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Badi H. Baltagi

Econometrics

Fifth Edition

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To My Wife Phyllis

Preface

This book is intended for a first year graduate course in econometrics. I tried to strike a balance between a rigorous approach that proves theorems, and a completely empirical approach where no theorems are proved. Some of the strengths of this book lie in presenting some difficult material in a simple, yet rigorous manner. For example, Chapter 12 on pooling time-series of cross-section data is drawn from my area of expertise in econometrics and the intent here is to make this material more accessible to the general readership of econometrics.

This book teaches some of the basic econometric methods and the underlying assumptions behind them. Estimation, hypotheses testing and prediction are three recurrent themes in this book. Some uses of econometric methods include (i) empirical testing of economic theory, whether it is the permanent income consumption theory or purchasing power parity, (ii) forecasting, whether it is GNP or unemployment in the U.S. economy or future sales in the computer industry. (iii) Estimation of price elasticities of demand, or returns to scale in production. More importantly, econometric methods can be used to simulate the effect of policy changes like a tax increase on gasoline consumption, or a ban on advertising on cigarette consumption.

It is left to the reader to choose among the available econometric/statistical software to use, like EViews, SAS, Stata, TSP, SHAZAM, Microfit, PcGive, LIMDEP, and RATS, to mention a few. The empirical illustrations in the book utilize a variety of these software packages but mostly with Stata and EViews. Of course, these packages have different advantages and disadvantages. However, for the basic coverage in this book, these differences may be minor and more a matter of what software the reader is familiar or comfortable with. In most cases, I encourage my students to use more than one of these packages and to verify these results using simple programming languages like GAUSS, OX, R and MATLAB.

This book is not meant to be encyclopedic. I did not attempt the coverage of Bayesian econometrics simply because it is not my comparative advantage. The reader should consult Koop (2003) for a more recent treatment of the subject. Nonparametrics and semiparametrics are popular methods in today's econometrics, yet they are not covered in this book to keep the technical difficulty at a low level. These are a must for a follow-up course in econometrics, see Li and Racine (2007). Also, for a more rigorous treatment of asymptotic theory, see White (1984). Despite these limitations, the topics covered in this book are basic and necessary in the training of every economist. In fact, it is but a 'stepping stone', a 'sample of the good stuff' the reader will find in this young, energetic and ever evolving field.

I hope you will share my enthusiasm and optimism in the importance of the tools you will learn when you are through reading this book. Hopefully, it will encourage you to consult the suggested readings on this subject that are referenced at the end of each chapter. In his inaugural lecture at the University of Birmingham, entitled "Econometrics: A View from the Toolroom," Peter C.B. Phillips (1977) concluded:

> *"the toolroom may lack the glamour of economics as a practical art in government or business, but it is every bit as important. For the tools (econometricians) fashion provide the key to improvements in our quantitative information concerning matters of economic policy."*

As a student of econometrics, I have benefited from reading Johnston (1984), Kmenta (1986), Theil (1971), Klein (1974), Maddala (1977), and Judge, et al. (1985), to mention a few. As a teacher of undergraduate econometrics, I have learned from Kelejian and Oates (1989), Wallace and Silver (1988), Maddala (1992), Kennedy (1992), Wooldridge (2003) and Stock and Watson (2003). As a teacher of graduate econometrics courses, Greene (1993), Judge, et al. (1985), Fomby, Hill and Johnson (1984) and Davidson and MacKinnon (1993) have been my regular companions. The influence of these books will be evident in the pages that follow. Courses requiring matrix algebra as a pre-requisite to econometrics can start with Chapter 7. Chapter 2 has a quick refresher on some of the required background needed from statistics for the proper understanding of the material in this book.

For an advanced undergraduate/masters class not requiring matrix algebra, one can structure a course based on Chapter 1; Section 2.6 on descriptive statistics; Chapters 3–6; Section 11.1 on simultaneous equations; and Chapter 14 on time-series analysis.

The exercises contain theoretical problems that should supplement the understanding of the material in each chapter. Some of these exercises are drawn from the Problems and Solutions series of Econometric Theory (reprinted with permission of Cambridge University Press). In addition, the book has a set of empirical illustrations demonstrating some of the basic results learned in each chapter. Data sets from published articles are provided for the empirical exercises. These exercises are solved using several econometric software packages and are available in the Solution Manual. This book is by no means an applied econometrics text, and the reader should consult Berndt's (1991) textbook for an excellent treatment of this subject. Instructors and students are encouraged to get other data sets from the internet or journals that provide backup data sets to published articles. The Journal of Applied Econometrics and the Journal of Business and Economic Statistics are two such journals. In fact, the Journal of Applied Econometrics has a replication section for which I am serving as an editor. In my econometrics course, I require my students to replicate an empirical paper. Many students find this experience rewarding in terms of giving them hands on application of econometric methods that prepare them for doing their own empirical work.

I would like to thank my teachers Lawrence R. Klein, Roberto S. Mariano and Robert Shiller who introduced me to this field; James M. Griffin who provided some data sets, empirical exercises and helpful comments, and many colleagues who had direct and indirect influence on the contents of this book including G.S. Maddala, Jan Kmenta, Peter Schmidt, Cheng Hsiao, Tom Wansbeek, Walter Krämer, Maxwell King, Peter C. B. Phillips, Alberto Holly, Essie Maasoumi, Aris Spanos, Farshid Vahid, Heather Anderson, Arnold Zellner and Bryan Brown. Also, I would like to thank my students Wei-Wen Xiong, Ming-Jang Weng, Kiseok Nam, Dong Li, Gustavo Sanchez, Long Liu and Liu Tian who read parts of this book and solved several of the exercises. Martina Bihn at Springer for her continuous support and professional editorial help. I have also benefited from my visits to the University of Arizona, University of California San-Diego, Monash University, the University of Zurich, the Institute of Advanced Studies in Vienna, and the University of Dortmund, Germany. A special thanks to my wife Phyllis whose help and support were essential to completing this book.

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Data

The data sets used in this text can be downloaded from the Springer website in Germany. The address is: *http://www.springer.com/978-3-642-20058-8.* Please select the link "Samples & Supplements" from the right-hand column.

Table of Contents

Part I

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.*
>
> Trygve Haavelmo (1944)

> *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.*
>
> Samuelson, Koopmans and Stone (1954)

> *Econometrics is concerned with the systematic study of economic phenomena using observed data.*
>
> Aris Spanos (1986)

> *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.*
>
> J. Geweke, J. Horowitz, and M.H. Pesaran (2008)

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.*