to involve themselves with the planning process by access to those portions of the model which is of concern to them.

It is this process of aggregation and explosion that is not adequately catered for in existing systems and should form the basis of the integrated system.

Powerful software has been developed for mathematical programming, simulation, forecasting and database management. We believe that there should be an easy interface between the integrated corporate planning system and such packages. The system must provide an appropriate framework for linking quite complex models. A facility to extend the system to incorporate user defined techniques should be possible. Specialised subroutines to deal with major corporate issues such as acquisitions, company valuations, taxation, etc. could be included in such a system.

Finally the system must be easy to use and operate and must have flexible report generation capabilities. Once again we believe that a VDU screen with an English-like planning language will be ideal to provide the interface between the corporate planner and the integrated corporate planning system.

Summary

In this paper we have investigated the requirements for corporate planning systems based on opinions of senior executives from a wide range of industries, the analysis of existing systems and impressions gained from other practitioners. It is believed that future development in this area should concentrate on ease-of-use and flexibility and easy communication between the planner and the model. Two distinct systems are recommended:

1. A simple financial modelling system which is a natural extension to currently available systems;
2. Integrated corporate planning system.

The design characteristics for both the systems are considered. The IBM (UK) Scientific Centre is presently conducting research into both. It is hoped to publish the findings in a later paper.

References

BALL, R. J. (1966). *Short-Term Forecasting Model of the UK Economy*—A private report issued from London Graduate School of Business.

BIERMAN, H. *et al.* (1969). *Management Decision-Making*, Pan Books Limited, London.

FRAZIER, G. D. (1970). The Corporate Planning Model in a Large Decentralised Industrial Organisation. Paper presented at the NATO conference on *Operational Research in Industrial Systems* held at St. Louis, France in July 1970.

GERSHEFSKI, G. W. (1969). Corporate Models—The State-of-the-Art, *Managerial Planning*, November/December 1969.

GREGGAINS, A., and CARRUTHERS, A. (1971). Simulation under Focus, *Computer Management*, September 1971.

HIGGINS, J. C. and WHITAKER, D. (1972). Computer Aids to Corporate Planning, *The Computer Bulletin*, September 1972, pp. 434.

WAGLE, B. V. (1969). The Use of Models for Environmental Forecasting and Corporate Planning, *Operation Research*, Q.20, 327.

WAGLE, B. V., and JENKINS, P. M. (1971). *The Development of a General Computer System to aid the Corporate Planning Process—A Feasibility Study*. This is an IBM (UK) Scientific Centre Report Number 0024.

Book review

Introduction to Matrix Computations, by G. W. Stewart, 1973; 441 pages (*Academic Press*, £7·60.)

This book has seven chapters, four appendices, a bibliography, and three indices, on notation, the algorithms in the book, and the subject matter.

Chapter 1 (Preliminaries, 67 pages) gives the theory of vectors, matrices, linear dependence, spaces, bases, manipulative treatment and the theory of linear equations and matrix inversion. Chapter 2 (Practicalities, 36 pages) discusses inherent errors, computer arithmetic and numerical stability, introduces a simplified programming language to assist the reader to understand the algorithmic description of techniques, and uses this immediately in a discussion of the coding of various matrix operations.

Chapter 3 (the direct solution of linear systems, 55 pages) and Chapter 4 (Norms, limits and condition numbers, 48 pages), treat the solution of linear equations by Gauss elimination and its matrix equivalent with complete and partial pivoting, the Crout reduction (preferable when inner products can be accumulated in double precision), the Cholesky decomposition, and the back substitution or its equivalent. Backward error analysis is introduced and applied, though the details of the analysis are suppressed and incorporated partially in an appendix (a useful teaching tip!). Norms and limits are defined and analysed, and used mainly to measure the effect of perturbations and the condition of a problem, and to give the theory and practice of iterative refinement of approximate solutions.

Chapter 5 (the linear least squares problem, 42 pages) introduces orthogonal vectors and matrices, and uses them to discuss existence, uniqueness, perturbation and practical methods for the least squares problem. Apart from computation with the normal equations (valuable in special cases) the main techniques use elementary reflectors (Householder transformations) to reduce a matrix to upper trapezoidal form (the QR factorization), and the resulting least squares solution is again corrected by iterative refinement.

The rest of the book treats the algebraic eigenvalue problem, with Chapter 6 (Eigenvalues and eigenvectors, 77 pages) containing the theory and Chapter 7 (The QR algorithm, 68 pages) the numerical practice. The theory includes standard material, together with a discussion of the condition of eigensolutions, deflation techniques, and a section on singular value decomposition and its applications for determining the rank of a matrix and solving degenerate least squares problems. The practice concentrates on the QR algorithm, with sections on similarity reduction to Hessenberg or tridiagonal forms, using elementary reflectors (with a side-glance at the corresponding use of elementary elimination-type processes) direct, inverse and Rayleigh-quotient iteration (and their value in explaining the remarkable success of QR), the explicit QR shift using plane notations, the implicit QR shift for finding complex eigenvalues of real matrices, and applications of the QR algorithm to compute singular eigenvalues and vectors and to solve the generalised eigenvalue problem.

I have given most of the contents in some detail because this is a very fine book, combining theory and practice in the right proportions, containing a large number of exercises which include more theory and practice, frequent historical notes and references to what is not included (with another such list in an appendix), material which has been developed since the J. H. Wilkinson classic (to which frequent reference is made), and above all getting everything absolutely correct! My only criticisms are that the determinant appears only in an appendix (and even then the author gives a gracious apology for this), and that the title does not make specific the fact that there is no material on iterative methods for linear equations. But these are minor, and A. S. Householder, to whom the book is dedicated, would certainly be pleased with his friend and former pupil!

L. FOX (Oxford)