Importance of Models in Economics

Introduction

There are many tools that help people perform a task or an activity in everyday life easier; map is used for telling the direction and helping people choose the right way; microwave is an important kitchen tool in the modern life-style that reduces time to warm and to cook food; or electronic mail is an important information technological innovation that allow people to keep in contact with the people who live far away from them. In the same way, biologists use human body models as their tools to explain how internal organs work; engineers build models to see how the system works; also, economists use models as their tools to help them in dealing with problems or historical data in the economy.

Economics is one branch of social sciences that is concerned with money flows, trade activities, and industrial systems in the society. Economists use the scientific approach for developing economic theories. Considering the way to test a theory, in economics it is not easy as it is in the scientific world; scientists can make an experiment under the controlled environment or the given conditions to test their theories. How do economists make a real experiment in economic system which is concerned with the real society? In this case they need specific tools, i.e. models and historical data, to fulfill their approach.

What are models in economics? How do they differ from each other? Where and when do economists use them? And the most important question, why do they need models in economics?

Answers to all these questions will give more understanding about the role and the importance of models in economics. In the following parts these issues will be discussed in more detail .

What is a 'Model'?

Firstly, it is better to start with the meaning of a *model*. In Oxford Advanced Learner's dictionary by Hornby (2000) there is one meaning of a model as the following paragraph:

> A *model* is a simple description of a system which used for explaining how something works or calculating what might happen, etc: *a mathematical model for determining the safe level of pesticides in food, a realistic model of evolution*

This definition of a model shows the general way of thinking about it; a model can be used for many purposes such as an explanation of the system or a calculating process. Many economists have their own specific definitions of a model in economics. The following definitions are taken from some economic textbooks.

> Samuelson and Nordhaus (1998) gave the definition of a *model* as a formal framework for representing the basic features of a complex system by a few central relationships. Models take the form of graphs, mathematical equation, and computer programs.

> Begg, Fischer, and Dornbusch (2000) found that a *model* or theory makes a series of simplification from which it deduces how people will behave. It is a deliberate simplification of reality.

Scientists and mathematicians use their models in problem-solving and problem-analyzing process. In the same way economists also use a model in economics to analyze and visualize the economic problem. One branch of mathematics concerning the problem-solving process is called mathematical modeling, in this field mathematicians try to construct and simplify a model (a set of mathematical equations) to explain how the whole system works and use the model to calculate and predict what might happen in case that the system continues working in the same given conditions. Like mathematical modeling, econometrics is one branch of economics that uses the methods of statistics to measure and estimate quantitative economic relationships. Samuelson and Nordhaus (1998) gave the definition of an econometric model as the following:

> An econometric model is a set of equations, representing the behavior of the economy, that has been estimated using historical data.

Nowadays there is an entire industry of econometricians estimating macroeconomic models and forecasting the future of the economy. Many of them developed computer programs in order to calculate the complicated system of mathematical equations. We will discuss more about the different types of models in economics in the following section.

