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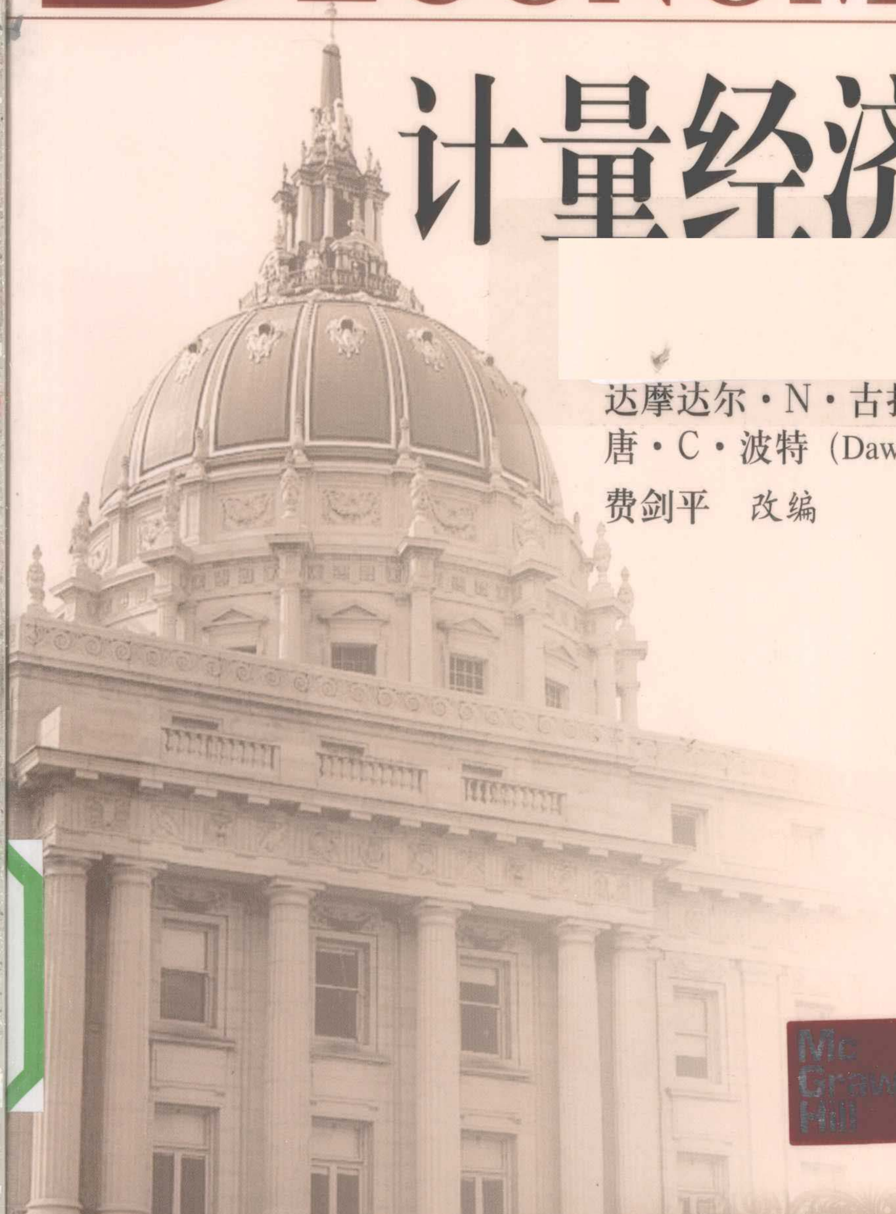
BASIC ECONOMETRICS

(Fifth Edition)

计量经济学基础

(第五版)



