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Book Selection

Edited by JM Wilson

Fractional Programming: Theory, Methods and Applications

IM Stancu-Minasian

Kluwer Academic Publishers, Dordrecht/Boston/London, 1997. viii + 418 pp. £135; $226; Dfl 365. ISBN 0 7923 4580 0

A fractional programming (FP) problem is a constrained optimisation problem in which the objective function is a ratio of functions such as cost/volume, output/input, profit/capital, return/cost and signal/noise etc. Most of this book is of a technical mathematical form concentrating on theory and solution methods. The first chapter describes over two dozen applications, devoting about a page to each. I would have liked these treatments to be longer. The applications include blending, cutting stock, transportation with multiple objectives, investment allocation, and set covering.

The good news, for those familiar with linear programming, is that if the objective is a ratio of linear functions then the FP problem reduces to a linear programme, assuming the constraints are linear too. More generally, if the numerator function is nonlinear but concave and the denominator function is convex (on the feasible region), then a local optimum will be a global optimum. There are separate chapters on duality, nonlinear FP, multiple objectives, integer FP, the fractional transportation problem, and even FP in the complex plane! Each chapter concludes with a section of historical notes and commentaries. As well as the usual subject index there is an extensive author index.

I am aware of two other books on FP. The one by Craven[1] which is also a theoretical treatment, and a book written in German by Schaible[2]. This present book has been translated from Romanian by Victor Giurgiutiu; in which I found the English to be always comprehensible.

Many readers may be surprised by how much research has been published in FP but the author has done a great service by collecting together a bibliography of over one thousand references. The bibliography is arranged by author. Despite this broad coverage the book still leaves untouched two important areas. One is in numerical analysis and deals with the use of rational functions (ratios of polynomials): (i) to fit/model data; and (ii) for the approximation of complicated functions. For example, pocket calculators use rational functions to evaluate certain elementary functions, and these provide greater accuracy than power series for the same number of terms. The other area is DEA (data envelopment analysis) which has a literature as large as the bibliography we have here[3]. DEA is surely the most common application of FP and has now reached a level of importance such that it can be found in university textbooks, yet it is not discussed. It is almost as if there are three groups of researchers with an interest in FP, but with little cross-fertilisation between them.

Another item that would have been useful is a section describing what software is available today. I know of one specialist FP package by Bajalinov and Pannell,[4] but there must be others.

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Reference

1 Craven BD. (1988). *Fractional Programming*. Heldermann Verlag: Berlin.
2 Schaible S. (1978). *Analyse und Anwendungen von Quotientprogrammen*. Mathematical Systems in Economics 42, Hain-Verlag, Meisenheim.
3 Emrouznejad A and Thanassoulis E. (1996). *An Extensive Bibliography of DEA*. Volume I: Working Papers. Volume II: Journal Papers. (There is also a supplementary update.) Warwick Business School Research Papers, University of Warwick.
4 Bajalinov EB and Pannell DJ. GULF (General User-friendly Linear and linear-Fractional programming package). Downloadable from: http://neumann.math.klte.hu/~erik/tr93-86.html.

Systems Modelling for Energy Policy

DW Bunn and ER Larsen (eds)

Wiley, Chichester, 1997, ix + 331 pp. £50. ISBN 0 471 955794 1 (hb)

This edited collection involving 23 authors from nine different countries presents 14 different case studies which illustrate the range of issues and modelling alternatives where a systems perspective can contribute to the analysis of energy policy. Most of the contributions were prepared specially for the book, while some result from presentations made at the Energy Modelling Symposium held at the London Business School in July 1995.

The book begins with a short introductory chapter by the editors which contextualises the case studies in terms of a brief review of modelling traditions in the energy sector. This distinguishes the large scale econometric or optimisation-based systems that formed the traditional approach to energy modelling, and their later linking with macroeconomic models in order to incorporate explicit consideration of previously exogenous variables, from the use of input-output models, Computable General Equilibrium approaches, and systems dynamic modelling. Case studies ranging across most of the approaches identified in the review are included in the volume. A number of the case studies deal with the issue of using different modelling techniques in a co-ordinated way, some illustrate the combination of both hard and soft OR approaches.