Types of Models in Economics

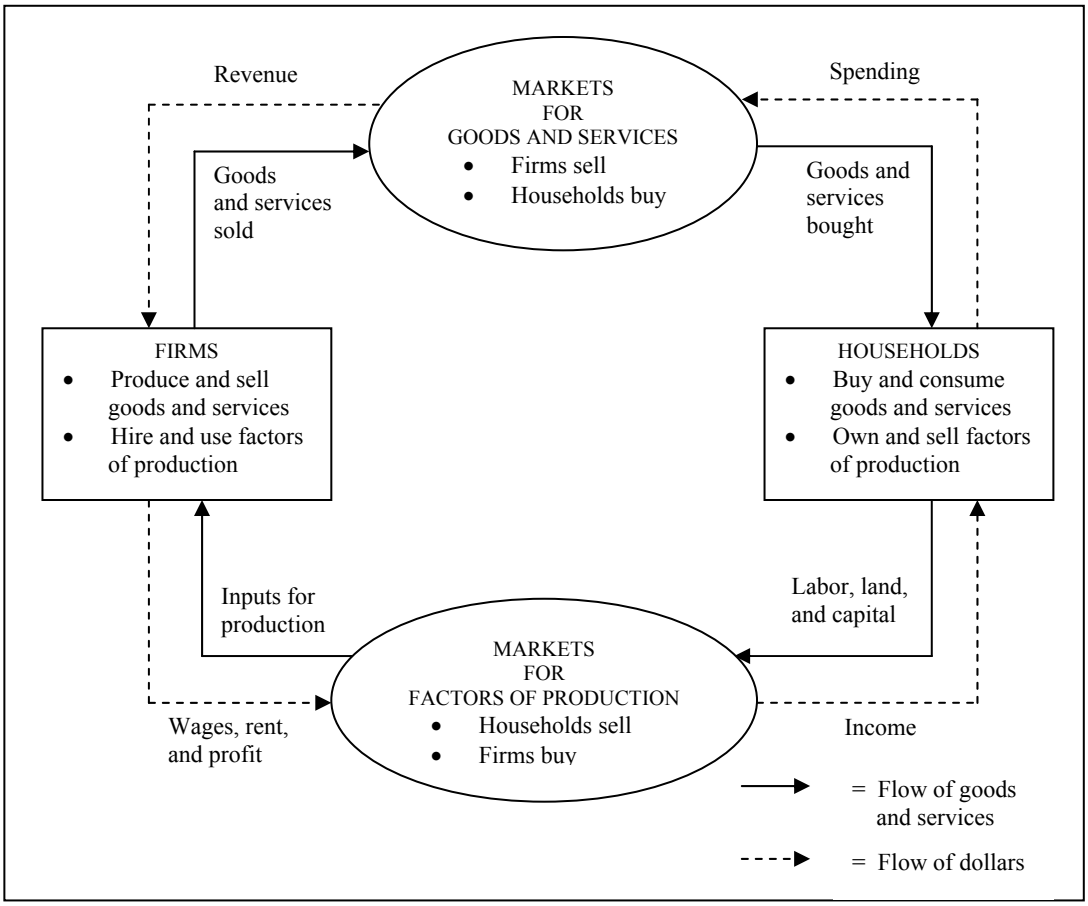
From the definition of a *model*, it has been said that models in economics have the wide range of forms including graphs, diagrams, and mathematical models. Economists use these models in different purposes; it depends on many factors such as what type of raw data they have, how they can represent the data, and what they want from the model they use. In this section it will be more explanation about what is the main role of these different models and also some important examples in economics.

Flow Chart

Flow chart is a diagram that shows the connections between the different stages of a process or parts of a system. Economists use a flow chart to explain how the economy is organized and how participants in the economy interact with one another. If people follow the right connections in the flow chart diagram It will be easier for them to understand the relationship between participants in the economy.

One of the important flow chart using in economics is called the c*ircular-flow diagram,* presented in Figure 1. *Circular-flow diagram* is a visual model of the economy that shows how dollars flow through market among households and firms.

FIGURE 1 Circular-flow diagram



Graph

Graph is a planned drawing, consisting of a line or lines, showing how two or more sets of numbers are related to each other. In general the different types of graphs can be separated by using the number of variables represented in the graph, i.e. graphs of a single variable such as pie graphs, bar graphs, or time-series graphs; graphs of two variables (these variables are represented by the x- and y-coordinate) such as scatter diagrams; and graphs of more than two variables (these graphs are represented by more than 2 coordinates). In economics many kinds of graphs are used: some graphs show how variables change over time; other graphs show the relationship between different variables. So it is important to know what is the difference between these graphs and how to choose the right one to represent observed or interested data.

While there are so many different kinds of graph in general meaning, it is better to focus on only the important types of graphs using in economics. The following part is provided more explanation about the main types of graphs in economics including *production possibilities frontier (PPF), time-series graph, scatter diagrams, and multicurve diagrams.*

Production possibilities frontier or PPF is a graph that shows the combinations of output that the economy can possibly produce given the available factors of production and the available production technology.