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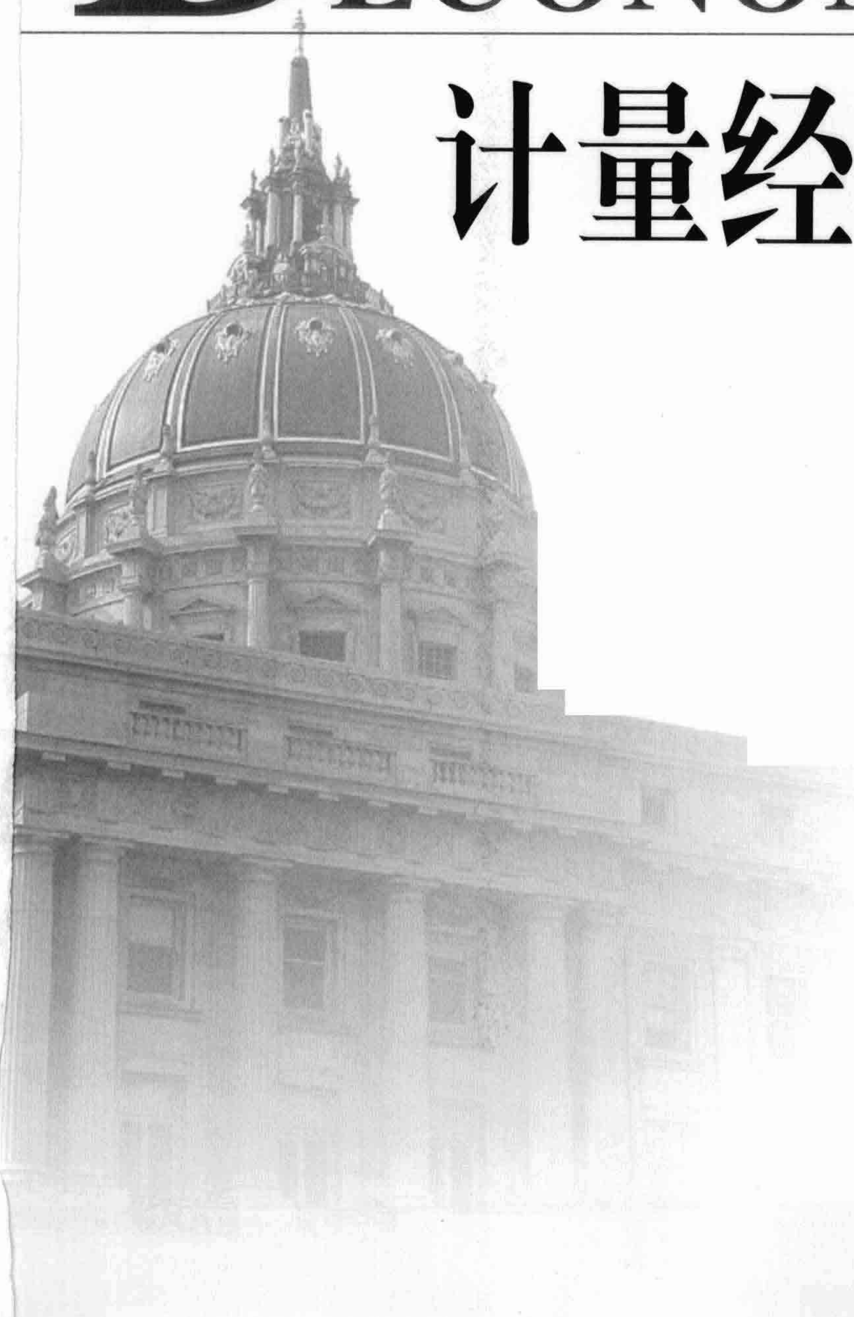

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出版说明

中国的入世，使其真正融入到经济全球化的浪潮中。中国政府“引进来，走出去”战略，使得中国经济的发展需要大量的“国际化”人才储备。这就对我国一般本科院校多年来所采取的单一语言（母语）教学提出严峻挑战，财经院校涉外经济类专业实行双语教学改革迫在眉睫。

顺应这一潮流，中国人民大学出版社携手众多国际知名的大出版公司，如麦格劳-希尔、培生教育出版公司等，面向大学本科层次，遴选了一批国外最优秀的经济类原版教材，包括宏观经济学、微观经济学、计量经济学、金融学等经济类专业基础课。

