

# Chapter 1

## Preliminaries on Modern Economics and Mathematics

In this chapter, we first set out some basic terminology and key assumptions imposed in modern economics in general and in these lecture notes in particular. We will discuss the standard analytical framework adopted in modern economics. We will also discuss methodology for studying modern economics as well as some key points one should give their attention to. The methodology for studying modern economics and key points include: providing studying planforms, establishing reference/benchmark systems, developing analytical tools, generality and limitation of an economic theory, the role of mathematics, distinguishing necessary and sufficient conditions for a statement, and conversion between economic and mathematical language. We will then discuss some basic mathematics results that we will use in these lecture notes.

### 1.1 Nature of Modern Economics

#### 1.1.1 Modern Economics and Economic Theory

- What is economics about?

*Economics* is a social science that studies individuals' economic behavior, economic phenomena, as well as how individual agents, such as consumers, firms, and government agencies, make trade-off choices that allocate limited resources among competing uses.

People's desires are unlimited, but resources are limited, therefore individuals must make trade-offs. We need economics to study this fundamental conflict and how these trade-offs are best made.

- Four basic questions must be answered by any economic institution:

- (1) What goods and services should be produced and in what quantity?
- (2) How should the product be produced?
- (3) For whom should it be produced and how should it be distributed?
- (4) Who makes the decision?

The answers depend on the use of economic institutions. There are two basic economic institutions that have been so far used in the real world:

- (1) Market economic institution (the price mechanism): Most decisions on economic activities are made by individuals. This primarily decentralized decision system is the most important economic institution discovered for reaching cooperation amongst individuals and solving the conflicts that occur between them. The market economy has been proven to be only economic institution, so far, that can keep sustainable development and growth within an economy.
- (2) Planning economic institution: Most decisions on economic activities are made by governments, which are mainly centralized decision systems.

- What is Modern Economics?

*Modern economics*, developed in last fifty years, systematically studies individuals' economic behavior and economic phenomena by the scientific studying method – observation → theory → observation – and through the use of various analytical approaches.

- What is Economic Theory?

An *economic theory*, which can be considered an axiomatic approach, consists of a set of assumptions and conditions, an analytical framework, and conclusions (explanations and/or predications) that are derived from the assumptions and the analytical framework.

Like any science, economics is concerned with the explanation of observed phenomena and also makes economic predictions and assessments based on economic theories. Economic theories are developed to explain the observed phenomena in terms of a set of basic assumptions and rules.

- Microeconomic theory

Microeconomic theory aims to model economic activities as the interaction of individual economic agents pursuing their private interests.

### **1.1.2 Key Assumptions and Desired Properties Commonly Used Economics**

Economists usually make some of the following key assumptions and conditions when they study economic problems:

- (1) Individuals are (bounded) rational: self-interested behavior assumption;
- (2) Scarcity of Resources: Individuals confront scarce resources;
- (3) Economic freedom: voluntary cooperation and voluntary exchange;
- (4) Decentralized decision makings: One prefers to use the way of decentralized decision making because most economic information is incomplete or asymmetric to the decision marker;
- (5) Incentive compatibility of parties: the system or economic mechanism should solve the problem of interest conflicts between individuals or economic units;
- (6) Well-defined property rights;
- (7) Equity in opportunity;
- (8) Allocative efficiency of resources;

Relaxing any of these assumptions may result in different conclusions.

### **1.1.3 The Basic Analytical Framework of Modern Economics**

The basic analytical framework for an economic theory consists of five aspects or steps: (1) specifying economic environments, (2) imposing behavioral assumptions, (3) presenting economic institutional arrangements, (4) determining equilibria, and (5) making evaluations. The framework is used to study particular economic issues and questions that economists are interested in. To have good training in modern economics, one needs to master these five aspects. To understand various economic theories and arguments, it is also important to understand these five aspects.

Understanding this basic analytical framework can help people classify possible misunderstandings about modern economics, and can also help them use the basic economic principles or develop new economic theories to solve economic problems in various economic environments, with different human behavior and institutional arrangements.

#### **1. Specifying Economic Environment**

The first step for studying an economic issue is to specify the economic environment. The specification on economic environment can be divided into two levels: 1) description of the economic environment, and 2) characterization of the economic environment. To perform these well, the description is a job of science, and the characterization is a job of art. The more clear and accurate the description of the economic environment is, the higher the possibility is of the correctness of the theoretical conclusions. The more refined the characterization of the economic environment is, the simpler and easier the arguments and conclusions will obtain.

Modern economics provides various perspectives or angles to look at real world economic issues. An economic phenomenon or issue may be very complicated and be affected by many factors. The approach of characterizing the economic environment can grasp the most essential factors of the issue and take our attention to the most key and core characteristics of an issue so that we can avoid unimportant details. An economic environment usually consists of (1) a number of individuals, (2) the individuals' characteristics, such as preferences, technologies, endowments, etc. (3) informational structures, and (4) institutional economic environments that include fundamental rules for establishing the basis for production, exchange, and distribution.

