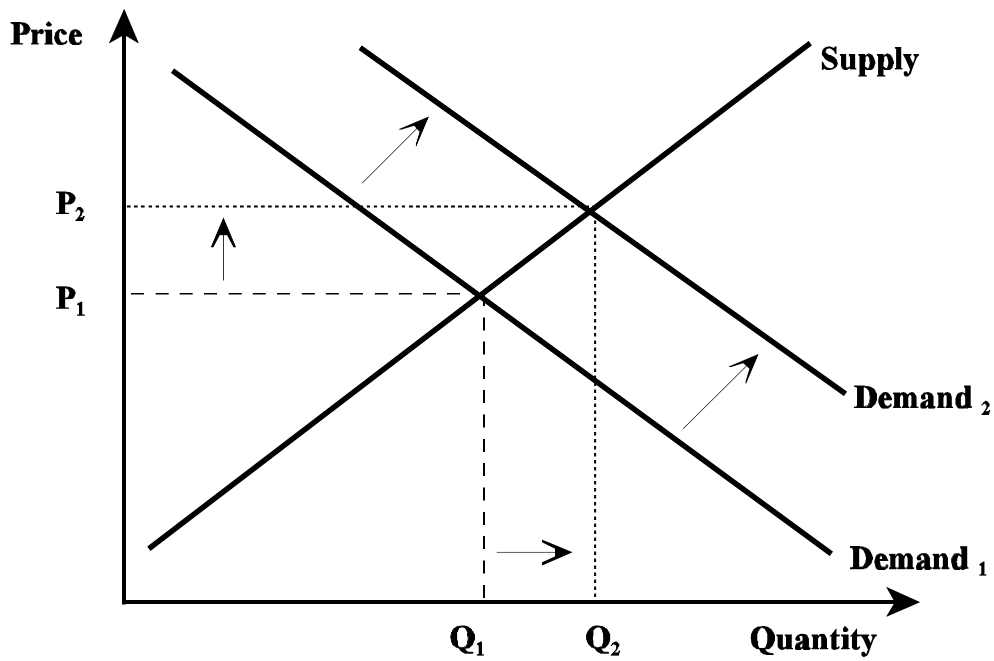
Visual models are simply pictures of an abstract economy; graphs with lines and curves that tell an economic story. They are primarily used in textbooks and teaching, and the reader who has had any exposure to economics at all has probably seen dozens, if not hundreds of them.

Some visual models are merely diagrammatic, such as those which show the flow of income through the economy from one sector to another. In other words, they employ a visual device to present a very general economic concept. Most visual models, though, are visual extensions of mathematical models. Implicit in their structure is an underlying mathematical model. Sometimes when they are presented the mathematics are explained, sometimes they are not. The models do not normally require a knowledge of mathematics, but still allow the presentation of complex relationships between economic variables. These models are relatively easy to understand, but are somewhat limited in their scope.

Figure 1.1 shows the common supply-and-demand model that most economics students see in their first exposure to economics. This model will be discussed in more detail at the end of the chapter. The example is meant to show the effect of inflationary expectations upon price and output. In this application, an increase in inflationary expectations causes demand to shift, raising prices and output.

Two of the primary models used in this book, the *Aggregate Supply/Aggregate Demand (AS/AD)*

Figure 1.1
An Example of a Visual Economic Model:
The Elementary Supply and Demand Model with Inflationary Expectations



(1) The first demand curve represents demand prior to the formation of inflationary expectations.

(2) The second demand curve represents the effects of inflationary expectations upon demand.

(3) Prices and output finally settle at $\mathbf{P_2}$ and $\mathbf{Q_2}$, higher in both cases.

Model, the *Loanable Funds Model* are visual models.

Mathematical Models

The most formal and abstract of the economic models are the purely mathematical models. These are systems of simultaneous equations with an equal or greater number of economic variables. Some of these models can be quite large. Even the smallest will have five or six equations and as many unknown variables. The manipulation and use of these models require a good knowledge of algebra or calculus.

For example, a very simple microeconomics model would include a supply function (explaining the behavior of producers, or those who supply commodities to the market), a demand curve (explaining the behavior of purchasers) and an equilibrium equation, specifying the simple conditions that must be met if the model's equilibrium is to be satisfied.

The variables in a model like this represent a type of economic activity (such as demand) or data (information) that either determines or is determined by that activity (such as a price or interest rate).

Variables can usually be classified as *endogenous* or *exogenous*. An endogenous variable is one that is determined within the model, or by the model's solution. Its value becomes known when the model is solved. For example, if the final level of demand is determined by the model's solution, demand is an endogenous variable. On the other hand, if the value of a variable comes from outside the model, if its value is preset, it is an exogenous variable. In macroeconomics, many policy variables, such as the income tax rate or money supply growth rate, are treated as exogenous. For example, the money supply growth rate is regarded as exogenous because it is set by policy-makers rather than determined by the dynamics of the model.[1]

Figure 1.2 shows an example of a very elementary mathematical model. It is the mathematical version of the visual model shown in **Figure 1.1**. The reader might recognize it as a variation of the simple supply-and-demand model taught in microeconomics, where the purpose is to determine equilibrium price and quantity in a market.

The model has three equations; a supply equation (**1**), a demand equation (**2**), and an equilibrium identity (**3**), which declares that at equilibrium supply will equal demand (and is represented by '**Q**', for "quantity.") There are three *endogenous* variables with unknown values; price, quantity supplied, and quantity demanded. There is one *exogenous* value, inflationary expectations (**IE**) in the demand equation, the value of which would have to be provided before the model could be solved. The values **a**, **b**, **c**, **d**, and **e** are called coefficients or parameters.

The solution values for price and quantity are shown in equations (4) and (5). This simple model is provided merely for illustration. Obviously, reliable macroeconomic mathematical models are much larger and more complex than this.

Sometimes the purely mathematical model is simply solved, to see what result is produced. Often, however, the analyst merely tries to evaluate the sensitivity of one variable to another. For example, the analyst might only want to evaluate the sensitivity of investment to income, essentially asking a question like, "What will happen to investment if income rises one percent?" Using calculus, these questions can usually be answered without actually solving the model (deriving a general solution for the model's variables). Numerical values do not even necessarily have to be assigned to the model's variables to do this.[2]

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[1]These terms are carefully introduced here because they are used later throughout the book. The reader will see numerous applications and distinctions.

