CHAPTER 1

What Is Econometrics?

1.1 Introduction

What is econometrics? A few definitions are given below:

> *The method of econometric research aims, essentially, at a conjunction of economic theory and actual measurements, using the theory and technique of statistical inference as a bridge pier.*

<div align="right">Trygve Haavelmo (1944)</div>

> *Econometrics may be defined as the quantitative analysis of actual economic phenomena based on the concurrent development of theory and observation, related by appropriate methods of inference.*

<div align="right">Samuelson, Koopmans and Stone (1954)</div>

> *Econometrics is concerned with the systematic study of economic phenomena using observed data.*

<div align="right">Aris Spanos (1986)</div>

> *Broadly speaking, econometrics aims to give empirical content to economic relations for testing economic theories, forecasting, decision making, and for ex post decision/policy evaluation.*

<div align="right">J. Geweke, J. Horowitz, and M.H. Pesaran (2008)</div>

For other definitions of econometrics, see Tintner (1953).

An econometrician has to be a competent mathematician and statistician who is an economist by training. Fundamental knowledge of mathematics, statistics and economic theory are a necessary prerequisite for this field. As Ragnar Frisch (1933) explains in the first issue of Econometrica, it is the unification of statistics, economic theory and mathematics that constitutes econometrics. Each view point, by itself is necessary but not sufficient for a real understanding of quantitative relations in modern economic life.

Ragnar Frisch is credited with coining the term 'econometrics' and he is one of the founders of the Econometrics Society, see Christ (1983). Econometrics aims at giving empirical content to economic relationships. The three key ingredients are economic theory, economic data, and statistical methods. Neither 'theory without measurement', nor 'measurement without theory' are sufficient for explaining economic phenomena. It is as Frisch emphasized their union that is the key for success in the future development of econometrics.

Lawrence R. Klein, the 1980 recipient of the Nobel Prize in economics "for the creation of econometric models and their application to the analysis of economic fluctuations and economic policies,"[1] has always emphasized the integration of economic theory, statistical methods and practical economics. The exciting thing about econometrics is its concern for verifying or refuting economic laws, such as purchasing power parity, the life cycle hypothesis, the quantity theory of money, etc. These economic laws or hypotheses are testable with economic data. In fact, David F. Hendry (1980) emphasized this function of econometrics:

> *The three golden rules of econometrics are test, test and test; that all three rules are broken regularly in empirical applications is fortunately easily remedied. Rigorously tested models, which adequately described the available data, encompassed previous findings and were derived from well based theories would enhance any claim to be scientific.*

Econometrics also provides quantitative *estimates* of price and income elasticities of demand, returns to scale in production, technical efficiency in cost functions, wage elasticities, etc. These are important for policy decision making. What is the effect of raising the tax on a pack of cigarettes by 10% in reducing smoking? How much will it generate in tax revenues? What is the effect of raising minimum wage by $1 per hour on unemployment? What is the effect of raising beer tax on motor vehicle fatality?

Econometrics also provides predictions about future interest rates, unemployment, or GNP growth. Lawrence Klein (1971) emphasized this last function of econometrics:

> *Econometrics had its origin in the recognition of empirical regularities and the systematic attempt to generalize these regularities into "laws" of economics. In a broad sense, the use of such "laws" is to make predictions – about what might have or what will come to pass. Econometrics should give a base for economic prediction beyond experience if it is to be useful. In this broad sense it may be called the science of economic prediction.*

Econometrics, while based on scientific principles, still retains a certain element of art. According to Malinvaud (1966), the art in econometrics is trying to find the right set of assumptions which are sufficiently specific, yet realistic to enable us to take the best possible advantage of the available data. Data in economics are not generated under ideal experimental conditions as in a physics laboratory. This data cannot be replicated and is most likely measured with error. In some cases, the available data are proxies for variables that are either not observed or cannot be measured. Many published empirical studies find that economic data may not have enough variation to discriminate between two competing economic theories. Manski (1995, p. 8) argues that

