

# Corporate planning, models and computer systems

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Corporate Planning became a fashionable term in the early sixties. Countless papers have been written on the subject, many seminars held and conferences organised, but it is only in the last five years or so that management scientists have turned their attention to this area. The purpose of this paper is to concentrate on the practical aspects of corporate planning and to consider how far computer models and systems can aid the corporate planning process.

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## 1. Introduction

We define corporate planning as: 'The formalised process of developing objectives for the corporation and its sub-parts, as well as formulating, evaluating and selecting between alternative strategies to achieve these objectives on the basis of a systematic appraisal of both the external environment and an internal audit of strengths and weaknesses'.

The process in practice tends to be extraordinarily difficult mainly because:

1. The information available for corporate planning either on the organisation or its trading environment is usually sadly inadequate.
2. The sheer complexity and variety of modern business mean that systematic planning is in practice too difficult, and at best unwieldy when it is attempted.
3. The plan needs constant revision and updating.

In the past therefore the process of corporate planning has been largely based on intuition and experience of top management. In recent years however, fairly sophisticated computer models have been developed (admittedly tied to a single company) which aid the corporate planning process. For example, Sun Oil Company (Gershefski, 1969) in the USA have built a financial model of their operations using the concepts of simulation and multiple regression. This model is essentially a computer program based on simple mathematical equations which simulates the physical operations and the accounting procedures of the company providing a projection of the financial performance over ten years. Another example is that of Boise Cascade Corporation in Canada (Frazier, 1970) who have developed a long-range corporate planning model using mathematical programming. The model has been structured to maximise profits over a ten year period under alternative assumptions about raw material availabilities, investments, costs, product demands, etc. In the UK, companies such as Esso, ICI, Rio Tinto, etc. have developed a variety of corporate planning models for their own operations. The sophistication of the analytical techniques used have varied from complex linear programming models to those where the data is merely converted into a more pertinent form. The primary aim of these individual models has been to improve the corporate planning process by presenting to top management the implications of pursuing alternative strategies.

General systems capable of being employed by a variety of organisations have made their appearance only in the last two or three years, mainly developed by computer and software concerns or consultancy organisations. This paper is an attempt to review some of these existing systems, identify the needs of corporate planners and consider how computer aids in general

and management science techniques in particular can be used to make a greater contribution to the corporate planning process. Although we deal primarily with computer systems it cannot be emphasised too strongly that the value of any system or a model however sophisticated the mathematics defining it will depend upon the original data, the validity of the underlying assumptions and the soundness of judgements incorporated in using the system. Corporate strategic decisions are seldom taken (or will ever be taken) by the directors or senior executives on the basis of a mathematical model. Judgement and intuition about the future are essential requirements for the corporate planner and so is the ability at conducting personal negotiations and bargaining with senior heads of departments and Board members, who may be competing with each other for scarce resources. Any planning system or corporate planner failing to recognise this and to take into account factors which are far from quantifiable is unlikely to be of much use in business. On the other hand one cannot deny the significant contribution which the computer system can make to the corporate planner by providing him with the ability to investigate a whole range of different assumptions and their implications to his organisation.

The second section discusses the methods and techniques used in corporate model-building. In the third section we present the findings of a three months survey (Wagle and Jenkins, 1971) carried out by IBM United Kingdom Limited and Durham University Business School to assess the current state-of-art in corporate planning. The fourth section covers computer packages which are generally available in the corporate planning area while the fifth section is devoted to a description of one such IBM offering. This is primarily included to illustrate a number of issues confronting planners in the selection of such a package. Certain overall conclusions and future developments are reviewed in the final section.

## 2. Models in corporate planning

### *Techniques of model building*

Before coming to corporate models it may be worthwhile summarising some of the techniques which are commonly used to build these models. A full description of these would be out of context here, but see for example, Bierman *et al.* (1969),

Forecasting:	Mathematical curve fitting
	Causal approach—Single equation
	Multiple equations
	Input/Output analysis
	Trend analysis
	Exponential smoothing
Investment	Discounted cash-flow methods
Planning:	Decision trees