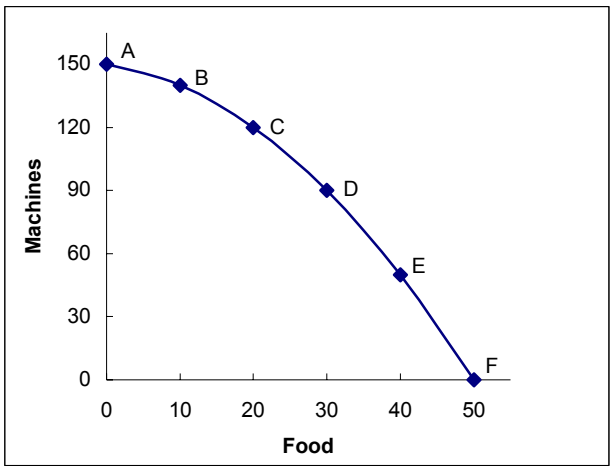


FIGURE 2 Production Possibilities Frontier

This figure shows the six possible pairs of food-machines production levels. A smooth curve fills in between the plots pairs of points, creating the production possibilities frontier.

Time-series graphs show how a particular variable moves over time. Time-series graphs have time on the horizontal axis and variables of interest on the vertical axis. Some example of time-series graphs using in economics is the *debt-GDP ratio*.

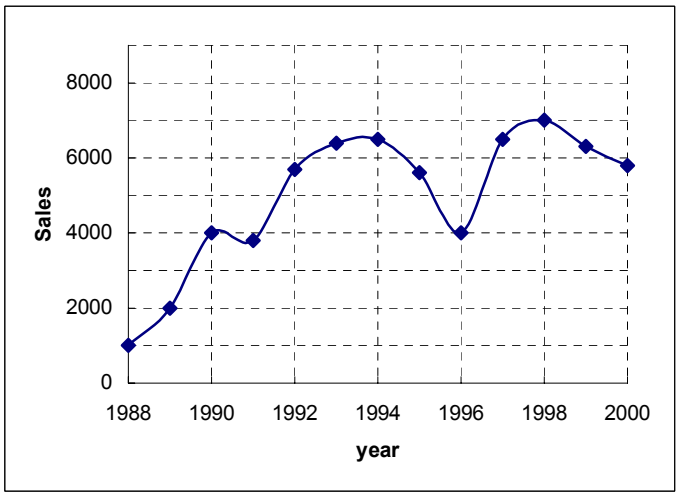


FIGURE 3 Time-Series graph

This figure shows a particular company's sales from 1988 to 2000

Scatter diagrams show observations on a pair of variables. In some cases only individual pairs of points will be plotted; in many cases it is normal to find scatter diagrams plotted as the combination of variables for different periods of time (month, year, etc.). An important example of a scatter diagram in macroeconomics is the *consumption function*.

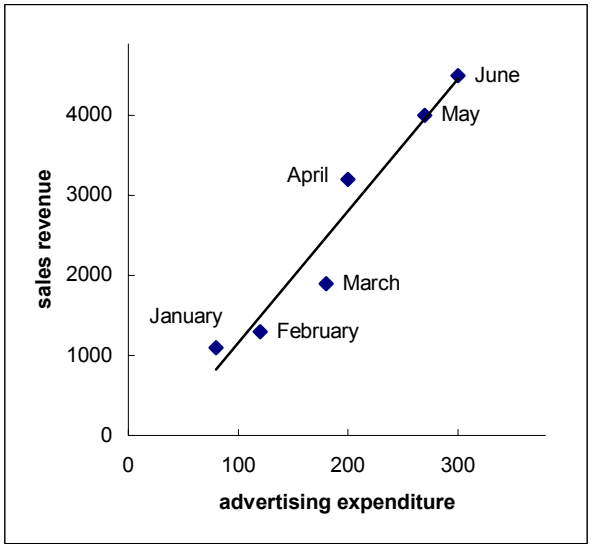


FIGURE 4 Scatter diagram

This figure shows the relationship between the monthly advertising expenditure and the monthly sales revenue of a company during 6 months. The line in the scatter diagram shows the trend of the data.