[2]For readers with a sufficient mathematical background, it can be said here that this is typically done by taking first derivatives. The reader familiar with concepts in microeconomics might recognize that the example provided in the text is an example of the use of the concept of elasticity.

Figure 1.2
An Example of a Mathematical Economic Model:
The Elementary Supply and Demand Model
with Inflationary Expectations

$$(1)\ S = a + bP$$

$$(2)\ D = c - dP + eIE$$

$$(3)\ S = D = Q^0$$

$$(4)\ P^0 = \frac{(c + eIE - a)}{(b + d)}$$

$$(5)\ Q^0 = a + bP^0$$

This model is the mathematical version of the model that was shown in **Figure 1.1**.. The model has three ***endogenous*** variables; **S**, representing the quantity supplied, **D**, representing the quantity demanded, and **P**, representing price. These variables are determined by the solution of the model. The value **Q** simply represents quantity, and reflects the fact that at the solution equilibrium, quantity supplied and quantity demanded are equal.

The model has one ***exogenous*** variable, **IE**, representing inflationary expectations. The value for this variable comes from outside the model, and a solution for the endogenous variables cannot be obtained unless the value is known.

The values **a**, **b**, **c**, **d**, and **e** are called ***coefficients*** or ***parameters***. These are *behavioral* variables that reflect the reaction of producers (supply) and buyers (demand) to price.

Equation **(1)** is the supply function and equation **(2)** is the demand equation, which includes the variable for inflationary expectations. Equation **(3)** tells us that at equilibrium supply will equal demand. By solving these three equations for **P** through substitution, we obtain the solution for price in equation **(4)** and quantity in equation **(5)**.

Empirical Models

Empirical models are mathematical models designed to be used with data. The fundamental model is mathematical, exactly as described above. With an empirical model, however, data is gathered for the variables, and using accepted statistical techniques, the data are used to provide estimates of the model's values. For example, suppose in an economic study the following question is asked: "What will happen to investment if income rises one percent?" The purely mathematical model might only allow the analyst to say, "Logically, it should rise." The user of the empirical model, on the other hand, using actual historical data for investment, income, and the other variables in the model, might be able to say, "By my best estimate, investment should rise by about two percent."[3]

For example, after manipulating the simple supply-and-demand model shown above in **Figure 1.1** and represented mathematically in **Figure 1.2**, and supposing this to represent an actual market for a commodity like an automobile, with data available, the econometrician might estimate that if inflationary expectations were to rise by ten percent, demand for the auto would shift and the price of this product would rise by six percent.[4]

Empirical models are advanced and cannot be understood unless the student has an introductory background in statistics. They will not be discussed in this text but are mentioned because they are important for more advanced research and are largely built from mathematical models.

Simulation Models

Simulation models, which must be used with computers, embody the very best features of mathematical models without requiring that the user be proficient in mathematics. The models are fundamentally mathematical (the equations of the model are programmed in a programming language like Pascal or C++) but the mathematical complexity is transparent to the user. The simulation model usually starts with initial or "default" values assigned by the program or the user, then certain variables are changed or initialized, then a computer simulation is done. The simulation, of course, is a solution of the model's equations. The user can usually alter a whole range of variables at will.

The computerized simulation model can show the interaction of numerous variables all at once, including hidden feedback and secondary effects that are not so apparent in purely mathematical or visual models. With such simulations, the careful user, especially if guided by a good text or instructor, can reason through the complicated chains of influence without necessarily understanding the underlying mathematics. Such models are therefore quite useful in classroom instruction. If you are reading a version of this text that includes four or more chapters, the fourth chapter introduces simulation models and includes a downloadable macroeconomic simulation model called ***HMCMacroSim***, complete with a homework set.

Static and Dynamic Models

Most of the models used in economics are comparative statics models. Some of the more sophisticated models in macroeconomics and business cycle analysis are dynamic models. There are some fundamental differences between these models and how they are used.

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[3]Empirical models produce only estimates, refined guesses, and the language that evaluates the likely accuracy of the estimate is much more precise and technical than is suggested here. This technique is taught in the specialized field of economics called *econometrics*.

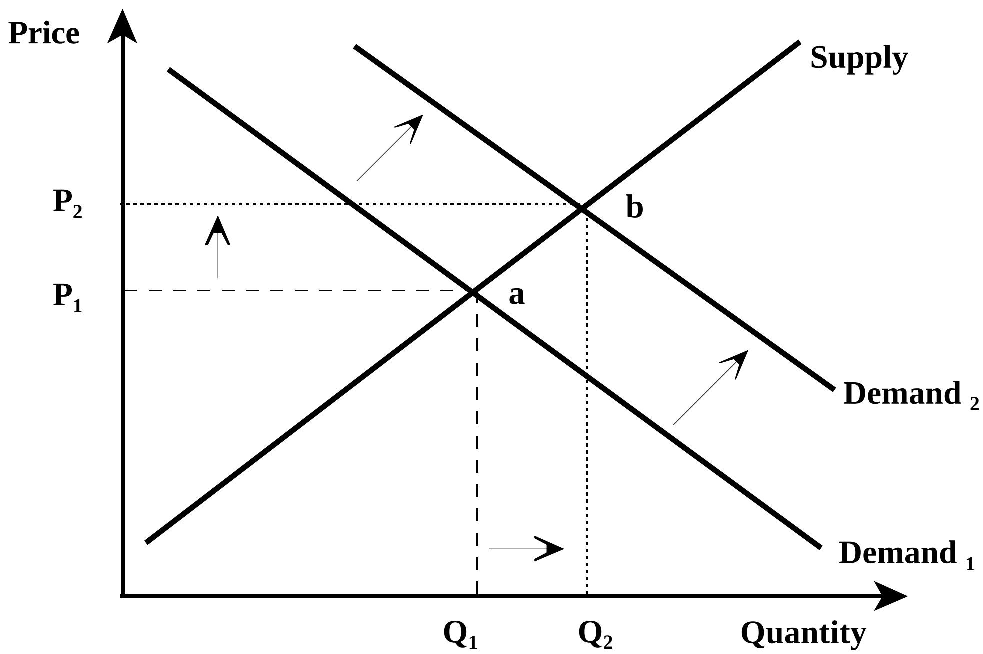
[4]Again, this example is for illustration only. An estimate based upon so simple a model would be entirely unreliable.

Comparative Statics Models

A good example of a comparative statics model was provided by the elementary supply-and-demand model shown in **Figure 1.1** and **Figure 1.2**. Most models used in economics and virtually all used in economics textbooks are comparative statics models.