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## MODEL-BUILDING DESIGN

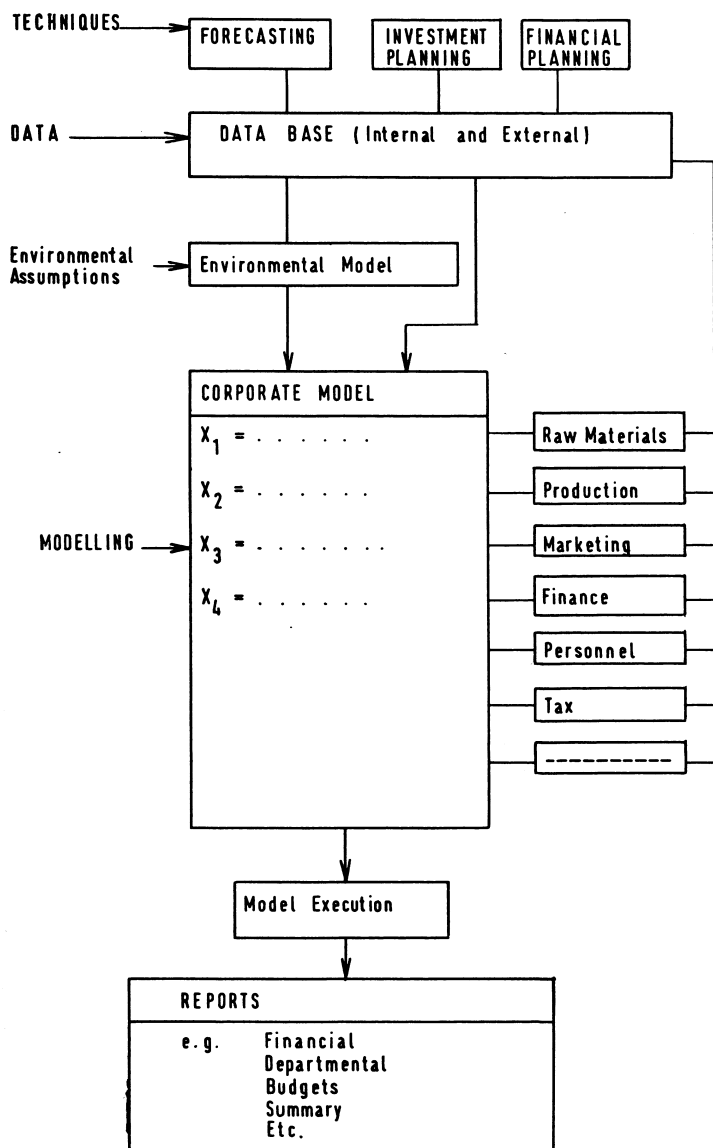


Fig. 1

- Risk analysis
- Mathematical programming
- Quadratic programming
- Simulation methods
- Mathematical programming

Three distinct phases of planning systems can be isolated:

1. The development of a forward database from historical information by the use of forecasting techniques,
2. Execution of the company model to predict the effects of alternative strategies,
3. The dissemination and analysis of the model predictions through reports.

The relationship between techniques, data and model is illustrated above. (Fig. 1).

There are two families of models relevant to corporate planning, econometric models for environmental forecasting; company models which deal with models of corporations.

### Econometric models

These models are primarily designed to study the economic environment especially as it affects the company. They try to

provide systematic ways of studying the past and specifying inter-relationships between economic variables which can lay the foundation for projecting economic factors such as industrial production, balance of payments, incomes, unemployment, etc. A number of such models have been developed for both the US and UK economy. The Treasury in the UK for example have two econometric models; an annual forecasting model for five years ahead containing over 250 equations and 600 variables which covers the complete economy and incorporates constant price and current price sectors. The model is used to support public expenditure decisions and longer term Government taxation reform strategy. The second model is approximately 60 equations in size and produces forecasts on a quarterly basis for a period of eighteen months ahead.

Its task is to support the short-term forecasts which lead to short-term budgetary or mid-term regulator action to steer the economy. At the London Graduate School of Business, Professor Ball *et al.* (1966) have developed an econometric model of the UK economy. The equations are based on national expenditure accounts. A few of the larger companies have also developed their own models laying particular emphasis on the sector with which they are concerned. Estimation procedures most favoured are ordinary least squares and two-stage least squares.

### Company models

By its very nature a corporate model will incorporate all the major functions of the company, e.g. raw materials purchases and availability, production, marketing, distribution, personnel, finance, etc. and also, most important, the interactions between the different functions. An environmental model can be used separately to provide external data to the corporate model or alternatively could form a part of the corporate model. Company models can be broadly categorised into:

- (a) optimisation models
- (b) simulation models.