Multicurve diagrams show two or more relationships in a single graph. In many cases only one curve in a graph is not enough to analyze the complicated system of economic problem. Therefore it will be useful to present more than one curve in the single graph in order to see the relationship between these curves. The most important example of the multicurve diagrams is the *supply-and-demand diagram*, shown in figure 5.

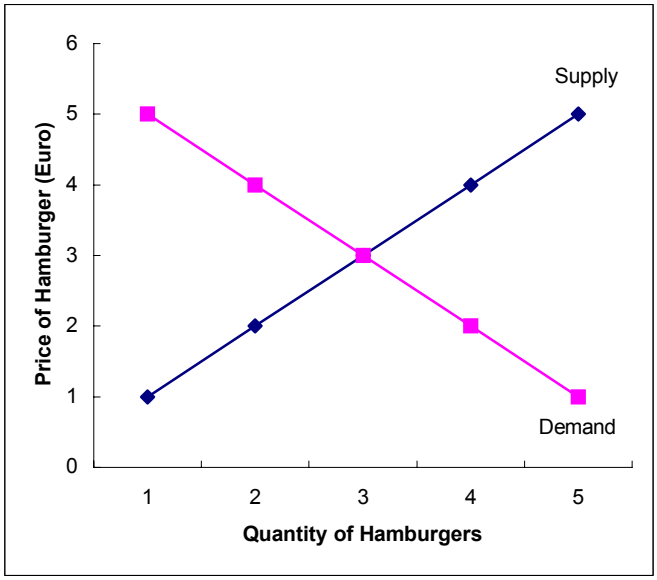


FIGURE 5 Supply-and-demand diagram

This figure shows the relationship between the quantity of hamburgers and the price of the hamburger, and the relationship between the supply curve and the demand curve.

Mathematical Model

A *mathematical model* can be broadly defined as a formulation or equation that expresses the essential features of a physical system or process in mathematical terms. In a very general sense, it can be represented as a functional relationship of the form

$$\text{Dependent variable} = f(\text{independent variables, parameters, forcing functions}) \qquad (1)$$

Where the *dependent variable* is a characteristic that usually reflects the behavior or state of the system; the *independent variables* are usually dimensions, such as time and space, along which the system's behavior is being determined; the *parameters* are reflective of the system's properties or composition; and the *forcing functions* are external influences acting upon it.

The actual mathematical expression of equation (1) can range from a simple algebraic relationship to large complicated sets of differential equations. Economists use a mathematical model as a 'theory' to determine the particular problem. Many proven mathematical models are used in economics as the formulas to help economists calculate and analyze the numerical issues easier, e.g. the rule of 70. Econometricians use the scientific way of thinking to develop a new econometric model or a theory to explain the economic system.

When a model is built up, it is a safe way to writing down all the factors that is related to the studied economic issue, otherwise it might have been forgotten some influenced factors that can make the trouble inside the model. More detail about how economists develop a model will be discussed later. Some example of econometric model is the model using for forecasting the GDP.

Why do economists need a 'Model'?

To answer this question, it is better to understand the way economists use to analyze, solve and foresee a particular economic issue. As it is mentioned before that economists use the scientific approach to deal with economic problems, the scientific approach starts from scientific observation (it can be the environment or other fields of interest), after that they will build up a hypothesis, then they will use the scientific experiment or existing theories to prove their hypothesis and they will reach a conclusion that can be true of false (it depends on the results from their experiment). Economists use this way when they think about a particular issue in the economy; they try to simplify an economic issue in the way that everyone will understand and be able to follow their thought; they try to find a formula that can help them calculate the numerical issue; they try to develop a new economic theory to explain the economic behavior in the real world. What do they need to fulfill these approaches? Absolutely, they need a tool to help them and in this case it is called a 'model'. The ways that economists use models can be classified into three purposes: explaining an economic process, examining an economic issue, and developing a new economic theory.