These models try to show what happens over time (or as time passes), but time itself is not

Figure 1.3
The Elementary Supply and Demand Model as an Example of a Comparative Statics Model



This is the same model as was shown in **Figure 2.1**. Equilibrium point **a** shows the initial condition **-** the first "snapshot" of the model. Equilibrium point **b** shows the second and final snapshot, the revised equilibrium after the "shock," which in this case was the sudden appearance of inflationary expectations. The analyst can see that prices and quantity have risen. It is presumed that some time has passed, but what has happened in the interim is not shown. The explanation, however, can be told as a story on the side.

represented or embodied directly in the model. The model usually begins with an equilibrium condition identified, then a "shock" to the model is presumed (the value of one or more of the coefficients or variables are changed), then the new equilibrium condition is identified without an exposition of what happened in the transition from one equilibrium to another.

For example, review **Figure 1.3,** which uses the same model shown in **Figure 1.1**. Given some presumed level of inflationary expectations, the initial equilibrium (point '**a**') identifies theprice and level of output that would obtain, given assumptions about supply and demand and the level of inflationary expectations. Then the model is shocked by introducing a higher level of expectations, demonstrating a new equilibrium at point '**b**'. Obviously this movement in equilibria and the shift in the model's solution happened over time, but neither the visual model nor its mathematical counterpart can demonstrate what happened in the interim. The model shows only the starting point and the ending point.

The comparative statics approach is roughly analogous to using snapshots from a camera to record developments during a dynamic event. With each snapshot a static but informative picture is presented. Imagine, for example, taking a picture at the beginning of a horse race, ten shots throughout the race, and one at the finish. The developed film would constitute a "comparative statics" record of a very dynamic race. As such it would have very useful information about the race, but probably not as much as a video record.

In a comparative statics economic model, each equilibrium solution is like a snapshot of the economy at one point in time.

Figure 1.4
A Difference Equation from a Dynamic Economic Model

$$I_t = a + b(Y_{t-1} - Y_{t-2})$$

This investment equation, drawn from a larger model of similar equations, is an example of a difference equation used in a dynamic model. Here discrete time is embodied directly into the model.

This equation can be interpreted to say that investment (**I**) at any time (**t**) is determined by the level of income in the previous period (**t-1**) less the level of income the period before (**t-2**).

More generally, if this time period is defined to be *months*, this equation says that investment this month depends upon the *change* in income last month (which is equal to the difference between income last month and the month before).

Dynamic Models

Dynamic models, in contrast, directly incorporate time into their structure. This is usually done in economic modeling by using mathematical systems of difference or differential equations. For an elementary example, refer to **Figure 1.4**. In this example, which uses a difference equation from a business cycle model, investment now depends upon changes in income in the past. Time is incorporated into the model through subscripts.

Dynamic models, when they can be used, sometimes better represent the subtleties of business cycles, because certainly lags in behavioral response and timing strongly shape the character of a cycle. For example, if there is a delay between the time income is received and when it is spent, a model that can capture the delay is likely to have higher integrity than a model that cannot.

Why Comparative Statics Models are Usually Used

One might ask, therefore, why comparative status models are usually used in business cycle theory. The answer is simple - comparative statics models are much easier to solve. Any student of calculus knows the difficulty of solving systems of difference or (especially) differential equations. The latter, as soon as they achieve any complexity, are sometimes impossible to solve. Therefore dynamic models must be kept extremely simple and are therefore so elementary that more is lost than gained.

Simple dynamic models, nonetheless, often provide valuable insights into the complex interactions between variables over time. They can capture remarkably subtle feedback effects that are easily missed by static models.

It should be noted that dynamic models are much easier to simulate on computers than they are to solve outright. The user can experiment with an endless variety of values and assumptions to see whether results obtained are realistic or insightful.[5] Since computers are now powerful and cheaper, the importance of dynamic simulation models should gradually grow in importance.

Expectations-Enhanced Models

Economic models often incorporate economic expectations, such as inflationary expectations. Such models are called expectations-enhanced models. The elementary supply-and-demand model presented earlier in this chapter, which incorporated inflationary expectations, was an example of such a model.

Generally, expectations-enhanced models include one or more variables based upon economic expectations about future values. For example, if consumers, for whatever reason, expect the inflation rate to be much higher next year than this year, they are said to have formed inflationary expectations. If numerical values are being used in a model and the current inflation rate is nine percent, if they expect inflation to be higher next year, the variable for inflationary expectations might be given a value of twelve percent. Normally, though, general models used for instruction or analysis merely assume an expectation value to be "high", where it will have an impact on the model's result, or "low" or "non-existent" where it will have no impact. In the simple supply-and-demand model presented earlier, inflationary expectations were "high", shifting the equilibrium and causing higher prices and output.

There are many types of expectations found in economics. In addition to inflationary expectations, economists might consider interest rate expectations, income expectations, and

[5]Or even to see if assumptions, values, or results are even possible. Dynamic models of difference and differential equations are extremely sensitive and can easily "explode" into nonsensical results. Finding "stability conditions", or the sets of initial values that prevent model disintegration is a very difficult task, aided greatly by simulation.

wealth expectations. This list is hardly exhaustive. For virtually any variable that might be included in a model, a corresponding expectations variable is logically possible.

Expectations matter because they have such a profound impact upon economic behavior. Consumers, for example, base their purchasing decisions not only upon their present income but also whether they expect that income to rise or fall (hence, expected income). In this age of consumer credit, readily available, consumers are less tied to direct income as a source of purchasing. If they expect a surge in income or wealth, many are inclined to use credit to buy now and pay later. As another example, business investment, or the new purchase of expensive plant and equipment or real estate, probably depends as much upon expected future profits as upon current profits. Therefore, changes in expectations about the future cause changes or fluctuations in current spending behavior. Given that business cycle theory investigates the causes of fluctuations in economic activity, the importance of expectations and expectations-enhanced models is evident.

There are two general approaches to theories explaining the development of expectations, the theory of adaptive expectations and the theory of rational expectations. Because these theories are fundamentally different and both are used in economic models, they are distinguished here.

Adaptive Expectations

The theory of adaptive expectations presumes that expectations are primarily learned from experience. For example, the theory of adaptive expectations would say that if consumers begin to actually see prices rising, say from three percent to five percent to seven percent, over a period of, say, two years, they will begin to form robust expectations of inflationary expectations - perhaps even expectations of double-digit inflation. The same theory might claim that consumers will expect an economic recovery to begin only after ample evidence that the turning point has been passed.

