PART ONE

SOME SIMPLE ALGEBRAIC EQUILIBRIUM MODELS

ECONOMIC THEORY 1: THEORIES AND MODELS

1. *An economic theory* is a connected set of beliefs about how the economy, or some part of it, works. We have microeconomic theories, macroeconomic theories, a theory of consumer behavior, theories of the firm, theories of oligopoly, theories of economic growth, theories of economic development, etc.

Theories are formulated in terms of *a set of hypotheses about the relationships between the variables we are interested in*. These hypotheses are ***always*** **qualitative** in nature, i.e. they attempt to specify the **direction** of change of one variable when one or more other variables change in particular directions - *increase* or *decrease*. (Sometimes the theory may also attempt to specify the *rate of change* of the dependent variable with respect to the changes in the other variables and/or the behavior of the variables over time – but you will not do much dynamics in your undergraduate economics studies because it requires you to be able to set up and solve differential or difference equations.)

Variables that are explained *within* the model are called **endogenous.** *Endogenous* variables depend on the value of at least one other variable in the model. Quantity transacted is usually an endogenous variable. Endogenous variables can be either dependent or independent variables. An *independent* variable is an argument in a function. Variables that are **not** explained in the model are called **exogenous**. *Exogenous*

variables do not depend on any of the other variables that appear in the model: forces outside the model determine their values. Exogenous variables are parameters. Exogenous variables are always independent variables.

The variables that appear in the theory are theoretical variables and are usually only approximated by the real world observed variables that we use in our empirical work. For example, the consumption variable in the consumption function is not the same as the variable called Personal Consumption Expenditures in the National Income Accounts. Quantity demanded and quantity supplied are not usually observable and do not correspond to the actual amount transacted unless the market is in equilibrium.

Economists theorize verbally, diagrammatically, algebraically, and by using some of the more sophisticated tools of the mathematician, such as differential calculus. In this course we will only begin to explore the economist's mathematical tool kit. When we theorize we are forming chains of logic that link the variables we wish to explain (the endogenous variables) to the explanatory variables – other endogenous variables, the exogenous variables, and the other parameters of the model. **We use mathematical arguments because they are the most powerful instruments of logical inference available to us** - honed by generations of mathematicians. There is no point in spending time analyzing a theory that can be shown to be logically inconsistent.

The economic theories we will discuss will be of two types: *equilibrium theories* requiring us to work with some equilibrium condition that requires us to solve a set of two simultaneous linear equations; and *extremization theories* that require us to maximize or minimize some function such as utility (perhaps subject to a constraint) and require us to do some simple differential calculus.

2. The economy is a **very** complex structure that we only partly understand, that is very difficult to measure, and that is continually changing. In some ways economic problems are very much more difficult to pose, and certainly to "solve", than the problems which face physicists - which is not to deny that much of physics is in practice intellectually more demanding than economics. To come to grips with economic problems the economist, like the physicist, has to **simplify**; to try to strip away inessential details so that we can deal with a **manageable** system - these stripped down systems we call **economic models**. What characterizes modern economics is its insistence that theorizing about the economy and economic policy must be done within the context of a well specified model.

3. *An economic model* is a representation of an economic theory or some part of a theory. Although economic models are now usually formulated in mathematical terms they do not have to be formulated using algebra or calculus or higher math. The mathematical models you are familiar with from Econ 206 and Econ 207 were formulated geometrically, e.g. the familiar supply and demand diagram in Econ 206, and the "Keynesian Cross" diagram in Econ 207. While we will continue to use diagrams to aid our intuition in Econ 208, there will be much greater **stress on algebra (**in the first third of the course) and **differential calculus** (in the final two thirds of the course).

The professional economists' preference for employing *analytical* tools - algebra and calculus as opposed to arithmetic and geometry – for solving economic problems stems from three major considerations. First, the process of translating the theory into algebra often forces us to make explicit some assumptions that tend to be hidden in verbal, arithmetic, or diagrammatic approaches. Secondly, geometric arguments tend to restrict us to bivariate situations whereas most economic problems are

multivariate. Finally, analytical methods provide us with the full power of mathematics, a method that has proved supremely successful in the analysis of physical phenomena. All of the theorems which have been proved by mathematicians during the last three thousand years are available to us; all we have to do is to learn *when* and *how* to **apply them.**

An economic model consists of a set of variables, a set of functions showing how the variables are linked together, and a decision rule - such as an equilibrium condition or a requirement that some variable be maximized or minimized (usually subject to one or more constraints). The economic theory underlying the model consists of: the *variables*, *functions*, *sets of inequalities* (that are imposed, e.g., to guarantee that the demand curves have negative slopes), and the *decision rule*. When you are writing out your economic models you must make sure you have included all of the elements of the model, especially the **inequalities** that give the model its particular economic characteristics.