Explaining an economic process

From Chinese proverb "A picture is worth a thousand words", it is true that a picture can express idea better than words or equations. Graphics help economists in many specific purposes: some shows the relationship of observed data; some shows how the economic process runs; some shows the trend from historical data. Graphs and flow charts play the main role in this purpose of using models. There are some examples from the previous part: the production possibilities frontier shows the relationship between the available factors of production and the available production technology; the circular-flow diagram shows how dollars flow through market among households and firms; and the famous supply-and-demand diagram shows the relationship of demand and supply curves in the same frame.

These types of models help them see the picture of the process, know how data relate to each others, and clarify the idea about the problem. These types of models will be used as a combination with mathematical models and applied in the other purposes.

Examining an economic issue

What do economists want to know from observed data? Not only do they want to see how the system looks like or the relationship in the graphic way, but they also want to see the trend or changes from observed data. Economists use the wide range of mathematical models to examine the economic issues: some simple formulas are used to calculate a new value from given data or analyze it; some mathematical models are used in the problem-solving process; some equations are used to estimate and forecast the change in the economy.

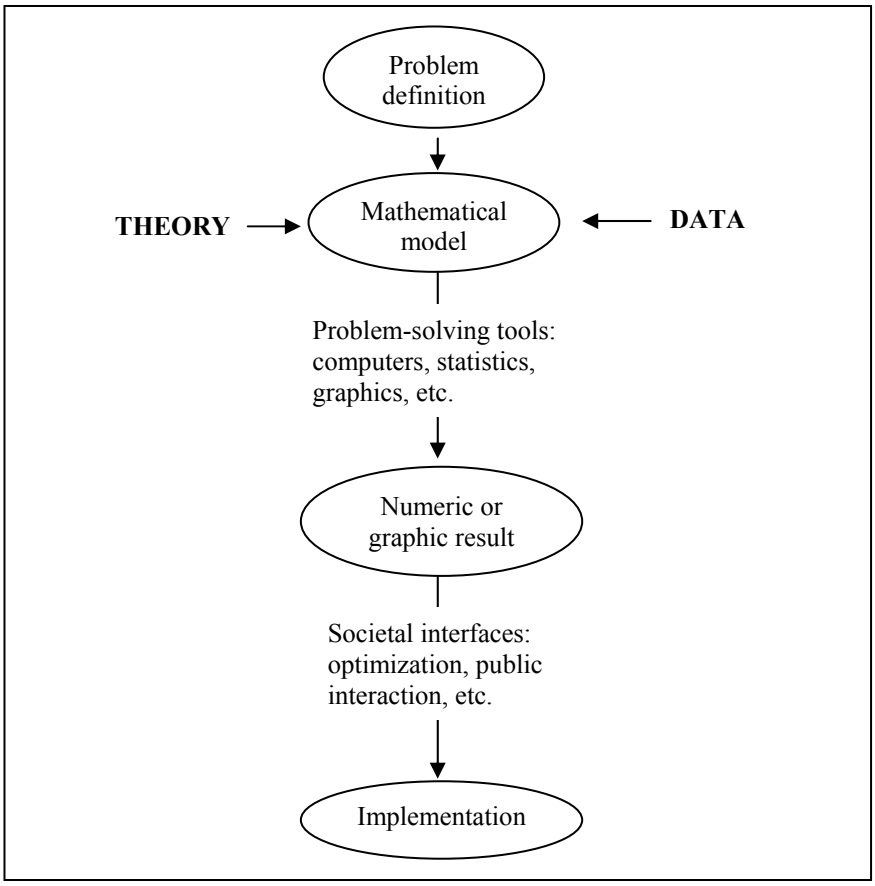
Firstly, it is the best way to start with a simple mathematical equation that is used to calculate and measure the change in the economy such as the *percentage change* and the *growth rate*.

> The *percentage change* is the absolute change divided by the original number, then multiplied by 100.

It is quite often to see economic data in the report presented as the percentage. When data is studied over the period of time it will defined as the growth rate that is the percentage change per period (typically per year). Economists usually use economic growth (the percentage annual change in the national income of a country a group of countries) in order to see, analyze and forecast the trend and the economic situation of the observed country.