### Optimisation models

The optimising family of company corporate models, as the name suggests, attempt to optimise some well defined objective function of the company taking into account any constraints under which the company operates. For example, the objective may be 'To optimise overall discounted rate of return over a given period', under constraints governing overall market growth rates of products, raw materials availability, and financing and dividend policies. Another objective function might be to achieve maximum appreciation in the company's market capitalisation over a given period of time or alternatively maximise rate of dividend payments. The methods of linear programming, dynamic linear programming, and integer programming have been used in building optimising models (Frazier, 1970; Wagle, 1969). These models are often difficult to formulate and have been found to be even more difficult to implement either because of size or because they cannot adequately represent the decision environment.

### Simulation models

The simulation model as used here includes not only stochastic but also descriptive models which simulate the progress of the company over a given period of time and provides projections of balance sheets, profit and loss accounts, cash flows, etc. The basic data required for this model are forecasts of sales, prices, costs, investment plans, depreciation rules, interest rates, etc. However it is not necessary that all the forecasts be stated explicitly as statistical, accounting and logical relationship can be built into the model which can generate values for the planned period based on historical data. The corporate simulation model can be more easily understood by senior and corporate management. Its greatest asset is the speed with which

it can answer a whole range of 'what if' questions e.g. What is the effect on the company's financial position:

- (a) if tax rate changes to 35 per cent.
- (b) if sales pattern becomes . . . .
- (c) if we increase dividend payments from 8 per cent. to 10 per cent.
- (d) if prices are increased by 5 per cent?

One of the limitations of the simulation approach is of course the lack of optimisation and hence the need to operate the model on a case-study basis. Nevertheless the approach has found considerable favour in recent years (Gershefski, 1969; Wagle, 1969).

### 3. Survey of current practice

The survey (Wagle and Jenkins, 1971) carried out in 1971 sought to determine how corporate planning is actually carried out in practice and assess the contribution of models and systems in this area.

The study used three sources of information:

1. The appraisal of published information on all aspects of corporate planning but in particular on those which used the computer to aid the process,
2. The interviewing of some fifteen companies covering a range of industries and of varying sizes to determine their current corporate planning methods, their needs for and their reaction to the possibility of having available a general system,
3. The examination of existing packages which aid in total or in part the corporate planning process. This was approached by looking at all major available systems but particular emphasis was placed on the availability and effectiveness of IBM systems. Twenty packages were examined (ten of these in detail).

The companies interviewed were so chosen as to cover a wide range of industries both in the nature of their business and the size of organisation. The turnover of the companies ranged from £2.5 million to £1,200 million. Five of the companies were from light industry, three from heavy industry, four from petrochemicals and three represented the financial sector. Informal interviews were also held with several other companies.

The topics discussed with each of the companies were:

1. Nature of corporate planning and its organisation;
2. Examination of financial criteria used in corporate planning;
3. Models, systems and computer aids used in the process;
4. What was the form and nature of the input information;
5. What reporting formats were used;
6. In which directions would the planning function develop;
7. Would a general system be acceptable and what characteristics should such a system have.

There are in excess of twenty packages currently available which to a greater or lesser extent aid the corporate planning process. Getting detailed relevant information on all of these within the time frame of the study was found to be difficult. Furthermore it must be said that the only satisfactory way of evaluating the packages would have been to use them for a range of problems. Promotional literature and manuals, to put it mildly, present a rosy picture of their attributes. The analysis laboured under this constraint, although the experience of users was procured for some of the packages. Given these limitations, the packages were critically analysed to discover the functions they were designed to perform and their user attributes. Ten packages which were considered to be representative of the systems available were examined in detail using two criteria for their evaluation. These can be broadly classified as system functions and system characteristics, especially those characteristics concerned with user interface.