Adaptive expectations imply, therefore, that economic agents learn from recent experience, or begin to see trends emerge that they expect to continue. The theory of adaptive expectations implies, therefore, that expectations are relatively slow to form. This feature of adaptive expectations - the relatively long lag in the formation of expectation, becomes a critical issue in the timing of such phenomena as business cycles.

Rational Expectations

The theory of rational expectations presumes that expectations are formed when economic agents see new developments in the economy and they logically deduce expectations based upon the information they have. For example, if the Federal Reserve System were to suddenly increase the money supply, according to the theory of rational expectations, consumers would immediately form inflationary expectations, not because prices are actually rising, but because they deduce that excessive money supply growth is likely to cause inflation.

The theory of rational expectations emphasizes the effects of changes in economic policy upon expectations, although the theory is not restricted to policy decisions alone.

Obviously, the theory of rational expectations presumes a relatively high degree of economic sophistication among those who make economic decisions. It also presumes that people have access to (or even care about) information on the economy, such as the money supply growth rate, the rate of taxation, etc.

With rational expectations there is normally a much shorter lag in response time between the initial stimulus and the formation of expectations. Sometimes rational expectations are formed immediately, whereas adaptive expectations may take months or even years to form.

Consider as an example the issue involving the money supply growth rate, discussed above. With rational expectations, virtually the moment it becomes known that the money supply has dramatically increased, inflationary expectations begin to form. Assuming adaptive expectations, the picture is more complex. Suppose the high money supply growth rate does eventually cause inflation.[6] This may not happen until many months have passed. Only then, when inflation is actually experienced, are adaptive inflationary expectations (of more inflation) formed.

Which Theory is Appropriate ?

When describing the economic activity of consumers in general or even certain types of business decisions the theory of adaptive expectations is probably most suitable. Rational expectations implies a degree of economic knowledge and sophistication among ordinary citizens that they probably don't have. The theory was developed by economists and seems to imply that most people think like economists. They probably don't.

When describing an environment, however, where the decision-makers are likely to be sophisticated and well-informed and where their decisions involve high stakes, the theory of rational expectations is more suitable. The activities of traders in the finance markets provide a good example. Institutional traders of financial assets, managing huge portfolios, watch and respond to new economic information virtually every moment of their working day. The markets respond instantly to even the most subtle shifts in Federal Reserve Policy, anticipating the impact of such policy on interest rates, for example.

The choice of the theory of expectations, therefore, depends upon context. Models incorporating both theories will be developed and used.

How Models Are Used

Students sometimes have the mistaken impression that the economic models found in textbooks are devices that are directly used by people making economic decisions, such as managers of a business firm. Students think they are learning an algorithm or tool that can be directly applied to a management decision. For example, a student learning the elementary supply-and-demand model used earlier in **Figure 1.1** might get the mistaken impression that

[6]Do not presume from this simple discussion that the money supply growth rate and the inflation rate are always correlated. The causes of inflation are more complex than implied here. This simplified example is merely meant to be illustrative.

managers in an industry might actually, from data, draw supply and demand curves (or solve the equations behind them) to help them set the actual market price they should be using.

Economic models are almost never used directly in this way.[7] These models are not applied models. They are meant to merely represent a type of consistent economic behavior either visually or mathematically. They provide a "picture" of that behavior.

Typically in a market economy economic decisions, and alterations to those decisions, are determined by market incentives, a series of rewards and penalties, that alter behavior in a way that it is forced to loosely conform to conditions described by the model. Models that identify a market equilibrium are not used by business managers to set price and quantity but instead represent the theory that rational market incentives will force the market to eventually move to the equilibrium.

An example of this important point will be made later in **Figure 1.6**.

The Limitations of Models

Even when used as a template or for instruction, models have limitations which reduce their reliability.

Improper Assumptions

Models have high integrity because they are mathematical and, hence, conform to the rigorous standards of logic inherent in mathematics. Nonetheless, mathematical models must begin with precise assumptions about economic activity. In great measure, the conclusions and insights offered by the model are restricted or even determined by the initial assumptions. Therefore, if the initial assumptions are wrong or misleading, or even if they are incomplete, despite the logical integrity of the model, the model's conclusions will be as much in error as the initial assumptions. A model can be logically consistent internally, and still yield bad results.

As an example, the theories of public policy, one economist might assume that elected officials are motivated to act on behalf of the interests of their constituency, performing a public duty. Other economists might assume that the same officials act on behalf of their own self-interest, formulating policy merely for the purpose of maximizing votes in an election, even if it is to the ultimate detriment of the voters. The former model might specify an objective function that is "socially optimal" (a mathematical equation that optimizes net social satisfaction, benefit, or gain), whereas the latter might specify an objective function which maximizes some measure of the individual politicians's personal gain. The contrary results from such different beginnings are hardly surprising. The first model will tend to promote the idea that interventionist government policy is advisable if not indispensable. The second will, in contrast, suggest that intervention is corruptly expedient and counter-productive.

Which model would be right? In part, this will depend upon the validity of the assumptions.

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[7] Some larger companies (very few apparently) try to get empirical estimates of demand curves (or demand "elasticities") for their products. But such estimates only give them useful marketing information.

Oversimplification

Macroeconomic models are widely used because they allow the analyst to simplify a situation. A real economy is a virtual porridge of interaction and data. To make some sense of this recondite chaos, the analyst will pull out those key variables which seem to have the most importance and fit only them into a logical scheme, omitting the others. Likewise, composites of individual human economic behavior are aggregated in macroeconomic models, and as such are simplified. A rational consumption function with all of its arguments (e.g. consumption depends upon income, wealth, expected income and wealth, the rate of inflation, etc.), for example, makes the useful simplifying assumption that individual consumers are fairly consistent and similar in their economic behavior, allowing for a generalization of the aggregate behavior.

Such simplifications are not only expedient but necessary. Nonetheless, the model in its simplicity is different than the real economy (or segment of the real economy) that it is designed to replicate. The omitted variables often do matter in the real economy. Likewise some generalizations end up being too crude to produce precise or accurate results.