## 2. Imposing Behavior Assumptions

The second step for studying an economic issue is to make assumptions on individuals' behavior. Making appropriate assumptions is of fundamental importance for obtaining a valuable economic theory or assessment. A key assumption modern economics makes about an individual's behavior is that an individual is self-interested. This is a main difference between individuals and other subjects. The self-interested behavior assumption is not only reasonable and realistic, but even when the assumption is not correct; the assumption poses little threat to viability of the research. A rule of a game designed for self-interested individuals is likely also suitable for altruists, but the reverse is likely not true.

## 3. Presenting Economic Institutional Arrangements

The third step for studying an economic issue is to give or determine the economic institutional arrangements, which are also called economic mechanisms, which can be regarded as the rules of the game. Depending on the problem under consideration, an economic institutional arrangement could be exogenously given or endogenously determined. For instance, when studying individuals' decisions in the theories of consumers and producers, one takes the market mechanism as given. However, when considering the choice of economic institutions and arguing the optimality of the market mechanism, the market institution is endogenously determined. The alternative mechanisms that are designed to solve the problem of market failure are also endogenously determined. Economic arrangements should be designed differently for different economic environments and behavior assumptions.

## 4. Determining Equilibria

The fourth step for studying an economic issue is to make trade-off choices and determine the "best" one. Once given an economic environment, institutional arrangement, and other constraints, such as technical, resource, and budget constraints, individuals will react, based on their incentives and own behavior, and choose an outcome from among the available or feasible outcomes. Such a state is called *equilibrium* and the outcome an *equilibrium outcome*. This is the most general definition an economic "equilibrium".

## 5. Making Evaluations

The fifth step in studying an economic issue is making evaluations and value judgments of the chosen equilibrium outcome and economic mechanism based on certain criterion. The most important criterion adopted in modern economics is the notion of efficiency or the "first best". If an outcome is not efficient, there is room for improvement. The other criteria include equity, fairness, incentive-compatibility, informational efficiency, and operation costs for running an economic mechanism.

In summary, in studying an economic issue, one should start by specifying economic environments and then study how individuals interact under the self-interested motion of the individuals within an exogenously given or endogenously determined mechanism. Economists usually use "equilibrium," "efficiency", "information", and "incentive-compatibility" as focal points, and investigate the effects of various economic mechanisms on the behavior of agents and economic units., show how individuals reach equilibria, and evaluate the status at equilibrium. Analyzing an economic problem using such a basic analytical framework has not only consistence in methodology, but also in getting surprising (but logically consistent) conclusions.

### 1.1.4 Methodology for Studying Modern Economics

As discussed above, any economic theory usually consists of five aspects. Discussions on these five steps will naturally amplify into how to combine these five aspects organically. To do so, economists usually integrate various studying methods into their analysis. Two methods used in modern economics are providing various levels and aspects studying planforms and establishing reference/benchmark systems.

#### Studying Planform

A studying planform in modern economics consists of some basic economic theories or principles. It provides a basis for extending the existing theories and analyzing more deep economic issues. Examples of Studying Planforms:

- (1) Consumer and producer theories provide a bedrock planform for studying

- individuals' independent decision choices.
- (2) The General equilibrium theory is based on the theories of consumers and producers and is a higher level platform. It provides a basis for studying interactions of individuals within a market institution and how the market equilibrium is reached in each market.
  - (3) The mechanism design theory provides an even higher level of studying platform and can be used to study or design an economic institution. It can be used to compare various economic institutions or mechanisms, as well as to identify which one may be an "optima".

### **Reference Systems/Benchmark**

Modern economics provides various reference/benchmark systems. A reference system is a standard economic model/theory that results in desired or ideal results, such as efficiency/the "first best". The importance of a reference system does not rely on whether or not it describes the real world correctly or precisely, but instead gives a criterion for understanding the real world. It is a mirror that lets us see the distance between various theoretical models/realistic economic mechanisms and the one given by the reference system. For instance, the general equilibrium theory we will study in these notes is such a reference system. With this reference system, we can study and compare equilibrium outcomes under various market structures with the ideal case of the perfectly competitive mechanism. Other examples include the Coase Theorem in property rights theory and economic law, and the Modigliani-Miller Theorem in corporate finance theory.

Although those economic theories or economic models as reference systems may have many unrealistic assumptions, they are very useful, and can be used to make further analysis. They establish criteria to evaluate various theoretical models or economic mechanisms used in the real world. A reference system is not required, in most cases it is actually not needed, to predicate the real world well, but it is used to provide a benchmark to see how far a reality is from the ideal status given by a reference system. The value of a reference system is not that it can directly explain the world, but that it provides a benchmark for developing new theories to explain the world. In fact, the establishment of a reference system is very important for any scientific subject, including

modern economics. Anyone can talk about an economic issue but the main difference is that a person with systematic training in modern economics has a few reference systems in her mind while a person without training in modern economics does not so he cannot grasp essential parts of the issue and cannot provide deep analysis and insights.