Secondly, a model is required in the problem-solving process. This process (shown in figure 6) can be divided into 4 steps: problem definition, mathematical model, numerical or graphic result, and implementation. Not only a mathematical model is used in the problem-solving process, but also the graphics, statistics, etc. are used as the problem-solving tools.

FIGURE 6 The problem-solving process



And the last point, some models are used to estimate and forecast the future trend. Economists have developed forecasting tools to help them foresee changes in the economy. Forecasting models are built up by the combination of mathematical models and historical data, as the system of equations. Nowadays large systems forecast from a few hundred to 10,000 variables. This is the main purpose of econometrics and it is not easy to deal with forecasting. An example of the important forecasting is GDP forecasting. The forecasting result can not 100% true some error can be occurred, it depends on how good the system of equations they set up and how many variables they put into their model.

Developing a new economic theory

The good theories help economists measure the changes, see the new trend, and predict the future result in the economy. How do they develop a new economic theory? They have to combine the scientific approach, the mathematical knowledge, and historical economic data together. Then they will use the problem-solving process to find the suitable model for the particular problem, after that they have to test their model and if it is true they can use it as a new theory. It sounds like an easy process but it is not easy to simplify reality to a model. Most of economic theories are developed by based on or related to the existing theories (or models).

Some simple formulas that use in economics , like the rule of 70, comes from the complex mathematical method. The rule of 70 or the doubling time is derived from the *exponential growth model*. The following part shows the way the rule of 70 is developed.

The equation (2) is called the *exponential growth model*. A quantity is said to have an *exponential growth model* if at each instant of time its rate of increase is proportional to the amount of the quality present.

If we are given a quantity y with an exponential growth, and if we know the amount present at some initial time, then we can calculate the amount present at any time t by using the following equation

$$y(t) = y_0 e^{kt} \tag{2}$$

where $y(t)$ is the amount present at any time t; y_0 is the amount present at some initial time $t = 0$; and the constant k ($k > 0$) is the growth rate.

Exponential growth models have proved useful in studies of population growth (for forecasting purpose). One useful application of the exponential growth model is the doubling time.

If a quantity y has an exponential growth model, then the time required for it to double in size is called the *doubling time*. Doubling times depend only on the growth rate and not on the amount present initially. By using the mathematical method, we can derive the equation (3) from assuming the amount y has an exponential growth model.

$$T = 1/k \ln 2 \tag{3}$$

Where T is the amount of time required for y to double in size; the constant k ($k > 0$) is the growth rate; and $\ln 2 \approx 0.6931$. In economics, we use this applied method and called it as the rule of 70. While the approximate value of ln 2 is 70, if 70 is divided by the percentage change it will be a required period that the initial amount will be double in size. From this origin of the rule of 70, it has been shown that it is not simple to develop a formula, though the formula itself looks very simple.

Conclusion

From the previous parts, it has been discussed about 'what is a model?', 'types of models in economics', and 'why do economists need a model?'. These topics give the better and clearer view about the role of models in economics. If economists didn't have models, how could they express their ideas in order to make other people follow and understand their ideas? It is not easy to explain any economic issues without using graphs, diagrams, or equations.

These Models are the essential tools for economists. The main purpose of using them is to simplify reality. It is easier to understand economic issues when they are represented data by models. In economics models have important roles in calculating numerical issues, showing the visualized version of data, and explaining how the process runs.

Econometrics is a supporting branch of economics for forecasting changes in economics and developing new economic theories. Econometricians apply a high level of mathematical knowledge to explain and foresee economic issues.

There are some criticisms about models in economics; for example, a contrast between models and the purpose of using models, models are used to simplify reality but most of them are not easy to understand and always explain by using complicated systems of equations. In this point there is no true or false agreement for it; not only is it true that models should be simple and easy to understand but it is also important to include all influenced factors in models in order to reduce errors.

Models are used widely in economic reports and researches. Importance of models in economics is not only tools for economists, but also how they use these tools; how to choose the right one. They separated econometrics as a branch of economics for further studies about models. From these discussions it can be concluded that models are very important in economics.

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