Mathematical Intractability

Models that are mathematical, directly or implicitly, are also limited because they must be tractable, which is to say, they are useless unless they can be solved or manipulated to produce insightful results. This poses serious mathematical problems that have nothing to do with economics. Macroeconomic models, such as those used in business cycle analysis, usually have a large number of equations and variables. All of these must be reduced to a solution if the model is to be of any value. Because of the difficulties in solving large mathematical systems, sometimes the underlying equations must either be linear, or easily converted to linear, such as exponential or log-linear.[8]

But real economic behavior doesn't necessarily exhibit patterns that are "linear", or even represented well by orderly equations that are non-linear and that can still be used in a large model. The "math of reality", if a term like that can be indulged for the moment, is remarkably complex, and cannot be faithfully duplicated in abstract model of human design.

Models are therefore quite useful, in fact indispensable, in economic analysis, but they do have their limitations. Again, they help us guide our thoughts, organize our thinking and, in exposition, explain our theories. But as abstractions, they are somewhat if not substantially

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[8]This is a technical point that some readers may not understand. An example of a linear equation is the elementary consumption function found in some introductory textbooks:

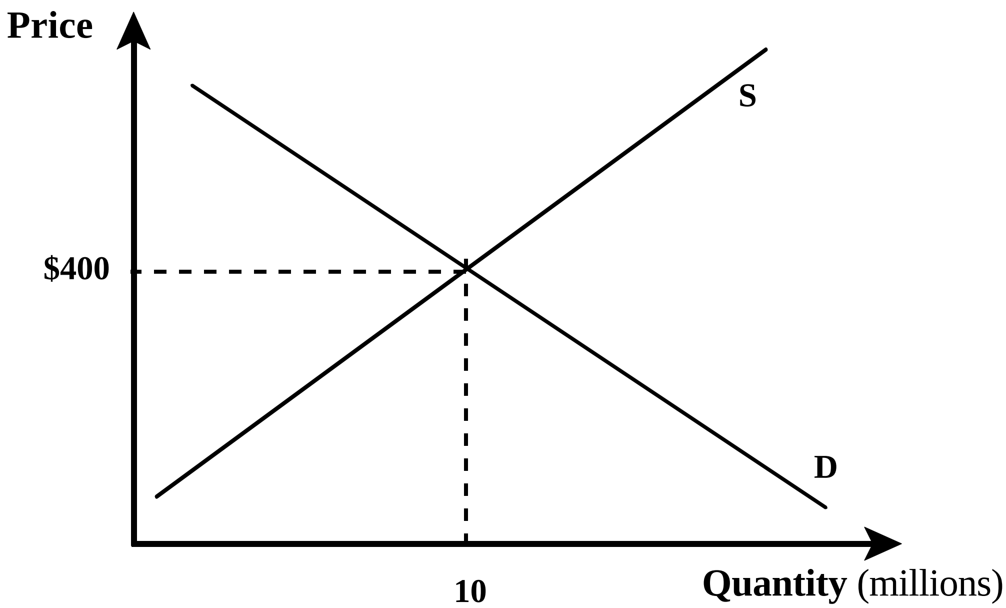
$$C = a + bY$$

where, when drawn or "mapped", is represented by a straight line, hence the term *linear*. Some non-linear equations (which, when drawn, are curves, for example) can be easily transformed mathematically to linear equations. It is not critical that the reader understand how this is done. The point is that a lot of economic behavior is "non-linear", to say the least, and non-linear mathematical systems are hard to solve.

different from the reality they purport to represent. They provide guidance and insight, but not

Figure 1.5

The Microeconomic Supply and Demand Model:
Digital Video Players (DVPs)



The supply curve (**S**) represents the production decisions of microcomputer manufactures of the Digital Video Player (DVP), which plays digital video disks and competes with VCRs and other consumer video output devices. The curve implies that the higher the price, the more of these machines will be manufactured.

The demand curve (**D**) represents the purchasing intentions of the potential buyers of the Digital Video Player. Obviously the lower the price, the higher the level of sales (demand).

The market-clearing equilibrium price, when the level of production (supply) equals the level of sales (demand) is $400 per machine. At this price 10 million machines would be produced and sold.

the final word. That is the spirit in which they are developed and discussed in this text.

The Microeconomic Supply-and-Demand Model Formally Presented

The first macroeconomics model to be presented in the text will be the **Aggregate Supply/ Aggregate Demand Model** (**AS/AD**) presented in the next chapter, followed by the

Loanable Funds Model in the chapter after that. Both models are special applications of the elementary microeconomic supply-and-demand model used in introductory textbooks and discussed briefly earlier in this chapter. Like the microeconomic model, the **AS/AD** and **Loanable Funds** models are comparative statics models. Because these models draw so heavily from the microeconomic supply-and-demand model, and are constructed and used in the same way, it will be useful to briefly review the microeconomic model.

The visual microeconomic supply-and-demand model is shown in **Figure 1.5**. In order to make the example realistic, it is presumed that the market represented is for Digital Video Players (hereafter DVPs), a relatively new technology offered to consumers by a large number of manufacturers.[9]

In this model, the supply curve (**S**) represents the quantity of DVPs that would be manufactured and supplied at various prices. Generally, the higher the price the higher the level of production. The demand curve (**D**) shows that the lower the price the greater will be the quantity demand by consumers.

There is a single market-clearing equilibrium price, '**e**', of $400 where the level of production (supply) will equal the level of sales (demand). At any other price, higher of lower, there will be a disequilibrium where production will exceed sales or sales will exceed production.

The Tendency Toward Equilibrium

As was stated earlier, this type of model is not a tool used by the manufacturers of digital video players to set their prices. It is not a management device. The numerous manufacturers of these computers don't have enough information on potential consumer responses to a full range of prices to even construct a demand curve. Since the supply curve represents the aggregate response of all competing manufacturers of DVPs, a reliable supply curve would be impossible to construct.[10]

Instead, the model represents an equilibrium price towards which the market automatically tends to converge. Although the location of the demand curve may not be known, the relationship described by the demand curve certainly exists, and at some given price only a certain quantity of machines will be sold. At a higher price fewer will be sold, at a lower price more will be sold. The demand curve is like a "ghost", invisible, but nonetheless acting as a constraint upon producer pricing decisions.