The overall conclusions of the study were:

1. The ultimate responsibility for corporate planning rested with one of the senior managers who was usually a financially oriented person with a professional accountancy qualification. The attitude to the use of computers in corporate planning varied from enthusiastic to downright hostile with a weighting towards the acceptance side.
2. All but one of the companies interviewed carried out some form of planning. Eleven of the fifteen companies said they were committed to corporate planning. Of those eight have a formal planning department.
3. Setting of corporate objectives was considered to be the most difficult part of the planning process. Companies tended to use both the top-down and bottom-up approach.
4. Various criteria were used in evaluating proposed corporate strategy. The most common ones were return on investment, earnings per share, market share and growth in profits. The importance of cash flow and liquidity was also stressed. The financial and insurance sector also considered various types of expense ratios.
5. It was generally felt that the decision making process at the strategic planning level does not (as yet at least) seem capable of being represented adequately by some optimising model. The factors taken into consideration for strategic decisions were believed to be incapable of being formulated into a set of formal objectives and relationships. This weighed heavily against the optimisation family of models. What was desired was corporate modelling systems, which are descriptive and capable of articulating the financial and other implications of following a policy. The executives themselves saw the role of such models as being to remove the computational tedium and enable them to examine the results of a range of alternative strategies by producing reports in a form with which they are familiar.
6. Various types of computer models were being used but these were largely functional models for tactical planning, e.g. LP models for refinery operations, statistical models for forecasting, pricing, etc. The nearest to corporate modelling were systems to cover their own operations and print financial statements. A number of companies have developed such systems through their own management services staff. Many of them would like to go further and develop more detailed and powerful models.
7. The larger the organisation the greater was the use of advanced methods but this did not necessarily go hand in hand with greater profitability.
8. Companies found it difficult to be specific about information flow and input data requirements for a computerised system. Only three of the fifteen companies were attempting a computer-based information system.
9. All the companies interviewed expressed their corporate plans primarily in financial terms with back-up material on physical plans, manpower, marketing plans, etc. The financial report covered periods from two to ten years in the future. The reports typically included balance sheets, profit and loss accounts, sources and disposition of funds analysis, cash flows and financial ratios.
10. The three areas which the companies regarded as important in corporate planning and which would be amenable to computer systems application were clearly identified as forecasting, investment planning and financial planning.
11. Essential forecasts required in corporate planning were divided into two categories:
  - (a) External: Economic environment, political and social developments, technology, competition

(b) Internal: Sales, prices, costs, manpower, etc.

12. Problems in investment planning were largely concerned with timing, size and location of investments and also selecting between alternative proposals.
13. In financial planning, companies were keen on the development of techniques/systems which would enable them to improve their ability to forecast future financial performance and monitor and control operations.
14. As far as computer packages for corporate planning are concerned, it was felt by the companies surveyed that none of the twenty available had made a significant impact.
15. The problem of communication between the management scientist and the corporate planner was identified as probably the most important single factor holding back the credibility of the modelling approach. For example a common criticism of large technique-oriented models is that the managers for whom they are developed do not understand them.
16. The companies made frequent pleas for flexible reporting including graphic output which could be easily assimilated and accepted by top management, for interactive modelling, for user-oriented simple planning languages (so that the user would not have to learn programming).

#### 4. Computer systems for corporate planning

##### *Why packages?*

The results of the survey indicate that senior executives believe that models can make a substantial contribution in the corporate planning area. However the models need to be simple and easy to develop and understand. An executive does not want to wait for years before his OR team turn up with answers to problems of yesterday.

It has in fact been estimated that it takes 3.5 man years (spread of 6 man months to 23 man years) to build the first working version of a corporate model (Gershefski, 1969; Wagle and Jenkins, 1971).

The median percentage times are:

Definition and formulation	25%
Collection and analysis of data	25%
System design and programming	40%
Implementation (defined here as getting a working version)	10%

We believe that suitably designed computer packages would enable the development time of corporate models to be considerably shortened. It is easy to understand why packages can reduce the individual effort required to develop the computer program itself. But, perhaps more important, packages often contain a framework for approaching the problem which can considerably aid the initial phase and further incorporate the statistical and analytic techniques for data analysis. Finally, implementation would be eased as a common package will have been implemented and tested by a number of organisations and the individual user can draw upon this experience. We also believe that it would help narrow the credibility gap between the computer and the Senior Executive by allowing him to express and develop his plans in a language and by means which he can understand.

##### *Existing packages*

Computer manufacturers and software houses were not slow in recognising this potential. In the last four years an array of systems purporting to aid the corporate planner have been marketed. They vary from simple packages using an English-like language designed to enable a manager to construct and run small models, to large and complex systems needed to be constructed and maintained by the computer professional. The

latter however do provide the executive with considerable flexibility to manipulate the data and logic within the system.