> *Social scientists and policymakers alike seem driven to draw sharp conclusions, even when these can be generated only by imposing much stronger assumptions than can be defended. We need to develop a greater tolerance for ambiguity. We must face up to the fact that we cannot answer all of the questions that we ask.*

To some, the "art" element in econometrics has left a number of distinguished economists doubtful of the power of econometrics to yield sharp predictions. In his presidential address to the American Economic Association, Wassily Leontief (1971, pp. 2–3) characterized econometrics work as:

> *an attempt to compensate for the glaring weakness of the data base available to us by the widest possible use of more and more sophisticated techniques. Alongside the mounting pile of elaborate theoretical models we see a fast growing stock of equally intricate statistical tools. These are intended to stretch to the limit the meager supply of facts.*

Economic data can be of the *cross-section* type, for e.g., a sample of firms or households or countries at a particular point in time. An important data source is the *Current Population Survey.* This is a monthly survey of 50,000 households in the U.S. which is used to estimate the unemployment rate. Data can also be of the *time-series* type, for e.g., macroeconomic variables like Gross Domestic Product (GDP), Personal Disposable Income, Consumption, Government Expenditures, etc. for the U.S. observed over the last 40 years. These can be found in the *Economic Report of the President.* See Chapter 14 for some basic *time-series* methods in econometrics. Data can also be following a group of households, firms, or countries over time, i.e., *Longitudinal data* or *panel data.* The *National Longitudinal Survey of Youth, 1979* consists of a nationally representative sample of 12686 young men and women who were 14–22 years old in 1979. These individuals were interviewed annually through 1994 and currently interviewed on a biennial basis. The list of variables include information on schooling and career transitions, marriage and fertility, training investments, child care usage and drug and alcohol use. See Chapter 12 for some basic *panel data* methods in econometrics.

Most of the time the data collected are not ideal for the economic question at hand because they were posed to answer legal requirements or comply to regulatory agencies. Griliches (1986, p. 1466) describes the situation as follows:

> *Econometricians have an ambivalnt attitude towards economic data. At one level, the 'data' are the world that we want to explain, the basic facts that economists purport to elucidate. At the other level, they are the source of all our trouble. Their imperfections make our job difficult and often impossible... We tend to forget that these imperfections are what gives us our legitimacy in the first place... Given that it is the 'badness' of the data that provides us with our living, perhaps it is not all that surprising that we have shown little interest in improving it, in getting involved in the grubby task of designing and collecting original data sets of our own. Most of our work is on 'found' data, data that have been collected by somebody else, often for quite different purposes.*

Even though economists are increasingly getting involved in collecting their data and measuring variables more accurately and despite the increase in data sets and data storage and computational accuracy, some of the warnings given by Griliches (1986, p. 1468) are still valid today:

> *The encounters between econometricians and data are frustrating and ultimately unsatisfactory both because econometricians want too much from the data and hence tend to be dissapointed by the answers, and because the data are incomplete and imperfect. In part it is our fault, the appetite grows with eating. As we get larger samples, we keep adding variables and expanding our models, until on the margin, we come back to the same insignificance levels.*

1.2   A Brief History

For a brief review of the origins of econometrics before World War II and its development in the 1940–1970 period, see Klein (1971). Klein gives an interesting account of the pioneering works of Moore (1914) on economic cycles, Working (1927) on demand curves, Cobb and Douglas (1928) on the theory of production, Schultz (1938) on the theory and measurement of demand, and Tinbergen (1939) on business cycles. As Klein (1971, p. 415) adds:

> *The works of these men mark the beginnings of formal econometrics. Their analysis was systematic, based on the joint foundations of statistical and economic theory, and they were aiming at meaningful substantive goals - to measure demand elasticity, marginal productivity and the degree of macroeconomic stability.*