我们在引进出版过程中，注重把好质量关，每一本书都经过该学科领域的专家审核选题和内容，争取做到把国外真正高水平的适合国内实际的优秀教材引进来。本套教材主要有以下特点：

第一，体系设计完整。本套教材精选了一批国外著名出版公司的优秀教材，基本上涵盖了经济学专业的核心课程。

第二，保持英文原版教材的特色。本套教材根据国内教学需要，部分图书进行了一定的改编，主要删减了一些不适合和不符合我国国情的内容，但体系结构和内容方面都保持原版教材的特色。

第三，内容紧扣学科前沿。本套教材在原著选择上紧扣国外教学的前沿，基本上都选择国外最流行教材的最新版本，有利于老师和学生掌握国外教学研究的最新发展趋势。

第四，篇幅合理，价格适中。为适应国内双语教学内容和课时上的实际需要，本套教材在篇幅上更为合理。同时，考虑到学生实际的购买能力，我们采取低定价策略，这样，读者既能领略原版图书的风貌，又避免了高额的购买费用。

第五，提供强大的教学支持。依托国外大出版公司的力量，本套教材为教师提供了配套的教辅资料，如教师手册、PPT 课堂演示文稿、试题库等，并配套有内容丰富的网络资源，从而使教学更为便利。

本套教材既适合高等院校经济类专业的本科教学使用，也适合从事经济类工作和研究的人员阅读和培训使用。我们在选书、改编过程中虽然全面听取了专家的意见，做到尽可能满足读者的需求，但由于各教材的作者所处的政治、经济和文化背景不同，书中内容仍可能有不妥之处，我们真诚希望广大读者提出宝贵意见和建议，以便我们在以后的版本中不断改进和完善。

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Preface

Objective of the Book

The first edition of *Basic Econometrics* was published thirty years ago. Over the years, there have been important developments in the theory and practice of econometrics. In each of the subsequent editions, I have tried to incorporate the major developments in the field. The fifth edition continues that tradition.

What has not changed, however, over all these years is my firm belief that econometrics can be taught to the beginner in an intuitive and informative way without resorting to matrix algebra, calculus, or statistics beyond the introductory level. Some subject material is inherently technical. In that case I have put the material in the appropriate appendix or refer the reader to the appropriate sources. Even then, I have tried to simplify the technical material so that the reader can get an intuitive understanding of this material.

I am pleasantly surprised not only by the longevity of this book but also by the fact that the book is widely used not only by students of economics and finance but also by students and researchers in the fields of politics, international relations, agriculture, and health sciences. All these students will find the new edition with its expanded topics and concrete applications very useful. In this edition I have paid even more attention to the relevance and timeliness of the real data used in the text. In fact, I have added about fifteen new illustrative examples and more than thirty new end-of-chapter exercises. Also, I have updated the data for about two dozen of the previous edition's examples and more than twenty exercises.

Although I am in the eighth decade of my life, I have not lost my love for econometrics, and I strive to keep up with the major developments in the field. To assist me in this endeavor, I am now happy to have Dr. Dawn Porter, Assistant Professor of Statistics at the Marshall School of Business at the University of Southern California in Los Angeles, as my co-author. Both of us have been deeply involved in bringing the fifth edition of *Basic Econometrics* to fruition.

Major Features of the Fifth Edition

Before discussing the specific changes in the various chapters, the following features of the new edition are worth noting:

1. Practically all of the data used in the illustrative examples have been updated.
2. Several new examples have been added.
3. In several chapters, we have included extended concluding examples that illustrate the various points made in the text.
4. Concrete computer printouts of several examples are included in the book. Most of these results are based on **EViews** (version 6) and **STATA** (version 10), as well as **MINITAB** (version 15).
5. Several new diagrams and graphs are included in various chapters.
6. Several new data-based exercises are included in the various chapters.
7. Small-sized data are included in the book, but large sample data are posted on the book's website, thereby minimizing the size of the text. The website will also publish all of the data used in the book and will be periodically updated.

8. In a few chapters, we have included class exercises in which students are encouraged to obtain their own data and implement the various techniques discussed in the book. Some Monte Carlo simulations are also included in the book.