### **Analytical Tools**

Modern economics also provides various powerful analytical tools that are usually given by geometrical or mathematical models. Advantages of such tools can help us to analyze complicated economic behavior and phenomena through a simple diagram or mathematical structure in a model. Examples include (1) the demand-supply curve model, (2) Samuelson's overlapping generation model, (3) the principal-agent model, and (4) the game theoretical model.

## **1.1.5 Roles, Generality, and Limitation of Economic Theory**

### **Roles of Economic Theory**

An economic theory has three possible roles: (1) It can be used to explain economic behavior and economic phenomena in the real world. (2) It can make scientific predictions or deductions about possible outcomes and consequences of adopted economic mechanisms when economic environments and individuals' behavior are appropriately described. (3) It can be used to refute faulty goals or projects before they are actually undertaken. If a conclusion is not possible in theory, then it is not possible in a real world setting, as long as the assumptions were approximated realistically.

### **Generality of Economic Theory**

An economic theory is based on assumptions imposed on economic environments, individuals' behavior, and economic institutions. The more general these assumptions are, the more powerful, useful, or meaningful the theory that comes from them is. The general equilibrium theory is considered such a theory.



## **Limitation of Economic Theory**

When examining the generality of an economic theory, one should realize the boundary, limitation, and applicable range of economic theory. Thus, two common mistakes in the use of an economic theory should be avoided. One mistake is to over-evaluate the role of an economic theory. Every theory is based on some imposed assumptions. Therefore, it is important to keep in mind that every theory is not universal, cannot explain everything, but has its limitation and boundary of suitability. When applying a theory to make an economic conclusion and discuss an economic problem, it is important to notice the boundary, limitation, and applicable range of the theory. It cannot be applied arbitrarily, or a wrong conclusion will be the result.

The other mistake is to under-evaluate the role of an economic theory. Some people consider an economic theory useless because they think assumptions imposed in the theory are unrealistic. In fact, no theory, whether in economics, physics, or any other science, is perfectly correct. The validity of a theory depends on whether or not it succeeds in explaining and predicting the set of phenomena that it is intended to explain and predict. Theories, therefore, are continually tested against observations. As a result of this testing, they are often modified, refined, and even discarded.

The process of testing and refining theories is central to the development of modern economics as a science. One example is the assumption of perfect competition. In reality, no competition is perfect. Real world markets seldom achieve this ideal. The question is then not whether any particular market is perfectly competitive, almost no market is. The appropriate question is to what degree models of perfect competition can generate insights about real-world markets. We think this assumption is approximately correct in certain situations. Just like frictionless models in physics, such as in free falling body movement (no air resistance), ideal gas (molecules do not collide), and ideal fluids, frictionless models of perfect competition generate useful insights in the economic world.

It is often heard that someone is claiming they have toppled an existing theory or conclusion, or that it has been overthrown, when some condition or assumption behind it is criticized. This is usually needless claim, because any existing theory can be criticized at anytime because no assumption can coincide fully with reality or cover everything. So, as long as there are no logic errors or inconsistency in the theory, we cannot say that

the theory is wrong. We can only criticize it for being too limited or unrealistic. What economists should do is to weaken or relax the assumptions, and obtain new theories based on old theories. We cannot say though that the new theory topples the old one, but instead that the new theory extends the old theory to cover more general situations and different economic environments.

### **1.1.6 Roles of Mathematics in Modern Economics**

Mathematics has become an important tool in modern economics. Almost every field in modern economics uses mathematics and statistics. The mathematical approach to economic analysis is used when economists make use of mathematical symbols in the statement of a problem and also draw upon known mathematical theorems to aid in reasoning. It is not difficult to understand why the mathematical approach has become a dominant approach since developing an analytical framework of a theory, establishing reference systems, and providing analytical tools all need mathematics.

Some of the advantages of using mathematics are that (1) the “language” used and the descriptions of assumptions are clearer, more accurate, and more precise, (2) the logical process of analysis is more rigorous and clearly sets the boundaries and limitations of a statement, (3) it can give a new result that may not be easily obtained through observation alone, and (4) it can reduce unnecessary debates and improve or extend existing results.

It should be remarked that, although mathematics is of critical importance in modern economics, economics is not mathematics. Economics uses mathematics as a tool in order to model and analyze various economic problems. Statistics and econometrics are used to test or measure the *accuracy* of our predication, and identify causalities among economic variables.

### **1.1.7 Conversion between Economic and Mathematical Languages**

The result of economics research is an economic conclusion. A valuable economics paper usually consists of three parts: (1) It raises important economic questions that give an objective to the paper. (2) It establishes the economic models and draws and proves the conclusions obtained from the model. (3) It uses non-technical language to explain the results and, if relevant, provides policy suggestions.