From an application-viewpoint the available packages can be classified into three broad categories.

##### *Fully pre-defined systems:*

In these, all logic of the model is pre-specified by the package developer, and the user has only the choice between using parts of the logic or not using it. The major problem with using a pre-defined system is that the developer may have looked at a problem from a very specialised viewpoint and that view may not be aligned with your own. The American banks such as the Chemical Bank and the First National City Bank have been the main originators of this type.

##### *Report generator systems:*

Most of the currently available packages belong to this category. These largely enable extrapolation of certain basic data series and then accumulation/consolidation of the divisional plans into corporate plans. The computer printout is generated into neat reports capable of easy understanding by senior management. The report generator systems usually encompass simple project evaluation and forecasting techniques in them for the user to build simple model logic. A whole range of these systems are available, e.g. Foresight developed by Applied Computer Technology Corporation, PSGII developed by IBM, FP/70 by Bonner and Moore, PROSPER by ICL, FMP by Rio Tinto Zinc, etc.

##### *General purpose systems:*

There is no real definition of a general system except that it is aimed at a whole range of problems. The overriding philosophy is to incorporate into a common systems framework a range of forecasting, planning, simulation and optimising techniques along with a subset of specialised subroutines to perform certain functions. The system is so structured that different models can be developed reasonably easily and the interface between functional (i.e. marketing, production, investment, finance, etc.) models is straightforward. An example of such a system would be FAPS (and its successor GPOS) developed by On-Line Decisions Inc.

If one reads feature articles or marketing literature supporting certain packages, one could be forgiven for assuming that all packages are equally flexible, equally sophisticated, equally imaginative and equally easy to use. This is most certainly not true.

The criteria we used to evaluate packages were:

1. What was the major function for which the package was originally developed.
- Assuming this purpose:
2. To what extent have data entry, manipulation and analysis requirements been met?
  3. What functional features are available for model construction, model execution, model maintenance, model linkage, etc?
  4. Do any specialised subroutines exist to facilitate the development of model logic?
  5. What features exist for report generation and analysis?
  6. How easy is the system to use? Does it require a DP background? What are the restrictions on the user?

The report generator systems are primarily aimed at the financial manager with simple but often effective planning languages and report generation capabilities but with very limited analytical tools. On the other hand the general purpose systems enable far more sophisticated modelling to be done but require specialised expertise, usually found only in planning departments with computer and OR personnel.

It must also be remembered that development and running costs escalate with flexibility and sophistication. Thus each system will have its proponents and its detractors and the user must tread carefully in choosing the package for his own organisation.

### 5. Illustration of a typical package: BUDPLAN

BUDPLAN is one of three IBM offerings for business planning. The others are PSGII—Planning Systems Generator and STRATPLN.

The first two are batch operated systems while STRATPLN is exclusively a time-sharing system. PSGII requires the models to be built in FORTRAN while the others have a special planning language.

BUDPLAN is a batch operated system operating under OS on IBM 360/370 series. The objective of BUDPLAN is to offer a framework for the definition and integration of the planner's needs with emphasis on ease-of-use and report generation.

BUDPLAN essentially consists of three modules performing the functions:

- (a) planning language translator,
- (b) data management facilities,
- (c) report generator.

The package provides many features which are transparent to the user, such as work space allocation, control and storage of user data and integration of user specified logic into executable modules.

The planning language enables the user to carry out the following functions in terms meaningful to him:

- (a) the creation, compilation and checking of the user model,
- (b) execution of the model with data either defined within the model or obtained from files created in the data phase,
- (c) production of reports.

While the language is simple, some aspects of report specification are highly formatted. The language on the whole is straightforward and requires very little computer knowledge. It has attractive features such as good sensitivity analysis features, the ability to express logical relationships and to loop through model sections.

The data management facilities are compact. There are three matrices (work areas) in which data can be manipulated, computations performed and results generated that appear in later reports. The three matrices are designated A, B and C. Matrix A is used for data input, so that when a user presents data to the program, either from input data cards or from previously stored data, this data will be available for processing in A. Matrix B is used primarily for storage of results of computation. Most of the available financial subroutines such as depreciation schedules, growth rates, ratios will perform on data in any matrix, but always store the results in Matrix B. It is also frequently used for storage of results to be printed. Matrix C is usually used for the summary of results. If the user was considering budgets for ten departments then basic data for each department would be successively entered into Matrix A, individual department results printed from Matrix B, and overall company budget consolidated in Matrix C.