Specific Changes to the Fifth Edition

Some chapter-specific changes are as follows:

1. The assumptions underlying the classical linear regression model (CLRM) introduced in Chapter 3 now make a careful distinction between fixed regressors (explanatory variables) and random regressors. We discuss the importance of the distinction.
2. Chapter 7 now discusses not only the marginal impact of a single regressor on the dependent variable but also the impacts of simultaneous changes of all the explanatory variables on the dependent variable. This chapter has also been reorganized in the same structure as the assumptions from Chapter 3.
3. A comparison of the various tests of heteroscedasticity is given in Chapter 11.
4. There is a new discussion of the impact of *structural breaks* on autocorrelation in Chapter 12.
5. New topics included in Chapter 13 are *missing data, non-normal error term,* and *stochastic,* or *random,* regressors.

Supplements

A comprehensive website contains the following supplementary material:

–Data from the text, as well as additional large set data referenced in the book; the data will be periodically updated by the authors.

–A Solutions Manual, written by Dawn Porter, providing answers to all of the questions and problems throughout the text.

–A digital image library containing all of the graphs and figures from the text.

For more information, please go to www.mhhe.com/gujarati5e

目 录

Contents

CHAPTER 9
Dummy Variable Regression Models 226

PART TWO
RELAXING THE ASSUMPTIONS OF THE CLASSICAL MODEL 261

CHAPTER 10
Multicollinearity: What Happens If the Regressors Are Correlated? 266

CHAPTER 11
Heteroscedasticity: What Happens If the Error Variance Is Nonconstant? 303

CHAPTER 12
Autocorrelation: What Happens If the Error Terms Are Correlated? 346

Introduction

I.1 What Is Econometrics?

Literally interpreted, *econometrics* means "economic measurement." Although measurement is an important part of econometrics, the scope of econometrics is much broader, as can be seen from the following quotations:

> Econometrics, the result of a certain outlook on the role of economics, consists of the application of mathematical statistics to economic data to lend empirical support to the models constructed by mathematical economics and to obtain numerical results.[1]

> . . . 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.[2]

> Econometrics may be defined as the social science in which the tools of economic theory, mathematics, and statistical inference are applied to the analysis of economic phenomena.[3]

> Econometrics is concerned with the empirical determination of economic laws.[4]

> The art of the econometrician consists in finding the set of assumptions that are both sufficiently specific and sufficiently realistic to allow him to take the best possible advantage of the data available to him.[5]

> Econometricians . . . are a positive help in trying to dispel the poor public image of economics (quantitative or otherwise) as a subject in which empty boxes are opened by assuming the existence of can-openers to reveal contents which any ten economists will interpret in 11 ways.[6]

> 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.[7]

[1]Gerhard Tintner, *Methodology of Mathematical Economics and Econometrics,* The University of Chicago Press, Chicago, 1968, p. 74.

[2]P. A. Samuelson, T. C. Koopmans, and J. R. N. Stone, "Report of the Evaluative Committee for *Econometrica,*" *Econometrica,* vol. 22, no. 2, April 1954, pp. 141–146.

[3]Arthur S. Goldberger, *Econometric Theory,* John Wiley & Sons, New York, 1964, p. 1.

[4]H. Theil, *Principles of Econometrics,* John Wiley & Sons, New York, 1971, p. 1.

[5]E. Malinvaud, *Statistical Methods of Econometrics,* Rand McNally, Chicago, 1966, p. 514.

[6]Adrian C. Darnell and J. Lynne Evans, *The Limits of Econometrics,* Edward Elgar Publishing, Hants, England, 1990, p. 54.

[7]T. Haavelmo, "The Probability Approach in Econometrics," Supplement to *Econometrica,* vol. 12, 1944, preface p. iii.

I.2 Why a Separate Discipline?

As the preceding definitions suggest, econometrics is an amalgam of economic theory, mathematical economics, economic statistics, and mathematical statistics. Yet the subject deserves to be studied in its own right for the following reasons.