The best way to illustrate this is to consider a disequilibrium condition and to see what happens when such a condition persists. Refer to **Figure 1.6**. Suppose the price of digital video

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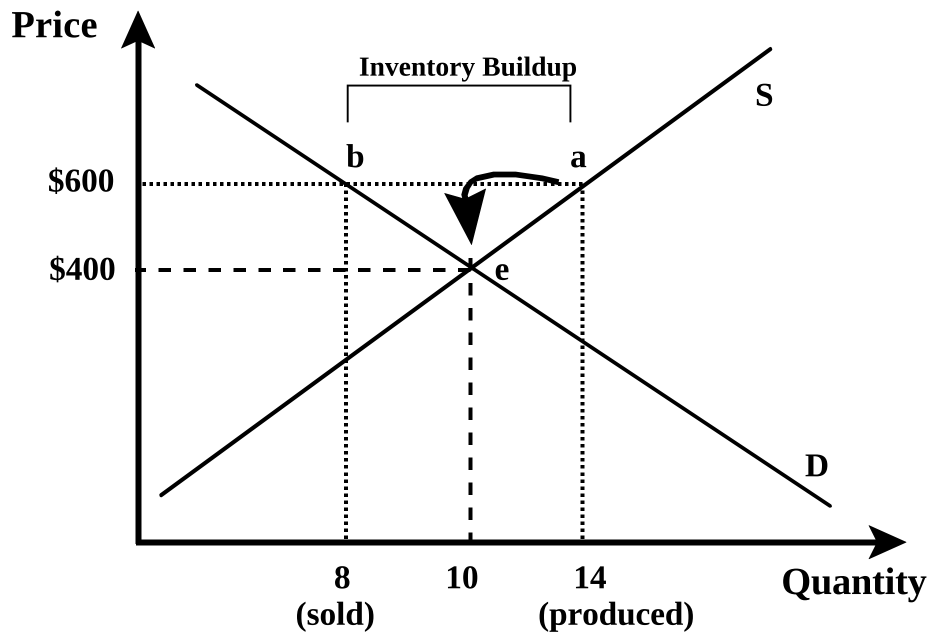
[9]This example was chosen because the more competitive an industry, the better it is represented by this model. It is understood that there are different types of digital video players and a considerable range of quality, but for the sake of developing this model, let us assume a uniform and similar product offered by a large number of manufacturers.

[10]As was stated in the previous chapter, it is possible for economists to make estimates of elasticities of supply and demand curves, but such estimates are limited in their usefulness and are rarely applied in industry.

players is too high, at $600 instead of the market-clearing price of $400. What would happen? The supply curve demonstrates that producers will manufacture more computers than are desired by consumers at that high price. At a price of $600 per unit, consumers only want 8 million units,

Figure 1.6

The Tendency Toward Equilibrium from a Disequilibrium Condition in the Market for Digital Video Players



The appropriate market clearing price is $400. Suppose the actual price was $600. At this price, the quantity of DVPs manufactured would be 14 million (see point **a**). The quantity sold, however, would only be 8 million (see point **b**). This would cause an inventory buildup of 6 million digital video players over the production period. Manufacturers, seeing slow sales and rising inventory, must respond by cutting back on production and reducing prices. This moves them closer to the equilibrium price and level of output described by point **e**.

whereas manufacturers are making 14 million. Because the market is not clearing (production exceeds sales, or supply is greater than demand), this is a disequilibrium condition.

Producers do not have supply and demand curves to tell them that this disequilibrium exists. They don't need them. They know they have problems because they are seeing disappointing sales and because they have an inventory buildup of unsold DVPs. This inventory buildup is represented by the distance between point '**a**' and '**b**' in **Figure 1.6** and, in this example, is equal to 6 million DVPs.

An unwanted inventory buildup is expensive for two reasons. First, the cost of manufactures still must be paid and yet revenues for sales are not being realized, and, second, the company (or retailers for the product) must pay storage and financing costs for maintaining the inventory.

The manufactures, therefore, have no choice but to cut back on production and reduce prices until such time as sales levels and production are at least roughly matched and inventory balances are reconciled. This reaction to the disequilibrium condition is indicated by the arrow in **Figure 1.6**, which demonstrates the tendency of the producer to move prices and production levels back into the general area of the equilibrium point '**e**'.

In the event that prices are too low (not shown), sales would exceed the level of production (i.e. demand would exceed supply), inventories would be depleted, and producers would have the incentive to raise prices and output, again moving them in the direction of equilibrium point '**e**'.

The model, in its purity, merely identifies the market-clearing equilibrium and does not suggest that the manufacturers will immediately and precisely move to the equilibrium. Instead, there would be an automatic tendency to move gradually into the vicinity of the equilibrium. Because in reality both supply and demand conditions are constantly changing, the actual equilibrium is actually shifting around. Producers are dynamically "chasing" that equilibrium by always monitoring inventory and adjusting both prices and levels of production.

The Model as an "Image" of Economic Activity

Two important points are being made here:

1. This model, like most in economies, is not an applied model, where anyone actually uses it to determine appropriate prices and levels of production. (To be more specific, it is not an applied management model; corporations don't use these models to make pricing decisions). Instead, the model represents a type of consistent behavior that economists see in the market place, and it presents an image of that behavior. It allows an economist to both ask and answer the question, "What would we expect to happen in a market where prices are too high or too low? What kind of adjustment would take place, and why?"

2. The market reactions of the economic decision-makers are not undertaken by virtue of their use of this model or any other, but is instead motivated by their necessary response to market signals that tell them that they must alter their decisions. In the example above, the primary signals were poor sales and an unwanted inventory build-up. The model, therefore, simply captures their responses to a series of market signals.

The price variable here is the automatic market-adjusted "clearing mechanism" that keeps production roughly matched to the level of sales. It is the "invisible hand" that regulates the market, as described by Adam Smith more than 200 years ago.

Generally, modeling economic behavior presumes that people consistently respond to the mix of market signals, adjusting their behavior as the incentives change.

Models like the one described here normally imply a more fluid case than is likely to be seen in a real market. Students of economic theory are always told that price movements are sometimes very "sticky" - especially price movements downward and that response times are often long. Likewise, the less competitive an industry, the less likely it is to be well represented by this model. Nonetheless, the model provides a reasonable approximation of economic behavior in competitive markets.

Using a Comparative-Statics Model

The elementary supply-and-demand model has not so far been used for very much. The model becomes interesting and useful when supply or demand is "shocked" or disturbed by some economic variable. When this happens, the supply or demand curve shifts (or both shift) and the model's equilibrium is changed. It is this change in equilibrium that can lead to important economic insights.

