

# **ECONOMETRICS**

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Alchemy or Science?

**DAVID F. HENDRY**



# Econometrics Alchemy or Science?

*Essays in Econometric Methodology*

David F. Hendry



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# Preface

This is a collection of my main essays on econometric methodology from the period 1974–85 during which the approach developed into its present form, integrated by a commentary on the motivations, personalities and ideas central to its formalization. Sue Corbett of Blackwell Publishers initiated the idea of drawing together the main steps through which the methodology had evolved, since a developmental viewpoint can be clarifying. In particular, an important part of the explanation for why a given methodology takes its current form are the successes and failures of its earlier incarnations. As each study reproduced below was undertaken, new issues and problems were highlighted, stimulating further developments and leading me to discard aspects of previous approaches as inadequate. Indeed, that process has continued unabated, so the story is still progressing, outdating some of the themes and interpretations discussed herein, but fortunately not the historical sequence. The ideas discussed below are now sufficiently developed, interrelated and formalized to allow an integrated treatment, and the outcome is the present volume.

Five criteria were used to select the included papers from the 40 that I published during 1971–85: their importance in the evolution of the methodology; their role in the continuity of the exposition; their focus on methodology; the subject matter of their empirical application; and the accessibility or otherwise of the original publication to economists world-wide. The first and third criteria eliminated technical papers on econometric theory, estimation methods (other than the synthesis in chapter 13) and Monte Carlo techniques (except for the second half of chapter 7). Conversely, despite their being accessible, eight papers from international econometrics journals were included because of their central role and the needs of continuity. Given an overall length restriction, the fourth criterion induced the arbitrary choice of including studies of consumers' expenditure and money demand but excluding most of my empirical papers on housing and credit markets, despite the fact that the latter came high on the fifth criterion. The second and fifth criteria then led to the choice of most of the remaining chapters, except for the Postscript which extends the horizon to 1989.

The book is divided into four parts: Roots and Route Maps, Empirical Modelling

**Strategies, Formalization, and Retrospect and Prospect.** The preambles to each part and to each chapter sketch the points that I believe I was trying to make at the time, the lessons I learnt, the developments which were triggered in turn, and the crucial issues I completely missed! Since the chapters differ greatly in the mathematical, statistical and conceptual demands they make of the reader, the major departures in their ordering from the historical sequence arise from attempting to ensure a more even progression in difficulty. In practice, most of the methodological developments recorded below derived from confronting substantive empirical problems. Not only are theory and application inseparable below, each empirical study is itself the vehicle for the exposition and the analysis of the associated methodological advance or rethink. Often, precise formalization of the concepts, principles and procedures came later. Consequently, while chapters 2, 3, 6–12 and 18 concern specific empirical problems, they have a substantial theoretical component as well as analyses of practical problems like collinearity, seasonality, autocorrelation, simultaneity and parameter constancy. Throughout, attention is restricted to the analysis of economic time-series data, based on linear models (perhaps after suitable data transformation).

‘Methodology’ is construed in the wide sense of ‘the study of methods’ (see, for example the usage in chapter 2) and most of the book concerns specifics rather than grand themes. It seems self-contradictory to claim that there exists a single valid methodology for discovering hitherto unknown features of our world: until they are discovered, we cannot know what would have been the ‘best’ way of discovering them. This argument does not render methodology otiose: there may be no best way to drive a car, but steering with one’s eyes closed is patently a bad way. Critical appraisal of currently used methods is feasible and can reveal serious flaws in them. Much of the book concerns doing so (destructive criticism) and then offering a less objectionable alternative (constructive criticism) which is evaluated in turn. Criticisms are based on theoretical economic and econometric analyses, empirical applications and Monte Carlo simulations, which interact to narrow down the range of legitimate (or perhaps ‘best practice’) methods. By pursuing such an approach to the study of economic time series, the book contributes to the steady progress of econometric methodology that we have witnessed in recent years. Finally, since half of the chapters were originally written as expositions of important technical developments, methodological advances or new concepts, most of which remain germane, the material should help in understanding recent debates about econometric methodology.