Economic theory makes statements or hypotheses that are mostly qualitative in nature. For example, microeconomic theory states that, other things remaining the same, a reduction in the price of a commodity is expected to increase the quantity demanded of that commodity. Thus, economic theory postulates a negative or inverse relationship between the price and quantity demanded of a commodity. But the theory itself does not provide any numerical measure of the relationship between the two; that is, it does not tell by how much the quantity will go up or down as a result of a certain change in the price of the commodity. It is the job of the econometrician to provide such numerical estimates. Stated differently, econometrics gives empirical content to most economic theory.

The main concern of mathematical economics is to express economic theory in mathematical form (equations) without regard to measurability or empirical verification of the theory. Econometrics, as noted previously, is mainly interested in the empirical verification of economic theory. As we shall see, the econometrician often uses the mathematical equations proposed by the mathematical economist but puts these equations in such a form that they lend themselves to empirical testing. And this conversion of mathematical into econometric equations requires a great deal of ingenuity and practical skill.

Economic statistics is mainly concerned with collecting, processing, and presenting economic data in the form of charts and tables. These are the jobs of the economic statistician. It is he or she who is primarily responsible for collecting data on gross national product (GNP), employment, unemployment, prices, and so on. The data thus collected constitute the raw data for econometric work. But the economic statistician does not go any further, not being concerned with using the collected data to test economic theories. Of course, one who does that becomes an econometrician.

Although mathematical statistics provides many tools used in the trade, the econometrician often needs special methods in view of the unique nature of most economic data, namely, that the data are not generated as the result of a controlled experiment. The econometrician, like the meteorologist, generally depends on data that cannot be controlled directly. As Spanos correctly observes:

> In econometrics the modeler is often faced with **observational** as opposed to **experimental** data. This has two important implications for empirical modeling in econometrics. First, the modeler is required to master very different skills than those needed for analyzing experimental data. . . . Second, the separation of the data collector and the data analyst requires the modeler to familiarize himself/herself thoroughly with the nature and structure of data in question.[8]

I.3 Methodology of Econometrics

How do econometricians proceed in their analysis of an economic problem? That is, what is their methodology? Although there are several schools of thought on econometric methodology, we present here the **traditional** or **classical** methodology, which still dominates empirical research in economics and other social and behavioral sciences.[9]

[8]Aris Spanos, *Probability Theory and Statistical Inference: Econometric Modeling with Observational Data*, Cambridge University Press, United Kingdom, 1999, p. 21.

[9]For an enlightening, if advanced, discussion on econometric methodology, see David F. Hendry, *Dynamic Econometrics*, Oxford University Press, New York, 1995. See also Aris Spanos, *op. cit.*

Broadly speaking, traditional econometric methodology proceeds along the following lines:

1. Statement of theory or hypothesis.
2. Specification of the mathematical model of the theory.
3. Specification of the statistical, or econometric, model.
4. Obtaining the data.
5. Estimation of the parameters of the econometric model.
6. Hypothesis testing.
7. Forecasting or prediction.
8. Using the model for control or policy purposes.

To illustrate the preceding steps, let us consider the well-known Keynesian theory of consumption.

1. Statement of Theory or Hypothesis

Keynes stated:

> The fundamental psychological law . . . is that men [women] are disposed, as a rule and on average, to increase their consumption as their income increases, but not as much as the increase in their income.[10]

In short, Keynes postulated that the **marginal propensity to consume (MPC),** the rate of change of consumption for a unit (say, a dollar) change in income, is greater than zero but less than 1.

2. Specification of the Mathematical Model of Consumption

Although Keynes postulated a positive relationship between consumption and income, he did not specify the precise form of the functional relationship between the two. For simplicity, a mathematical economist might suggest the following form of the Keynesian consumption function:

$$Y = \beta_1 + \beta_2 X \qquad 0 < \beta_2 < 1 \tag{I.3.1}$$

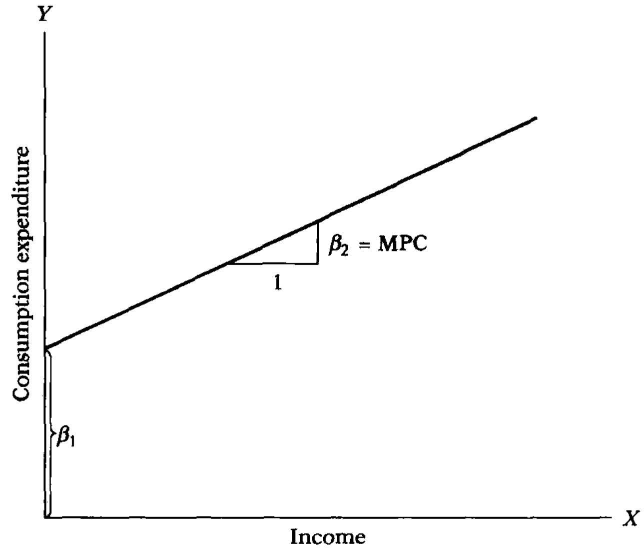
where Y = consumption expenditure and X = income, and where β_1 and β_2, known as the **parameters** of the model, are, respectively, the **intercept** and **slope** coefficients.

The slope coefficient β_2 measures the MPC. Geometrically, Equation I.3.1 is as shown in Figure I.1. This equation, which states that consumption is linearly related to income, is an example of a mathematical model of the relationship between consumption and income that is called the **consumption function** in economics. A model is simply a set of mathematical equations. If the model has only one equation, as in the preceding example, it is called a **single-equation model,** whereas if it has more than one equation, it is known as a **multiple-equation model** (the latter will be considered later in the book).

In Eq. (I.3.1) the variable appearing on the left side of the equality sign is called the **dependent variable** and the variable(s) on the right side is called the **independent,** or **explanatory,** variable(s). Thus, in the Keynesian consumption function, Eq. (I.3.1), consumption (expenditure) is the dependent variable and income is the explanatory variable.

[10] John Maynard Keynes, *The General Theory of Employment, Interest and Money,* Harcourt Brace Jovanovich, New York, 1936, p. 96.

FIGURE I.1
Keynesian consumption function.



3. Specification of the Econometric Model of Consumption

The purely mathematical model of the consumption function given in Eq. (I.3.1) is of limited interest to the econometrician, for it assumes that there is an *exact* or *deterministic* relationship between consumption and income. But relationships between economic variables are generally inexact. Thus, if we were to obtain data on consumption expenditure and disposable (i.e., aftertax) income of a sample of, say, 500 American families and plot these data on a graph paper with consumption expenditure on the vertical axis and disposable income on the horizontal axis, we would not expect all 500 observations to lie exactly on the straight line of Eq. (I.3.1) because, in addition to income, other variables affect consumption expenditure. For example, size of family, ages of the members in the family, family religion, etc., are likely to exert some influence on consumption.

To allow for the inexact relationships between economic variables, the econometrician would modify the deterministic consumption function in Eq. (I.3.1) as follows:

$$Y = \beta_1 + \beta_2 X + u \qquad \text{(I.3.2)}$$

where u, known as the **disturbance,** or **error, term,** is a **random (stochastic) variable** that has well-defined probabilistic properties. The disturbance term u may well represent all those factors that affect consumption but are not taken into account explicitly.

Equation I.3.2 is an example of an **econometric model.** More technically, it is an example of a **linear regression model,** which is the major concern of this book. The econometric consumption function hypothesizes that the dependent variable Y (consumption) is linearly related to the explanatory variable X (income) but that the relationship between the two is not exact; it is subject to individual variation.

The econometric model of the consumption function can be depicted as shown in Figure I.2.