Figure 1.7
Variables that Effect Supply and Demand Curves

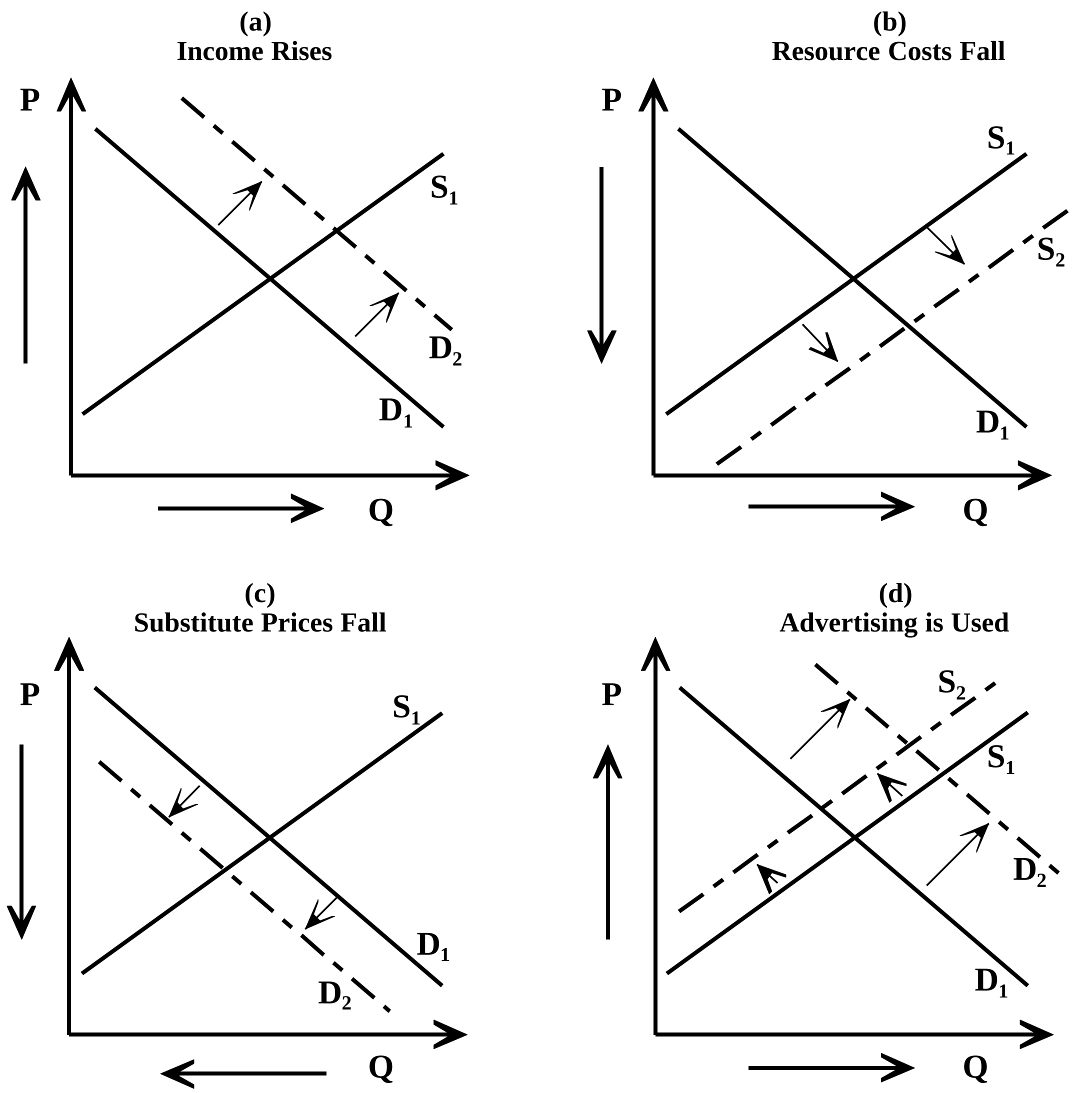
Factors that Effect Demand		**Factors that Effect Supply**	
1. *Price*	**(–)**	**1.** *Price*	**(+)**
2. Income	**(+)**	**2.** Labor Costs	**(–)**
3. Wealth	**(+)**	**3.** Resource Costs	**(–)**
4. Population	**(+)**	**4.** Advertising Costs	**(–)**
5. Advertising	**(+)**		
6. Substitute Prices	**(+)**		
7. Inflationary Expectations	**(+)**		

(+) Shift curve right
(–) Shift curve left

These are some of the variables that will effect supply and demand. The price variables are reflected in the slopes of the supply and demand curves. The other variables, when they change, will cause the appropriate curve to shift to the right or left. The direction of the shift is shown by the sign in the parenthesis: a (+) implies a shift right, a (–) implies a shift left.

Although the supply and demand curves look rather simple, embodied in their structure is a complex relationship to many other economic variables. Refer to the table in **Figure 1.7**. Shown in that table are a list of variables that will influence supply and demand curves. The list is

Figure 1.8
Examples of Shifts in Supply and Demand Curves



In graph **(a)** consumer income rises. This causes demand to shift right, raising prices and output.

In graph **(b)** a fall in the cost of resources used in manufacturing increases supply, causing prices to fall and output to rise.

In graph **(c)** the price of a substitute good falls, lowering demand for this product, with the obvious result.

In graph **(d)** advertising influences both demand and supply, the latter because it is a cost.

not exhaustive; it is meant to be illustrative. These variables represent the fact that the demand and supply curves implicitly reflect demand and supply functions in all of these variables. In other words, to list the factors that effect demand is merely another way of saying that "the quantity demanded is a function of the price of the product, consumer income, consumer wealth, etc.

The **(+)** and **(-)** signs to the right of the variable names indicate the presumed sensitivity of supply or demand to that variable. For example, the **(+)** sign next to **Income** in the list of factors that effect demand indicates that if income rises, demand will rise.

The sensitivity of the price variables are represented by the slopes of the curves. The **(-)** sign next to the price variable for demand indicates the demand curve will have a negative slope. The equivalent sign on the supply side indicates that the supply curve will have a positive slope. Both were drawn this way in **Figure 1.5**. All other variables cause a shift in their respective curves. The plus **(+)** sign indicates a shift to the right if the variable is rising, and a shift to the left if it is falling. A negative **(-)** sign indicates a shift to the left if the variable is rising and a shift to the right if it is falling.[11]

For some examples, see **Figure 1.8**. In **graph (a)** income has risen. The **(+)** sign next to Income in the table in **Figure 1.7** indicates that this should shift the demand curve to the right, as shown. Consequently at the new equilibrium, price and output will be higher. **Graph (b)** shows the effect of a decline in resource costs. Since the sign associated with costs is negative **(-)**, a decline in costs will cause the supply curve to shift right. (A rise in costs would cause the supply curve to shift left.) Prices fall and output grows, a result that confirms intuition.