The case studies illustrate both investigation of restructuring within the energy sector, for example away from planned national energy policies to new market structures, and responses to concerns such as global warming, in terms of the evaluation of alternative policy options. Issues such as climate change, greenhouse gases, mechanisms for reducing carbon dioxide emissions and energy conservation measures all receive attention. The case studies include some with a focus on specific energy sectors (oil and electricity notably), as well as multi-sectoral models. The case studies also illustrate energy modelling at a variety of different levels: global, national, and regional. Examples relating to a variety of different countries are included: Australia, Colombia, Denmark, Germany, the Nordic countries, Turkey, the UK, and the US (four different case studies in this case).

By and large, the case studies do succeed in going beyond the mere description of different models, and provide interesting discussion of *some* aspects of their use, but not as much as might be wished in some cases. In some cases the focus of the discussions is on the evaluation of alternative policy options, in others on technical aspects of modelling, and in others still on the use of models for organisational learning. The case studies are admirably diverse, although in many instances frustratingly short, so that only a selective presentation can be given. The most successful, for this reader, were those where the presentation was long enough to pay attention not only to aspects of the model structure and estimation, but also to discuss results and their implications in some detail. I found the case studies by Claudia Kemfert and W Kuckshinrichs (energy analysis in Germany), Poul Erick Grohnheit (models for electricity capacity development, discussed with reference to examples for Denmark), John Morecroft and Brian Marsh (Royal Dutch/Shell simulation model of global oil markets, used to facilitate strategic thinking in industry executives) and Derek Bunn, Eric Larsen and Kiriakos Vlahos (effects of privatisation on electricity investment in the UK), particularly stimulating.

While a number of the chapters set out admirable procedures for model formulation (for example Andy Kydes and Susan Shaw on the US Energy Information Administration's National Energy Modelling System), generally there is very little attention to the issue of model validation (the term does not even appear in the index). For some chapters this disturbs me less than others. For example John Morecroft and Brian Marsh's chapter on Royal Dutch/Shell work on global oil markets, concerned with scenario planning 'as a way to discover new concepts and language that enable the organisation to become more agile in recognising significant industry trends, defining emerging business problems and preparing the mind of senior managers to deal with such problems' (page 167) and not with predicting or forecasting the future, arguably need not be too concerned with issues of validity if the aim is training or gaming. It however becomes much more crucial where evaluation of policy options is taking place, and where prediction/forecasting is intended. I noted with wry amusement the following footnote to one of the US case studies: 'The cobweb model does not always converge to equilibrium.... Convergence to equilibrium has not formally been tested in IDEAS (the model concerned), but in fifteen years of use it has not been known to exhibit behavior typical of an exploding system. It is therefore felt that an equilibrium exists even though it has not yet formally been tested' (p 46). In terms of other irritations, the most frustrating was the lack of a glossary of acronyms; this would certainly have been useful to me and I suspect to many others like me, who are not specialists in this field.

To conclude, the book succeeds in bringing together a diverse range of interesting systems modelling applications in the field of energy policy, and most importantly, gives the reader an insight into the process of their use and their usefulness. The book will be an extremely useful addition on to the reading lists for a wide range of courses in operational research, systems science and management science, in providing a rich fund of case studies to illustrate different modelling approaches for energy policy.

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Stochastic Programming

A Prekopa

Kluwer Academic Publishers, London, 1995. xviii+599 pp. £178.00. ISBN 0 7923 34825

Introduction to Stochastic Programming

JR Birge and F Louveaux

Springer, London, 1997. xix+421 pp. £32.50. ISBN 0387 98217 5

To someone interested in LP and IP, stochastic programming may seem something of an ideal. Many of the assumptions made about data and logic in LP and IP can be reconsidered when stochastic programming allows the introduction of probabilities and distributions which will provide a framework for the inclusion of tolerances and errors. However, stochastic programming is less discussed than LP and IP. Some commentators feel that using stochastic programming is an admission of woolly thinking and it is better to use a deterministic approach and explore sensitivity. The authors of these two books could not be accused of woolly thinking.

The two books offer a contrast. Firstly, the book by Prékopa, unfortunately being reviewed belatedly, is the more formal and traditional. Its intentions (from the back cover) are to provide an introduction to the subject, but with the inclusion of high level mathematics, and the reader will certainly find plenty of advanced mathematics, for example, Borel and Lebesgue measures. The book is very densely packed (as well as being almost 600 pages long), contains some 'interesting' English, but does generally have plenty of exercises to jolly the reader along. The book starts with three chapters of LP and IP preliminaries—simplex, duality, 2-person games, convex polyhedra, IP cutting planes, and Dantzig-Wolfe decomposition. Then Chapters 4–7 offer statistical preliminaries—measures, moment problems (deriving quantiles of a distribution when only certain moments are known), approximating probabilities, and statistical decisions.