# Acknowledgements

Writing this part of a book is a double pleasure: the thought that most of the hard work has been completed combines with the remembrances of the kindnesses and help accorded by so many at every stage in the book's creation, from my first strivings to understand econometrics, through the evolution of the various ideas described below, to the final collation of this collection.

Since ideas can be understood only in relation to pre-established knowledge, I owe an immense, if implicit, debt to earlier econometricians and statisticians: the references are partial acknowledgement of that debt. Peter Fisk and Bert Shaw steered me into economics; Derek Peare guided my first steps in econometrics; Denis Sargan and Jim Durbin respectively established my technical knowledge of econometrics and of time-series analysis; and Meghnad Desai, Bill Phillips and Denis Sargan taught me how to link econometrics and economic analysis in quantitative economics. I am greatly indebted to them all for their efforts, and to the London School of Economics for financing my graduate studies.

The individual chapters explicitly acknowledge the advice and intellectual and financial help which I received while writing each paper – except, of course, for the role of each of my co-authors! Co-authors kindly agreed to the publication of the many joint papers reprinted here, and helpfully commented on earlier drafts of preambles. I can record with pleasure not only the essential part they played in bringing their respective papers to fruition, but also their invaluable encouragement and assistance in helping to set straight the historical record and the analyses presented below: my grateful thanks to Gordon Anderson, James Davidson, Rob Engle, Neil Ericsson, Robin Harrison, Grayham Mizon, John Muellbauer, Adrian Neale, Adrian Pagan, Jean-François Richard, Denis Sargan, Aris Spanos, Frank Srba, Pravin Trivedi, Thomas von Ungern-Sternberg, Ken Wallis and Stephen Yeo.

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As the Preface notes, the book was the brainchild of Sue Corbett of Blackwell Publishers and I am delighted to record my thanks to her both for suggesting the project and for sustaining it through its initial stages. To Romesh Vaitilingam goes the credit for stimulating me to complete the book in a finite time.

I am grateful to the following companies, organizations and societies for their kind permission to reprint the papers herein: Cambridge University Press, The Econometric Society (*Econometrica*), *Economica*, *European Economic Review*, Federal Reserve Bank of Minneapolis, Gower Publishing Company Ltd, International Statistical Institute (*International Statistical Review*), *Journal of Econometrics*, London Business School, Elsevier Science Publishers B.V. (North-Holland), *Oxford Review of Economic Policy*, Oxford University Press, Royal Economic Society (*Economic Journal*), Scottish Economic Society (*Scottish Journal of Political Economy*), Society for Economic Analysis Ltd (*Review of Economic Studies*) and Tieto Ltd.

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# Introduction

The collection begins with the paper after which it is named, since that chapter provides a gentle romp through many of the major topics and offers a guide to the main themes of the book. Moreover, it was written at about the half-way stage in time between my first rudimentary grapplings with model specification issues and my views as of 1990. Nevertheless, chapter 1 has a serious message: econometrics is potentially scientific precisely because alchemy is creatable, detectable and refutable. Although important technical difficulties about the properties of tests and of model selection procedures based on sequential testing await resolution, model evaluation is a legitimate activity independently of past and present controversies about the constructive uses of econometrics. That ‘the three golden rules of econometrics are test, test and test’ is a constant theme from my first research to my latest writings. The validity of a model is a property of the model in relation to the evidence and so cannot be affected by how that model is selected. If the model is valid, it will pass all of our tests at an appropriate significance level (usually dependent on the sample size, the number of tests and the data characteristics). If the model is invalid, we should be able to detect that by a sufficiently rigorous test procedure. In neither case, therefore, can validity be affected by how the model was found, designed or created. In practice, models are more or less adequate approximations rather than strictly valid or invalid, but the point remains that the adequacy of an empirical model is an intrinsic property which is not impugned by the method of construction. As we shall see, however, such an implication does not make the selection method irrelevant: in particular, some methods (e.g. guessing) have little chance of discovering adequate models. Much of the present volume concerns developing criteria for model adequacy and analysing alternative approaches to building empirical models, so ‘methodology’ is construed in the general sense (‘with a small m’ as Boland (1989) expresses it) and does not entail only the grand issues (as, for example, in Popper, 1968).