The story of the early progress in estimating economic relationships in the U.S. is given in Christ (1985). The modern era of econometrics, as we know it today, started in the 1940's. Klein (1971) attributes the formulation of the econometrics problem in terms of the theory of statistical inference to Haavelmo (1943, 1944) and Mann and Wald (1943). This work was extended later by T.C. Koopmans, J. Marschak, L. Hurwicz, T.W. Anderson and others at the Cowles Commission in the late 1940's and early 1950's, see Koopmans (1950). Klein (1971, p. 416) adds:

> *At this time econometrics and mathematical economics had to fight for academic recognition. In retrospect, it is evident that they were growing disciplines and becoming increasingly attractive to the new generation of economic students after World War II, but only a few of the largest and most advanced universities offered formal work in these subjects. The mathematization of economics was strongly resisted.*

This resistance is a thing of the past, with econometrics being an integral part of economics, taught and practiced worldwide. Econometrica, the official journal of the Econometric Society is one of the leading journals in economics, and today the Econometric Society boast a large membership worldwide. Today, it is hard to read any professional article in leading economics and econometrics journals without seeing mathematical equations. Students of economics and econometrics have to be proficient in mathematics to comprehend this research. In an Econometric Theory interview, professor J. D. Sargan of the London School of Economics looks back at his own career in econometrics and makes the following observations: "... econometric theorists have really got to be much more professional statistical theorists than they had to be when I started out in econometrics in 1948... Of course this means that the starting econometrician hoping to do a Ph.D. in this field is also finding it more difficult to digest the literature as a prerequisite for his own study, and perhaps we need to attract students of an increasing degree of mathematical and statistical sophistication into our field as time goes by," see Phillips (1985, pp. 134–135). This is also echoed by another giant in the field, professor T.W. Anderson of Stanford, who said in an Econometric Theory interview: "These days econometricians are very highly trained in mathematics and statistics; much more so than statisticians are trained in economics; and I think that there will be more cross-fertilization, more joint activity," see Phillips (1986, p. 280).

Research at the Cowles Commission was responsible for providing formal solutions to the problems of identification and estimation of the simultaneous equations model, see Christ (1985).[2] Two important monographs summarizing much of the work of the Cowles Commission at Chicago, are Koopmans and Marschak (1950) and Koopmans and Hood (1953).[3] The creation of large data banks of economic statistics, advances in computing, and the general acceptance of Keynesian theory, were responsible for a great flurry of activity in econometrics. Macroeconometric modelling started to flourish beyond the pioneering macro models of Klein (1950) and Klein and Goldberger (1955).

For the story of the founding of Econometrica and the Econometric Society, see Christ (1983). Suggested readings on the history of econometrics are Pesaran (1987), Epstein (1987) and

Morgan (1990). In the conclusion of her book on The History of Econometric Ideas, Morgan (1990; p. 264) explains:

> *In the first half of the twentieth century, econometricians found themselves carrying out a wide range of tasks: from the precise mathematical formulation of economic theories to the development tasks needed to build an econometric model; from the application of statistical methods in data preperation to the measurement and testing of models. Of necessity, econometricians were deeply involved in the creative development of both mathematical economic theory and statistical theory and techniques. Between the 1920s and the 1940s, the tools of mathematics and statistics were indeed used in a productive and complementary union to forge the essential ideas of the econometric approach. But the changing nature of the econometric enterprise in the 1940s caused a return to the division of labour favoured in the late nineteenth century, with mathematical economists working on theory building and econometricians concerned with statistical work. By the 1950s the founding ideal of econometrics, the union of mathematical and statistical economics into a truly synthetic economics, had collapsed.*

In modern day usage, econometrics have become the application of statistical methods to economics, like biometrics and psychometrics. Although, the ideals of Frisch still live on in Econometrica and the Econometric Society, Maddala (1999) argues that: "In recent years the issues of Econometrica have had only a couple of papers in econometrics (statistical methods in economics) and the rest are all on game theory and mathematical economics. If you look at the list of fellows of the Econometric Society, you find one or two econometricians and the rest are game theorists and mathematical economists." This may be a little exaggerated but it does summarize the rift between modern day econometrics and mathematical economics. For a world wide ranking of econometricians as well as academic institutions in the field of econometrics, see Baltagi (2007).