Suppose in the DVP example, the price of digital VCRs, a close substitute for the DVP, falls. This will cause the demand curve for the DVP to shift left representing a decline in demand, as is shown in **graph (c)**. This makes sense because the price of the competing product, the digital VCR, makes it more attractive, and some consumers are lured away. Hence, the manufacturers of the DVP must lower their prices as well.

The reader should now understand what would happen if the manufacturers of the DVP refused to lower their prices in the face of such competition. Because of the collapse in the demand for their product, they would face an unwanted inventory buildup. Eventually they would have no choice but to cut production and prices.

Finally, **graph (d)**shows the effect of a variable, advertising, which influences both supply and demand. Demand grows, shifting right (that is the purpose of advertising) but because advertising is a cost, supply also shifts right. Presumably the effect upon demand would be far greater than upon supply, as shown, or the advertising would not be justified.

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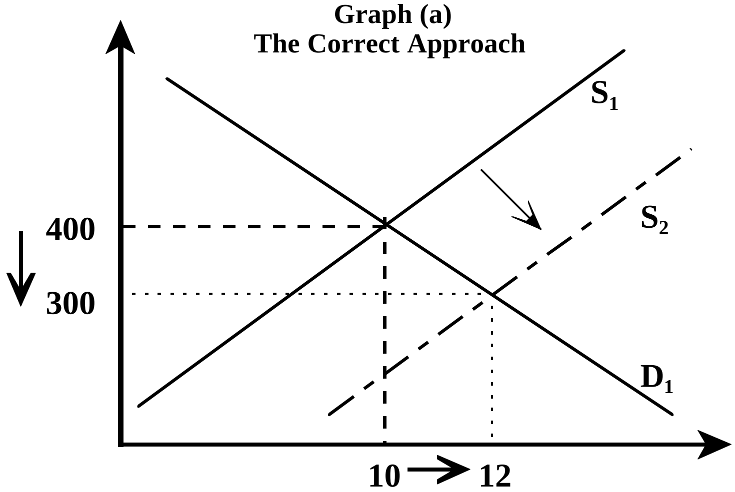
[11]For the reader who knows calculus, the signs merely represent the signs of the first derivatives of these variables in the supply and demand functions. For example, given that quantity demanded is a function of price, income, wealth, etc., the positive sign next to income indicates that the first derivative of quantity supplied with respect to income is positive, or $(\partial S / \partial I) > 0$.

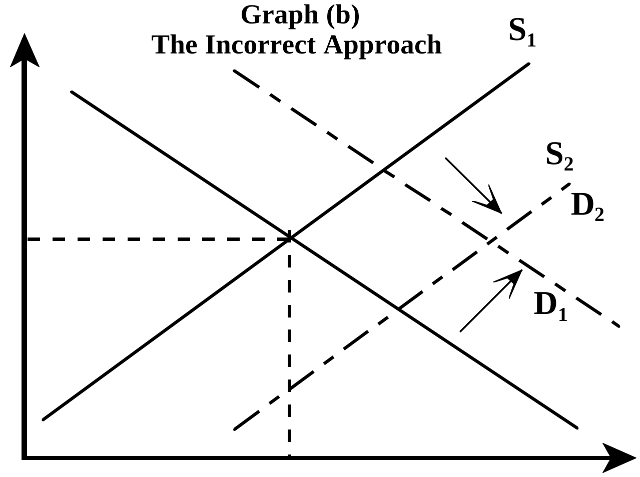
Figure 1.9
The Effect of Cost Reductions Upon Quantity Demanded:
A Correct and an Incorrect Approach

Graph (a)
The Correct Approach



Cost is a factor that effects the Supply Curve only. Therefore only the supply curve shifts.

Graph (b)
The Incorrect Approach



Since none of the factors (except price) effecting the Demand Curve have changed, the Demand Curve should not shift.

Cause and Effect in Comparative Statics Models

Students using comparative statics models sometimes confuse the direction of cause and effect, or the direction of influence of one variable upon another.

For an example, consider the answer to the following question:

"Assume that technology lowers manufacturing costs for this product. How would one show, using the microeconomic supply-and-demand model, that quantity demanded of the product will ultimately rise because of this impact of technology?"

Refer to **Figure 1.9**. Shown are two answers, one correct and the other incorrect. **Graph (a)**, where only the supply curve shifts, is the correct answer, and **graph (b)**, which is incorrect, shows an answer often provided by students. In **graph (a)**, the reduction in costs due to new technology causes the supply curve to shift to the right. This causes the equilibrium price to fall, from $400 to $300. The stationary demand curve indicates at this lower price, the quantity demanded will rise. In this example, it rises from 10 million to 12 million units. Quantity demanded has grown by 2 million units because of the decline in price, which in turn is due to cost reduction.

A common mistake among students is to reason ahead of the model, presuming that to show the increase in demand, the demand curve must be shifted. This is a mistake. The slope of the demand curve already represents the response to different prices. Therefore, if the price change is originating on the supply side, the change in equilibrium must be shown as due to a shift in the supply curve, and the change in quantity demanded is shown as a movement along the stable demand curve.

Generally, the following rule must be remembered: A supply or demand curve cannot be shifted unless one of the variables (except price) in the list of factors that effect that curve have changed. In this example, the initial equilibrium was changed because of a change in production costs. This was the initial cause. Costs are included in the list of factors that affect supply (refer back to **Figure 1.7**) but not demand. Therefore, only the supply curve shifts.

The reduction of cost was the initial cause, the decline in price was the intermediate effect, and the resulting decline in quantity demanded was the final effect.

What Comes Next?

This completes our introduction to the conventional supply and demand model. It is now time to move on to the macroeconomics extension of this elementary model. In the chapter that follows, the **Aggregate Supply/Aggregate Demand** model will be developed. This comparative statics model is used to evaluate changes in demand or supply conditions upon the level of real output and the price level. Expectations-enhanced applications will also be shown.

In the subsequent chapter the **Loanable Funds** model will be developed. This is a model of the finance markets, used primarily to explain the determination of interest rates and explore developments in the finance markets that might affect business cycles.

[Note: In some editions of this text, the chapter on **Loanable Funds** is followed by a chapter on macroeconomics simulation models and a chapter on the IS/LM model].