The alchemy practised in chapter 1 is to explain UK inflation ‘better’ by rainfall than by the stock of money. Since chapter 1 was written, an immense literature has evolved concerning the analysis of non-stationary data and nonsense regressions,

## 2 Introduction

and the converses of cointegration and error correction. These analyses help resolve when we can attach meaning to empirical regressions, so the associated concepts recur many times below.

The roots of the approach are taken up in chapters 2 and 3, which embody many of my later ideas in embryonic form. My first empirical modelling exercise was a small system of aggregate demand relationships in the UK, using estimators specifically developed to tackle the ‘problems of autocorrelation and simultaneity’. Chapter 2 sought to apply the approaches in Sargan (1958) and (1964a) to small simultaneous systems, in order to discriminate between cases where (vector) residual autocorrelation arose from autoregressive errors or from mis-specification of the lag structure of the observed data series, and to ascertain the relative importance of dynamic mis-specification and simultaneity. Rather than simply asserting that residual autocorrelation reflected autoregressive errors and therefore applying a ‘more sophisticated’ estimation method to resolve that problem, tests were used to check whether the dynamics of the pre-specified model needed to be generalized. Therein lay three difficulties that I did not clearly perceive at the time of writing (1969), but which became increasingly obvious as my work on the approach proceeded.

- 1 In practice, the correct model was not known *a priori*, merely requiring estimation of its parameters. An awkward model selection problem generally confronted any empirical investigator and the conventional paradigm of assuming that the model was known in advance of examining the data was simply not appropriate.
- 2 It was not legitimate to use the outcomes of model specification tests for constructive revision of a model. If a model was incorrect, many test statistics might yield rejection outcomes and so it could not be appropriate in general to assume that, if any given null hypothesis was false, the postulated alternative must be true: both could be false, because the framework was incorrect.
- 3 Generalizing an initial simple model in the face of specification test rejections raised a host of problems, not least that of when to stop and what sense to make of earlier interpretations when a later test rejected.

At this stage, these were merely puzzles to me. Chapter 3 was written five years after chapter 2 and embodies (albeit in an inchoate form) a number of roots that have since proved dominant. The approach is more nearly that of simplifying an initial general system; an attempt is made to account for the performance of previous empirical models by testing them for mis-specifications predicted by the economic theory; and the underlying economic theory, which patched a static long run onto dynamic adjustment, delivered a model form which I later recognized as an error correction mechanism. Both chapters skirt around, but miss, Denis Sargan’s later notion of common factors in lag polynomials (denoted COMFAC; see Sargan (1980a) and chapter 4), and the importance of data non-stationarities, issues which play an important part in what follows.

Part I is completed by chapter 4, again written about five years further on (1980), jointly with Adrian Pagan and Denis Sargan. Written with ‘hindsight’ relative to most of the other chapters herein, it is offered as a route map, sketching the major

issues, models, concepts and techniques, and referring forwards to later chapters. All of part I is explicitly system oriented, but my empirical efforts had starkly revealed that few of the component equations were trustworthy, and so without any conscious decision my attention gradually became focused on single-equation models.

Part II, which describes the development of empirical modelling strategies, reflects that tendency. Throughout the late 1960s and early to mid-1970s, much of the research into time-series econometrics reflected an intense rivalry between a data-analytic viewpoint (closely related to Box and Jenkins, 1976) and economic-theory-driven econometric modelling. At the London School of Economics (LSE), from where most of the material in this book originated, the econometrics research group included (for substantial periods up to 1980) James Davidson, Meghnad Desai, James Durbin, Andrew Harvey, myself, Grayham Mizon, Denis Sargan, Pravin Trivedi and Kenneth Wallis. At the risk of simultaneous over-simplification and excessive generality, we emphasized the complementarity of the two approaches, and sought to synthesize the best elements in both. In setting the scene for part II, chapter 5 commences with an extract evaluating the 'time-series' approach to econometrics, which summarizes the main themes to follow. These include a critique of pure time-series methods, as well as brief discussions of non-stationarity, differencing and error correction models, the reinterpretation of residual autocorrelation (now using Denis Sargan's COMFAC idea), the explanation of competing models' findings and ways to reduce the proliferation of conflicting results, and the respective roles of criticism and construction.