The user specifies line by line the format of the report. Facilities provided include up to 60 reporting columns, distribution charts, graphs, selective printing at execution time. The report generation can be executed without data, enabling management reports to be developed independently from the model logic or development of the database.

BUDPLAN operates iteratively on one submodel at a time. All input data are read into the A matrix. Output data are moved or computed into the B matrix. A and B are then re-set at the beginning of each new iteration. The C matrix is only re-set at the beginning of each system iteration and is, therefore, available for consolidation of detailed data. This summary data

may then be moved back into the B Matrix and printed under the same format as the detailed data, or separate reports may be specified for printing consolidated reports directly from C.

BUDPLAN also contains a library of subroutines to perform calculations frequently used by planners. These include growth rates, ratios, interpolation/extrapolation, time-shifting and consolidation.

It is worthwhile summarising some of the advantages conferred to the BUDPLAN user as they are typical of the advantages that packages can provide:

1. The handling of input and output functions by BUDPLAN enable the programmer to concentrate his attention on the planning logic. This appears to offer a greater saving in development time, than might have been imagined. Obviously considerable time is normally spent designing and programming input and output functions and the pre-determined methods imposed by BUDPLAN remove this consideration.
2. The facility to make multiple studies based on small variations about a basic set of data by only specifying the data changes is essential to a corporate planning model and is an area which would normally occupy a considerable portion of the program development time.
3. The printout formats appear particularly good for financial applications and the production of printouts via print specifications cards is extremely easy. The graphical outputs are a worthwhile feature.

Experience has shown that BUDPLAN is extremely easy to learn and a non-DP trained planner can develop quite complex models in a matter of a few weeks. However it has the major disadvantage of being exclusively batch operated making direct communication between planner and model difficult.

### 6. Conclusions and future developments

#### *Future needs of corporate planners*

Perhaps it would be best to state at the outset that we consider it foolish to imagine that an 'ideal system' for corporate planning exists. It is the aim here to put together the opinions of corporate planners from the survey, the analysis of existing systems and the impressions gained from other practitioners in an attempt to describe the path that should be taken by future systems.

We consider:

- (a) that packages can significantly aid the corporate planning process,
- (b) there is a demand for such packages both by sophisticated users and by unsophisticated users. It is however unlikely that the needs of these two categories of planners could be met by a single package,
- (c) that any package should embrace in a single framework the ability to represent in sufficient detail each function within a company.
- (d) the nature of corporate planning is such that executives are not interested in large complex optimising models. Descriptive models which enable them to see clearly the implications for following alternative strategies are preferred,
- (e) it is crucial that the planner be involved in all aspects of the modelling process. This indicates the need for an English-like language and the ability to provide reports in a simple manner,
- (f) that it is important that features which promote the dialogue between the planner and the model are prominent. Thus terminal based systems using conversational routines are desirable. In fact, it is thought that visual display units (VDU) terminals (such as IBM's 3270) would be superior

as they would provide fast and easy communication eliminating many of the frustrations involved with type-writer terminals,

- (g) any system should mirror the natural planning phase of
  - Developing the database
  - Constructing and executing the company models
  - Generating and analysing reports,
- (h) ease of use and flexibility are crucial in closing the credibility gap between senior executives and the use of the computer.

*Development of future systems*

From these conclusions we consider that two distinct types of systems are appropriate:

1. A simple financial modelling system
2. An integrated corporate planning system.

The former aimed at unsophisticated users while the latter would be designed for large sophisticated corporate planning departments with appropriate management science and systems expertise.

The process of corporate modelling was shown to be the development of a database usually of time series data; the construction and execution of the model; and the provision of reports. In both systems the above functions of the packages can be broken down into these three modes. This delineation mirrors the way in which any planner would use the system.

1. The data would not only be the creation of a database for the model, but where statistical analysis, forecasting, investment appraisals on historical or projected company information would be carried out. It is here that the information for the model is developed,
2. The modelling mode is where the planner creates his company model in terms which he understands, tests a whole range of alternative strategies and seeks sensitivity of the preferred strategies to changes in the data,
3. The reporting mode is the display of user or re-defined reports such as profit-loss accounts, balance sheets, projected cash position, graphical plots, etc.

