Introduction

This book has a distinct philosophy and it is appropriate to make this explicit at the outset. In our view good applied econometrics can reveal important and useful insights about real-world behaviour; econometrics is not simply a body of abstract theory but a fundamental tool of the economic analyst. As with any tool it can easily be misused and its power lies at least partly in the skill of the practitioner. Many formal econometric courses leave the student with a detailed knowledge of the analytical tools of econometrics but often little feel for how it can be applied and of the practical dangers which face the applied econometrician. Our view is that good applied econometrics requires an amalgam of up-to-date statistical knowledge, good economic theory and a knowledge of real-world institutional factors. It is only when these diverse elements are successfully brought together that useful empirical results can be obtained.

The view expressed above is neither particularly new nor controversial, but there are several real problems which face any student nearing the end of an econometrics course. Most notably there has been a number of recent advances in econometrics which are often not covered comprehensively in the standard textbooks. However, some of these techniques are central to much current applied work. It is also true that the link between much textbook theory and what econometric modellers do often in practice, is not always apparent. This book then is designed to bridge the gap between a standard third-year undergraduate or a postgraduate econometric theory course and the practical work which will be asked of most applied economists, some of whom are employed in government or in large corporations.

We try to achieve this aim in two ways: We give a series of overviews of topics which we regard as particularly important; for example, general-to-specific modelling, cointegration, Kalman filters, maximum likelihood, etc. In each overview we attempt to concentrate on the implications of these concepts for practical work. Thus we do not generally dwell on formal proofs or a complete exposition of the theory. Instead we attempt to draw out important practical insights, give an intuitive feel for the techniques and show how these relate to other areas of econometrics. The second part of our approach is to illustrate the techniques discussed with actual examples of applied work. These examples are not constructed specially for this book but each one represents a genuine piece of economic research which has been undertaken on a real-world problem. So they contain many instances of the problems which arise constantly in real applied work; problems of data availability, problems of possible structural, institutional and policy changes, etc. This emphasis on illustrating techniques by real applications rather than by simple constructed examples is, in our view, important. It demonstrates that these techniques really do provide insights to real-world problems and that making them work is neither simple nor automatic. Applied econometrics can not be done mechanically: it needs understanding, intuition and skill. Much of the material in the book is based on our own practical experience of the Bank of England, H.M. Treasury, International Monetary Fund, The National Institute of Economic and Social Research, The London Business School and for private sector organisations. We hope that some will gain useful insights from the examples used and that passing it on in this way we may shorten the learning time of others.

One way to view the structure of this book is to contrast it with many standard textbooks. A common approach is to discuss basic estimation methodology and then devote much of the book to the problems which arise when the underlying assumptions fail; serial correlation, multicollinearity, heteroscedasticity, endogenous regressors, omitted variables, latent variables, etc. Often each of these is seen as a single isolated problem. The resulting undesirable effects of the problem are described and a 'solution' is offered, based usually on a rather simplified, stylised equation. There is nothing wrong with this approach; after all, the basic concepts of econometrics need to be understood fully before further progress can be made. However, for most of this book we are interested in developing the student's awareness of practical problems that require further development of these concepts. For example Kalman filtering provides an answer to the problem of latent variables and time-varying parameters. Cointe-

gration deals with non-stationarity, and our approach to dynamic modelling allows us to deal with problems of serial correlation, multicollinearity and thorough testing of all aspects of a model. Thus much of this book is about practical solutions to problems, and how we proceed with 'real-world' econometrics despite the difficulties which always exist.

The opening Chapter is designed to provide a brief survey of the theoretical underpinnings of 'standard econometrics'. In most of the book we assume that the reader is familiar with this basic material and this Chapter is designed primarily as a 'refresher course'. We hope it will be useful as a reference source for background information for the later Chapters but we are aware that our exposition is probably too concise to be of use to students coming to econometrics for the first time.

Chapter 2 deals with the unifying principle which underlies much of the rest of the book, namely maximum likelihood. This provides the conceptual basis both for structural estimation and for classical inference which justify many of the techniques and procedures which are outlined later. In this Chapter perhaps even more than the later ones, we concentrate on an intuitive exposition and an understanding of the key results rather than detailed proofs. We illustrate both the power and generality of the maximum likelihood principle by outlining the way it may be applied to a range of models which would be particularly hard to deal with in any other way. These include discreet switching disequilibrium models, censored models (Tobit and Probit), and ARCH and GARCH models.