COMFAC in single equations is discussed at greater length in chapters 6 and 7, written jointly with Grayham Mizon. These comprise two closely related papers investigating the important conceptual clarification of autoregressive errors as common-factor dynamics. However, the evidence seemed less favourable to its being a solution to model selection problems in practice. Chapter 8 (written with James Davidson, Frank Srba and Stephen Yeo) also considers many of the issues raised in chapter 5, especially the explanation of other models' results, and while it is substantively focused on modelling aggregate consumers' expenditure, it has a strong methodological slant: modelling strategies, parameter constancy, collinearity, seasonality and encompassing are investigated. Although the main product was an empirical equation which could claim some success (since known as DHSY from the acronym of its authors), its properties immediately prompted a progressive improvement, stimulated by Thomas von Ungern-Sternberg and reproduced as chapter 9. A third extension, to test whether DHSY could encompass the rational-expectations permanent-income model of Robert Hall (1978), appears as chapter 10 (again with James Davidson), which *en route* allowed both replication and testing of the earlier findings. The penultimate chapter of this volume provides a retrospective evaluation of the empirical evidence on consumers' expenditure and the success of the chapter 8 model as of 1982, while doubling as a final exposition of the empirical methodology. This group of four papers is intended to illustrate the progressive nature of the research in practice. A recent review is provided in Hendry et al. (1990b).

The major area of application now switches from consumers' expenditure to



transactions money demand, although historically that switch actually happened after chapter 8. Contemporaneously, a major change took place in the methodology. DHSY was written as a ‘detective story’; investigators were viewed as acquiring evidence, forming conjectures, testing hypotheses and seeking to create a model which could account for the complete set of evidence confronting them, both successes and failures. Beyond rigorous testing and encompassing, the methodology was unstructured and almost anarchical in what stratagems were acceptable. This presented a gloomy prospect – did empirical researchers all need Sherlock Holmes’s acumen, industry and creativity to make any useful contributions?

Two events set the scene for the later integrated approach. First, in the COMFAC approach, one must commence from the most general model considered admissible and then sequentially simplify it, testing at each step whether or not a given lagged set of variables corresponds to an autoregressive error. It is inherently ‘general to specific’ as in testing (say) the order of a data autoregression in Anderson (1971). Pravin Trivedi (1973) had applied the Anderson approach and Grayham Mizon also adopted this viewpoint in his 1977a paper on selecting dynamic models using ordered and nested sequences of tests. Nevertheless, I did not realize the generality of that idea and hence did not perceive its wide applicability beyond dynamic specification. DHSY had stumbled over the need to test against the general model but did not focus on its central role in a structured methodology. Incidentally, note that chapter 8 was first written in 1974–5 and was essentially completed before chapter 7 was begun, even though they appeared in the reverse order – which is why the later publication does not reflect the earlier one.

Second, Jean-François Richard at the Centre for Operations Research and Econometrics (CORE) (Louvain-la-Neuve, Belgium, where a group was investigating model reduction methods) realized that there were close parallels between the emerging LSE approach and that evolving at CORE. Richard’s paper to the 1977 Econometric Society Meeting in Vienna (published as Richard, 1980) combined with the Sargan–Mizon viewpoint made me realize at last (probably after dozens of hours of discussion!) that the solution to most of my earlier puzzles lay in commencing empirical modelling from the general, not from the specific. Chapter 11 reflects this *gestalt* shift and opens up a far more positive prospect for empirical econometrics based on a structured and communicable approach. As Adrian Pagan notes in his 1987 survey, commencing from a general model is central to most of the major methodological approaches now extant in econometrics. Of course, generality is not a panacea to all econometric ills: no matter how general its initial specification in terms of dynamics, error structures, functional forms or evolving parameters, a relationship between inflation and rainfall must remain nonsense. Indeed, given the earlier argument that model validity is independent of the selection method, the issue about modelling strategy is really one of research efficiency, as will emerge below.

The initial objective in chapter 11 was to field-test the emerging methods in a new area and investigate their ability both to produce useful or improved models and to encompass previous findings. Chapter 11 also offers a critique of ‘simple-to-general’ modelling methods and contrasts the outcome with that achieved by working throughout within an initially general well-defined framework and seeking admissible simplifications which yield parsimonious, constant and encompassing