Hence, by using the report analysis, etc. coupled with sensitivity and 'what if' features of the modelling mode he can efficiently examine a range of alternatives facing the company.

*Simple financial modelling package*

The prime attribute should be the need for neither computer experience nor specialised knowledge of quantitative techniques. While its primary function would be to aid the financial managers of companies wishing to plan but not having departments committed to it, it may be useful for experienced planning departments.

Because the aim would be to provide a simple and easily used system and because the involvement of the planner himself is crucial a terminal based package is thought essential. Certainly development of a database and the production of reports could and often should be a batch operation. The development of models and the examination of alternative strategies on the other hand requires the level of user interface best accomplished through terminal operation, preferably a visual display terminal (VDU) such as the IBM 3270.

As can be seen, the simple financial modelling system is a natural extension to many of the current systems. It places greater emphasis on the interface between planner and the machine as it is thought that this is the crucial area for acceptance by corporate planners who are unfamiliar and often somewhat overawed by such systems.

*An integrated corporate planning system*

Corporate planning should be a function of many management

levels. It should involve individual departments or divisions not only providing information but also attempting to impress their viewpoint on the corporate plan. This viewpoint should not be restricted to financial matters but should be concerned with the allocation of other resources. A true integrative corporate planning system should attempt to consider not only financial but other resources and operate at different management levels. This has implications for the database for it will be insufficient just to develop information for the model or models, but a flexible information system will be necessary from which individual functional planners and the corporate planner can draw their own data requirements.

Information for planning with a company may be thought of as a pyramidal. In the base, detailed operational and control information is used to develop product plans.

In the intermediate layers this information is screened to provide aggregated information for departmental planning and control or for product group planning. At the apex of the pyramid further aggregation reduces detail and the information for corporate planning becomes primarily financial (see Fig. 2). This is so not only because financial data forms the basis for corporate planning, but also because it is only at this level that true measures of financial performance can be obtained. Unfortunately this has often led to corporate planning systems dealing almost exclusively with the financial function. We believe that effective corporate planning packages should not only be concerned with aggregation from individual building blocks (e.g. products, departments, divisions) but also with the disaggregation of planning decisions so that their implications for the company can be clearly articulated at the operational level.

An example may clarify the suggested mechanism. A company manufacturing a number of products evaluates each product by such criteria as sales revenue, cost of manufacturing, advertising cost, administrative cost, etc. The manufacturing cost is broken down into direct labour, direct material and processing cost. The products are grouped such that those capable of being manufactured by the same processes on the same machines are considered together. Thus the allocation of capacity is made at the product group level. The planning system suggested would enable each product to be modelled and first aggregated into groups and finally into the company positions. Thus the corporate plan could be developed by examination and aggregation of its parts. Further, any corporate policies developed could be exploded downwards into the pyramid so that its implications on individual departments could be seen. This would thus permit management at all levels

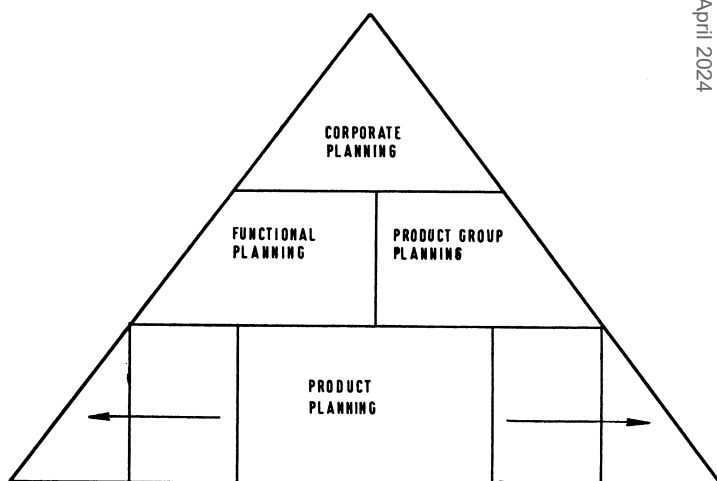


Fig. 2 Planning information database

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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.
- GERSHESKI, 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!

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