From a formal point of view constructing an economic theory can be thought of as following a series of steps. ***First***, you *determine an "interesting" problem*, which you wish to solve. ***Second***, you *determine which parts of the real economic system* with its very complicated set of institutional arrangements you think *you can handle* - essentially you choose the set of variables you will theorize about and determine which of these are to be treated as endogenous and which will be exogenous. ***Third***, you *formulate a set of hypotheses* about how the variables are interrelated. ***Fourth***, you *convert this theory into a mathematical model* - which may require further simplification (such as linearization of relationships) in order to achieve mathematical tractability. ***Fifth***, you solve the model. This is a mathematical exercise and in itself has no economic content. ***Sixth***, you *manipulate the model* to

generate its qualitative comparative static (QCS) predictions. This is another purely mathematical exercise. ***Seventh***, you place economic *interpretations* on the solution and the QCS predictions and draw *policy implications*. ***Eighth***, you *test the model's predictions* using real world data - for which you need a course (or several courses) in Econometrics!

4. The success of a real world modeling exercise is crucially tied to the ability of the model to correctly predict new phenomena. But **prediction** should not be confused with **forecasting,** although the two activities are related. **Prediction** involves deducing the **logical implications** of the assumptions, which make up the model. **Forecasting** involves determining which of these predictions has observable counterparts in the real world, and attempting to establish whether there is any *systematic* observational evidence that the predictions are born out by the real world data.

In principle we are looking for potential **refutations** of our theory but in practice most econometrics is concerned with seeing whether the model is consistent with what we observe in the real world. Prediction in the sense we are talking about does not necessarily involve the future, although successful prediction of what will be observed in the future is one of the greatest achievements of modern science. Prediction, in the sense we are using it here, is **essentially conditional:** in the jargon of the economist prediction assumes ***ceteris paribus*** - *all other things being equal.* (However, the models that we investigate in Econ 208 are in the nature of finger exercises – the purpose of the models is pedagogic, to teach you how to understand the mechanics of very simple systems before you cut your economic teeth on the more elaborate and realistic models that you encounter in your upper division courses.)

We are using prediction in the sense that ***if*** A, B, and C are true *and* ***if*** the **only** thing that changes is that x increases, ***then*** y will decrease - where we mean that **nothing else** changes that has any direct or indirect effect on the value of y. Situations in which we can plausibly invoke the ceteris paribus assumption in the real world are very rare. This is what makes economics difficult and fun!

On the other hand – as economists love to say – forecasting involves an attempt to predict what will happen in the *future*, and a model that makes perfectly correct *predictions* may fail to *forecast* what actually happens because its *ceteris paribus* assumptions are violated or because of the effects of exogenous factors, such as wars, that we would not attempt to incorporate in our model and therefore are not taken account of in its predictions.

5. ***It is not a legitimate criticism of an economic model to say that it is abstract*** - that is the nature of the beast! Just as an economic theory is a simplification of a real economy so most economic models are, in turn, simplifications of the theories they purport to represent. There is a constant tension between, *on the one hand,* the need to simplify (the need for mathematical tractability, and the desire to generate closed form (analytic) solutions), and *on the other hand,* the need to do justice to the institutional richness and the extreme complexity of real world systems. We must be careful not to impose limiting or patently false economic assumptions on our models, but we must be equally cognizant that mere descriptive realism is not useful. Systems that try to incorporate everything of possible relevance to the question at hand inevitably become so unwieldy that they cannot be handled at all and so end up telling us nothing about what we want to know.

There is certainly some truth in the argument that the dominance of mathematics in economic modeling has led to a tendency to marginalize and even ignore problems that are difficult to formulate mathematically. But I know of **no successful attempts by practitioners of non-mathematical economics to provide solutions to any practical policy issues that are more informative than the work of economic theorists.** And you should never attempt to criticize a model that you do not even understand!

Computer simulation of complex systems, such as economies, has recently become fashionable in scientific circles, and indeed there is much talk of a new scientific paradigm for the twenty-first century: the science of "complexity". However, all this is in its infancy. **In practice mathematical modeling is the only game in town.** In any case the sort of math that ***we*** will be doing is very straightforward and admirably suited to solving the economic problems that are contained within this course. (On the role of mathematics in economics see A&L Ch.1, John Cassidy's "The Decline of Economics", *p.53, The New Yorker*, 12/2/96, and the controversy in *Slate (*http://www.slate.com 10/24/96, 11/5-7/96 and 11/11/96.))

6. Other aspects of the modeling process include: choosing the economic actors; determining their roles in the model; deciding what information they posses; deciding whether there are costs associated with their transactions; what property rights they have; the physical, social, and technological constraints on their activities; whether they behave strategically with respect to the actions of other transactors. This list is by no means exhaustive!

For example, buyers purchase and consume goods and services, which are produced and sold by sellers who pay incomes to the buyers in order to hire the inputs that the buyers own. The model

attempts to explain and predict the behavior of the economic agents by, for example, *hypothesizing* that sellers are attempting to maximize their profits, and that consumers attempt to maximize utility -- both subject to constraints such as those imposed by technology and the positive prices of scarce resources.

7. There are three types of model with which you need to be confident dealing with: those with numbers, those with algebraic symbols, and those that use general functional specifications. In this course **we will almost always use symbols in our models** and you may initially find this a little daunting. However, *you may always replace the symbols by appropriate numerical constants* and *the functions by suitable algebraic expressions* - as an aid to your intuition but **not** as a substitute for actually doing the math!

You should work hard on really mastering the diagrams and their properties since they are the workhorses of the profession. However, you must be wary of arguments that are presented diagrammatically since they often represent special cases.