1.3   Critiques of Econometrics

Econometrics has its critics. Interestingly, John Maynard Keynes (1940, p. 156) had the following to say about Jan Tinbergen's (1939) pioneering work:

> *No one could be more frank, more painstaking, more free of subjective bias or parti pris than Professor Tinbergen. There is no one, therefore, so far as human qualities go, whom it would be safer to trust with black magic. That there is anyone I would trust with it at the present stage or that this brand of statistical alchemy is ripe to become a branch of science, I am not yet persuaded. But Newton, Boyle and Locke all played with alchemy. So let him continue.*[4]

In 1969, Jan Tinbergen shared the first Nobel Prize in economics with Ragnar Frisch.

Well cited critiques of econometrics include the Lucas (1976) critique which is based on the Rational Expectations Hypothesis (REH). As Pesaran (1990, p. 17) puts it:

> *The message of the REH for econometrics was clear. By postulating that economic agents form their expectations endogenously on the basis of the true model of the*

economy and a correct understanding of the processes generating exogenous variables of the model, including government policy, the REH raised serious doubts about the invariance of the structural parameters of the mainstream macroeconometric models in face of changes in government policy.

Responses to this critique include Pesaran (1987). Other lively debates among econometricians include Ed Leamer's (1983) article entitled "Let's Take the Con Out of Econometrics," and the response by McAleer, Pagan and Volker (1985). Rather than leave the reader with criticisms of econometrics especially before we embark on the journey to learn the tools of the trade, we conclude this section with the following quote from Pesaran (1990, pp. 25–26):

There is no doubt that econometrics is subject to important limitations, which stem largely from the incompleteness of the economic theory and the non-experimental nature of economic data. But these limitations should not distract us from recognizing the fundamental role that econometrics has come to play in the development of economics as a scientific discipline. It may not be possible conclusively to reject economic theories by means of econometric methods, but it does not mean that nothing useful can be learned from attempts at testing particular formulations of a given theory against (possible) rival alternatives. Similarly, the fact that econometric modelling is inevitably subject to the problem of specification searches does not mean that the whole activity is pointless. Econometric models are important tools for forecasting and policy analysis, and it is unlikely that they will be discarded in the future. The challenge is to recognize their limitations and to work towards turning them into more reliable and effective tools. There seem to be no viable alternatives.

1.4   Looking Ahead

Econometrics have experienced phenomenal growth in the past 50 years. There are six volumes of the *Handbook of Econometrics*, most of it dealing with post 1960's research. A lot of the recent growth reflects the rapid advances in computing technology. The broad availability of micro data bases is a major advance which facilitated the growth of panel data methods (see Chapter 12) and microeconometric methods especially on sample selection and discrete choice (see Chapter 13) and that also lead to the award of the Nobel Prize in Economics to James Heckman and Daniel McFadden in 2000. The explosion in research in time series econometrics which lead to the development of ARCH and GARCH and cointegration (see Chapter 14) which also lead to the award of the Nobel Prize in Economics to Clive Granger and Robert Engle in 2003. It is a different world than it was 30 years ago. The computing facilities changed dramatically. The increasing accessibility of cheap and powerful computing facilities are helping to make the latest econometric methods more readily available to applied researchers. Today, there is hardly a field in economics which has not been intensive in its use of econometrics in empirical work. Pagan (1987, p. 81) observed that the work of econometric theorists over the period 1966–1986 have become part of the process of economic investigation and the training of economists. Based on this criterion, he declares econometrics as an "outstanding success." He adds that:

The judging of achievement inevitably involves contrast and comparison. Over a period of twenty years this would be best done by interviewing a time-travelling

*economist displaced from 1966 to 1986. I came into econometrics just after the be-
ginning of this period, so have some appreciation for what has occurred. But because
I have seen the events gradually unfolding, the effects upon me are not as dramatic.
Nevertheless, let me try to be a time-traveller and comment on the perceptions of a
1966'er landing in 1986. My first impression must be of the large number of people
who have enough econometric and computer skills to formulate, estimate and sim-
ulate highly complex and non-linear models. Someone who could do the equivalent
tasks in 1966 was well on the way to a Chair. My next impression would be of the
widespread use and purchase of econometric services in the academic, government,
and private sectors. Quantification is now the norm rather than the exception. A
third impression, gleaned from a sounding of the job market, would be a persistent
tendency towards an excess demand for well-trained econometricians. The economist
in me would have to acknowledge that the market judges the products of the discipline
as a success.*

The challenge for the 21st century is to narrow the gap between theory and practice. Many
feel that this gap has been widening with theoretical research growing more and more abstract
and highly mathematical without an application in sight or a motivation for practical use.
Heckman (2001) argues that econometrics is useful only if it helps economists conduct and
interpret empirical research on economic data. He warns that the gap between econometric
theory and empirical practice has grown over the past two decades. Theoretical econometrics
becoming more closely tied to mathematical statistics. Although he finds nothing wrong, and
much potential value, in using methods and ideas from other fields to improve empirical work
in economics, he does warn of the risks involved in uncritically adopting the methods and mind
set of the statisticians:

*Econometric methods uncritically adapted from statistics are not useful in many re-
search activities pursued by economists. A theorem-proof format is poorly suited for
analyzing economic data, which requires skills of synthesis, interpretation and em-
pirical investigation. Command of statistical methods is only a part, and sometimes
a very small part, of what is required to do first class empirical research.*

In an Econometric Theory interview with Jan Tinbergen, Magnus and Morgan (1987, p. 117)
describe Tinbergen as one of the founding fathers of econometrics, publishing in the field from
1927 until the early 1950s. They add: "Tinbergen's approach to economics has always been a
practical one. This was highly appropriate for the new field of econometrics, and enabled him
to make important contributions to conceptual and theoretical issues, but always in the context
of a relevant economic problem." The founding fathers of econometrics have always had the
practitioner in sight. This is a far cry from many theoretical econometricians who refrain from
applied work.

  Geweke, Horowitz, and Pesaran (2008) provide the following recommendations for the future:

*Econometric theory and practice seek to provide information required for informed
decision-making in public and private economic policy. This process is limited not
only by the adequacy of econometrics, but also by the development of economic theory
and the adequacy of data and other information. Effective progress, in the future as
in the past, will come from simultaneous improvements in econometrics, economic*

theory, and data. Research that specifically addresses the effectiveness of the interface between any two of these three in improving policy — to say nothing of all of them — necessarily transcends traditional subdisciplinary boundaries within economics. But it is precisely these combinations that hold the greatest promise for the social contribution of academic economics.

Notes

1. See the interview of Professor L.R. Klein by Mariano (1987). Econometric Theory publishes interviews with some of the giants in the field. These interviews offer a wonderful glimpse at the life and work of these giants.

2. Simultaneous equations model is an integral part of econometrics and is studied in Chapter 11.

3. Tjalling Koopmans was the joint recipient of the Nobel Prize in Economics in 1975. In addition to his work on the identification and estimation of simultaneous equations models, he received the Nobel Prize for his work in optimization and economic theory.

4. I encountered this attack by Keynes on Tinbergen in the inaugural lecture that Peter C.B. Phillips (1977) gave at the University of Birmingham entitled "Econometrics: A View From the Toolroom," and David F. Hendry's (1980) article entitled "Econometrics - Alchemy or Science?"

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