Now, after some 230 pages, the author moves into stochastic programming proper. Chapter 8 is on static problems. Familiar problems such as the Newsboy Problem are discussed, and there is some game theory. In Chapter 9 we move to simple recourse problems, where simplex approaches (or dual ones) start to be used. This chapter has some good motivating examples, but some indication of the intensity of the treatment is given by one of the exercises for the reader which is to 'prove the Black and Scholes formula', familiar from share option pricing theory. Chapter 10 considers probabilistic constrained problems whilst Chapter 11 continues this theme into programming under probabilistic constraints and maximising probabilities under constraints. This latter chapter introduces examples on reservoirs and inventory and there are lots of numerical calculations.

In chapters 12 and 13 two-stage and multi-stage stochastic programming problems are introduced and the reader is now at the summit of the topics ready to move into the extremely useful Chapter 14 which is 50 pages of cases and applications. There is discussion of the water regulation problem of Lake Balaton, Hungary (see also Miser[1]) and other similar problems. The following chapter is a very technical chapter on the problems of finding distributions (or parts of them) via programming methods, and there the book ends, somewhat abruptly, with an Appendix which follows. There is no summary or review to end the book, and indeed such features are missing at chapter ends. Thus the book is not exactly a teaching book, as the author always assumes the reader follows the argument, but an encyclopaedic introduction to the field by an acknowledged expert in the area. This is a good book to read stage by stage over a long period because the reader will then gain a comprehensive knowledge of the topic. As the book is expensive, slow reading will at least give the reader the impression of recovering value for money.

The book by Birge and Louveaux, again exerts with an impressive publication list in the stochastic programming field, has a lighter touch.

This book is divided into four parts: Models (Chapters 1, 2), Basic Properties (Chapters 3, 4), Solution Methods (Chapters 5–8), Approximation and Sampling Methods (Chapters 9–11) and a Case Study (Chapter 12).

Chapter 1 sets off with some traditional style examples, (newsboy, farmer) but this time EU regulations affect people in examples and quotas feature. This introductory chapter shows how deterministic problems can be moved out into realistic situations when stochastic programming is possible. Lots of interesting examples are used in a readable style that sets the scene for the rest of the book. The exercises for the reader include determining strategies for Formula One racing and the long jump in the decathlon.

Preliminaries continue in Chapter 2, with probability concepts established. LP and duality are assumed known, but curiously then described in an appendix to the chapter, just in case.

In Part II of the book the emphasis moves to stochastic programming. Two-stage problems, chance constraints, stochastic IP and stochastic NLP are described in Chapter 3, whilst Chapter 4, a shortish chapter, establishes the value of performing stochastic programming by describing the 'value of information' computations.

Part III is very meaty. Chapter 5 is concerned with 2-stage linear recourse and introduces the L-shaped method, leading to feasibility cuts. In this chapter there is much manipulation of LP matrices and tableaux. Chapter 6 is the NLP counterpart of Chapter 5 and introduces the piecewise quadratic form L-shaped method, Lagrangian approaches,

Frank-Wolfe and so on. More stages are added in Chapter 7 when nested approaches to multi-stage stochastic programming are developed. Finally in this part, stochastic IP is described and models are solved using an integer L-shaped method which develops cuts in the style of valid IP inequalities.

Part IV has some fairly heavy mathematics. Multiple integrals are involved in computing bounds for evaluating and approximating expectations in Chapter 9. Chapter 10 describes Monte Carlo methods, used for example to sample in the L-shaped method. Then Chapter 11 introduces multi-stage approximations which are useful for linkages across periods.

The final chapter (and part) is slightly disappointing. It comprises nine pages only and is a single case study on capacity expansion. It would have been useful to see more, in the style of the Prékopa book. After the final chapter the book stops as abruptly as the first one, and then comes an appendix.

Throughout Birge and Louveaux introduce exercises for the reader and aim at a less comprehensive, but easier to read text than Prékopa. They describe their volume as a text book for a first course in stochastic programming.

Which book is preferable? Birge and Louveaux have produced a less expensive book but Prékopa's is more scholarly and yet makes more frequent excursions into practical applications. Both books are daunting for the uninitiated and not ones to recommend to managers but they do provide the details an analyst would require to gain an understanding of the topic. So, a good library should acquire both texts.

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Reference

1 Miser HJ (ed). (1995). *Handbook of Systems Analysis—Volume Three—Cases*. John Wiley & Sons: Chichester.