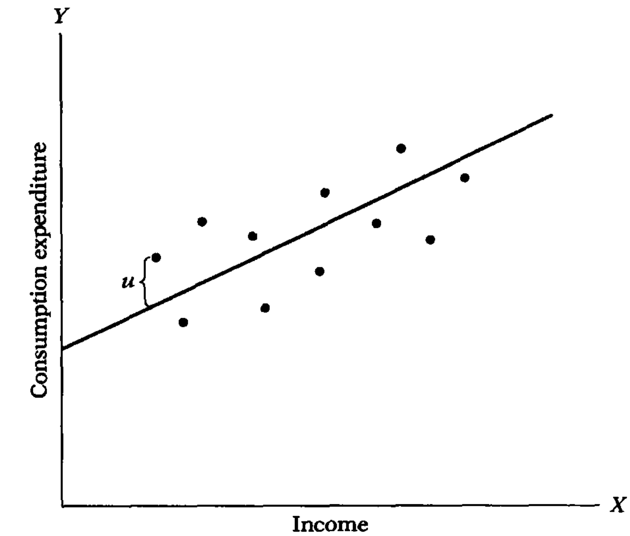


FIGURE I.2
Econometric model of the Keynesian consumption function.

4. Obtaining Data

To estimate the econometric model given in Eq. (I.3.2), that is, to obtain the numerical values of β_1 and β_2, we need data. Although we will have more to say about the crucial importance of data for economic analysis in the next chapter, for now let us look at the data given in Table I.1, which relate to the U.S. economy for the period 1960–2005. The Y variable in this table is the *aggregate* (for the economy as a whole) personal consumption expenditure (PCE) and the X variable is gross domestic product (GDP), a measure of aggregate income, both measured in billions of 2000 dollars. Therefore, the data are in "real" terms; that is, they are measured in constant (2000) prices. The data are plotted in Figure I.3 (cf. Figure I.2). For the time being neglect the line drawn in the figure.

5. Estimation of the Econometric Model

Now that we have the data, our next task is to estimate the parameters of the consumption function. The numerical estimates of the parameters give empirical content to the consumption function. The actual mechanics of estimating the parameters will be discussed in Chapter 3. For now, note that the statistical technique of **regression analysis** is the main tool used to obtain the estimates. Using this technique and the data given in Table I.1, we obtain the following estimates of β_1 and β_2, namely, −299.5913 and 0.7218. Thus, the estimated consumption function is:

$$\hat{Y}_t = -299.5913 + 0.7218X_t \qquad \text{(I.3.3)}$$

The hat on the Y indicates that it is an estimate.[11] The estimated consumption function (i.e., regression line) is shown in Figure I.3.

[11] As a matter of convention, a hat over a variable or parameter indicates that it is an estimated value.

TABLE I.1
Data on *Y* (Personal Consumption Expenditure) and *X* (Gross Domestic Product, 1960–2005), both in 2000 Billions of Dollars

Source: *Economic Report of the President*, 2007, Table B–2, p. 230.

Year	PCE(*Y*)	GDP(*X*)
1960	1597.4	2501.8
1961	1630.3	2560.0
1962	1711.1	2715.2
1963	1781.6	2834.0
1964	1888.4	2998.6
1965	2007.7	3191.1
1966	2121.8	3399.1
1967	2185.0	3484.6
1968	2310.5	3652.7
1969	2396.4	3765.4
1970	2451.9	3771.9
1971	2545.5	3898.6
1972	2701.3	4105.0
1973	2833.8	4341.5
1974	2812.3	4319.6
1975	2876.9	4311.2
1976	3035.5	4540.9
1977	3164.1	4750.5
1978	3303.1	5015.0
1979	3383.4	5173.4
1980	3374.1	5161.7
1981	3422.2	5291.7
1982	3470.3	5189.3
1983	3668.6	5423.8
1984	3863.3	5813.6
1985	4064.0	6053.7
1986	4228.9	6263.6
1987	4369.8	6475.1
1988	4546.9	6742.7
1989	4675.0	6981.4
1990	4770.3	7112.5
1991	4778.4	7100.5
1992	4934.8	7336.6
1993	5099.8	7532.7
1994	5290.7	7835.5
1995	5433.5	8031.7
1996	5619.4	8328.9
1997	5831.8	8703.5
1998	6125.8	9066.9
1999	6438.6	9470.3
2000	6739.4	9817.0
2001	6910.4	9890.7
2002	7099.3	10048.8
2003	7295.3	10301.0
2004	7577.1	10703.5
2005	7841.2	11048.6