Chapter 3 gives an account of time series modelling techniques looking at both autoregressive and moving average representations and discussing the Box–Jenkins methodology. While we have only limited interest in pure time series analysis (our main interest being in structural economic modelling), the techniques of time series modelling are both useful and important for many aspects of structural economic modelling. For example, time series representations of data will be seen to be of considerable use when we come to deal with the modelling of expectations variables and for cointegration in later Chapters.

The next Chapter gives a broad exposition of the dynamic modelling strategy which has grown out of the work of Sargan and his former students at the London School of Economics. This has developed into a major theme within modern economics. We have found these techniques to be both powerful and intuitively appealing in many practical applications and this Chapter in some sense provides the basis for many of our practical examples. We begin by

providing an overview of the methodology of general-to-specific modelling which is at the heart of this approach. We then consider the formulation and estimation of dynamic models in some detail and outline the broad range of econometric tests which are performed on such models. We conclude this Chapter with an illustration of modelling the demand for money for a number of countries.

Chapter 5 deals with the problem of non-stationarity and discusses the relatively new area of cointegration. This Chapter is strongly related to the previous one on dynamic modelling as developments in cointegration provide a sound theoretical underpinning for the dynamic modelling strategy. It also draws on some of the ideas developed within the 'time series' school of modelling which were outlined in Chapter 3. Cointegration is presented as a central concept for the econometric modelling of non-stationary data. It is an absolute prerequisite for the satisfactory modelling of most economic time series (e.g. output, consumption, interest rates, etc.) and thus testing for cointegration and the estimation of cointegrating relationships is a crucial element in economic modelling. This topic is still in its embryonic stage and we are aware that both the theory and practical techniques are developing at a rapid rate.

Chapter 6 considers how we may handle the important question of expectations of future economic variables. This is important both in terms of understanding the structure of the economy, as we believe that many structural relationships have important expectations effects, and in building models which are robust to structural change due to changing expectations formation procedures (the 'Lucas' critique). We concentrate principally on the limited information estimation techniques which have proved useful in applied work and we survey a range of methods for achieving both consistency in estimation and correct inference. This Chapter may be viewed as outlining one set of solutions to the problem of 'unobserved variables', namely agents expectations.

The next Chapter gives a different and, in many ways, complimentary approach to the problem of unobserved components, measurement error and time-varying coefficients by discussing the principle and application of the Kalman filter. This approach provides a general framework for estimating a wide range of models, including the ones mentioned above. We develop the Kalman filter as a generalisation of more conventional econometric techniques before giving a formal statement and derivation. We illustrate how a range of standard and non-standard models can be represented in state space form and estimated with the aid of the Kalman filter.

The final Chapter outlines a range of techniques which are rarely considered in econometrics courses or discussed in textbooks; these centre around the use of large models. Often one of the products from single-equation or small sub-system estimation is a collection of equations which together constitute a large non-linear econometric model. These models are used widely by governments in policy formation and analysis and by many forecasting organisations. A body of techniques has grown up which allows the model users to analyse and manipulate their models and this body of knowledge forms the core of the Chapter. The use of large models is a topic which does not usually receive much attention on most courses, which is unfortunate given that many applied economists in government and large corporations will often have to use such models during the course of their careers.

Econometrics at a formal level has a number of quite divergent views and philosophies, at a practical level these divergences become more marked. Three of the competing methodologies (although we do not claim to be exhaustive) are the Bayesian school, best typified by the work of Arnold Zellner, the non-structural modelling approach typified by the vector autoregressive models of Christopher Simms, and the dynamic modelling approach which has grown out of the work of Dennis Sargan and latterly David Hendry. There is also something of a divide at the practical level between those researchers who attempt to estimate and test a tightly defined theory and those who attempt to derive models which are broadly theory consistent but which are designed to characterise the actual data set used. We would not presume to attempt to judge between these views, but our background and experience give us competence to deal with only one of these approaches to our own satisfaction. We have been trained and we work within the framework which has been developed by the dynamic modelling approach. This book then sits firmly within that tradition which has developed out of Sargan's work at the LSE and which has been influenced profoundly by the many notable scholars who over recent years have contributed to this branch of the literature. The fact that this book does not attempt to give an exposition of some of the other modelling philosophies should not be taken as a criticism of these views but simply an admission of the limits of our own expertise.