THE USE OF COMPUTER-BASED MODELS IN RUNNING THE ICI PETROCHEMICALS DIVISION

P. V. Youle.

Rapporteurs: Mr. J. R. Reed
Mr. L. B. Wilson

Abstract: The purpose of this paper is to discuss the use the Petrochemicals Division of ICI have made of computer-based models. Some tentative conclusions are drawn from this experience of the type of University education which would prepare students for such work.

Part 1 - The purpose and Philosophy of Computer based models.

1. ICI and the Petrochemical Division

ICI is a very big firm with many divisions mainly in Western Europe. There are eight manufacturing divisions in the United Kingdom and two of these are on Teesside. The Petrochemical Division is the one I particularly want to talk about and it has a total size in terms of hardware on the ground of $1000 million. The organisation can be represented by the following matrix

Functions / Business Areas	Buy	Make	Sell	Think
	Purchasing Dept.	Production Dept.	Marketing Dept.	Research, Development & Planning Depts.
Hydrocarbons				
Chemical Products				
⋮				

There is an intermeshing of the Function and Business organisations and we have not gone entirely to a Business organisation or a Function organisation.

The Petrochemical Division has in my opinion been lucky in its method of using computers in that it does not have the reponsibility of running a computer. It uses one in another division of ICI and thus we use the computer only when we feel it is necessary and would assist the efficient running of our division. There is no pressure to use the computer because it is there. We have used an IBM 360/65 which we hope will be updated soon to one in the 370 series.

2. Optimisation of the Petrochemicals Division

Before computer techniques can be applied to any business, the overall objectives must be clearly stated and understood. In our case we had to convert oil into socially desirable chemicals with maximum efficiency.

Our first attempt to optimise in the petrochemical division using models was on three ethylene producing plants. The details of this model can be found in a paper (Stephenson (1965)) by its originator. It was found that the relations between the parts of the plant were essentially linear and so a linear programming optimisation model was possible. The result of implementing this model was a 5% improvement or £¼ million extra profit after the first year. One important lesson learnt was how necessary it is to gain the confidence of the manager of the plant being optimised, without this the model is purely theoretical. This then was our first use of modelling techniques and since that time we have introduced a whole hierarchy of models. Some control the plants on an hour by hour basis, others look at next months production, there are models for optimising next years production and marketing which consider alternative markets and costs. Finally there are models looking far into the future, 10-20 years hence. Here the data is very speculative and the speculative predictions of these models have to be tempered by a good deal of commonsense.

3. Integration of the Optimising Models

The integration of these optimising models in the operations of the Petrochemicals Division was a very important aspect. It is essential that the models are acceptable to the people responsible for running the plants. They must meet the needs of the plant manager. They must print out their results in a language and style comprehensible to the users. This means a dialogue between the computer systems people and the plant managers and operators before the details of the model are decided. Ideally the plant staff should take over the model as soon as possible. In particular it is very dangerous to make elaborate optimising models with dubious or unreliable data. An interesting illustration of the advantages of integrating models in the operation of Division was during the Arab/Israel conflict in 1967 when it was thought the supplies of naphtha would be reduced. The models were rerun with various reduced amounts of naphtha and it was found that some of the chemicals produced fell below the amount ICI was contractually bound to supply. The model was rerun with constraints on the levels of these chemical products and the cost of running the plant in this way was seen to be much more than simply buying more naphtha from elsewhere.

For optimising models to work well in practice it is important to know two things - what should the profit be on say one months trading and what was the actual profit. This latter is usually provided by our accountants about the middle of each month. In many Management Information Systems only the actual profit is known and not what it <u>should have been</u>. If suitable action is to be taken, <u>both</u> these quantities should be known and compared. Another important factor is the human one. If the optimising model is to represent reality then it must be provided with accurate raw data. The marketing people may not wish it to be generally known that there is not enough of some chemical in stock but unless the model is fed with the correct data it is unable to arrive at the correct optimisation and so their fears must be allayed. There must be trust and frankness between departments.

4. Engineering the Planning Systems

There are many important factors in engineering a complete planning system. An outline of these is given below and a more complete discussion of this topic is given in a paper by Collins and Whittaker (1971). We must put due emphasis on both the people and the mechanical systems, and therefore the Behavioural Science approach and the Operational Research approach must go together. This is not always easy as staff who like working with people are not always happy with mechanistic models and vice-versa. The role of Head Office is important and optimisation of one division would be no good without Head Office approving of its way of proceeding. Objectives must be clearly defined and the influence of the environment in which the system is to work cannot be neglected. This latter is of course often very difficult to include as it may depend on Government decisions over which the system planners have no control. It is important to realise there is a large amount of inertia in most of these systems. Industry is getting bigger to get the rewards of size and so changes are slow to happen and even very successful new innovations will not alter the pattern much for many years. This does not however mean that new ideas are not important: they are, but they will not change the industry significantly in a short time. It is still important in a big industry to have the ideas and an adventurous spirit to implement them, even though full reward will be years away.

I therefore am advocating a total systems approach with the objectives defined as well as possible. All systems in the firm must be working towards these common objectives and therefore we require very frank discussions initially on how they are to be achieved. It is important to remember that although research and development and computer models can help to take some of the risk out of business decisions, a risk still exists.

Part II - Models in Use.

5. Communication between the Universities and Industry.

In this second lecture examples of particular models used by ICI will be outlined in order to suggest what the qualities are that Business would like to see in graduates in Computing Science. There is a certain amount of friction and misunderstanding between the Business and University sectors but both are interconnected by the production of commodities consumed in the other sector and both are engaged in the search for truth. The nature of this truth may differ but the search in the Business Sector can be just as intellectually stretching as that in the University. If we are going to communicate then we have got to appreciate that the search for truth includes Business. It could be argued that it is the job of the University to analyse, assist and help what goes on in Industry and it is Industry's job to understand that Universities have difficulties with this process. So much of what goes on in Industry is ill understood, badly explained and therefore causes trouble. Improved communications between the two sectors could help to increase the levelof understanding of each others positions and problems, and it is worthwhile conferences like this one that can help a lot.

6. Model and Model Builders.

Fig. 1 shows the complex inter-related flows of intermediate products within ICI. Its production required a considerable amount of intellectual effort and research. There are considerable similarities between these flows and those of a program around a computer. The rules governing the flows are similar and require the same type of intellectual effort. It would be nice to recruit graduates who had a feel for such a system, so that they had the urge and ability to set things out clearly and simply to show what is actually happening in order to think about how it might be improved.

Fig. 2 and Fig. 3 show the range of models for each business area in terms of the time periods to which the models relate. The short term models are more precise and have more detail than the longer term models in that the inputs to these models are analytical and at a relatively high rate. The long term models have more variables but the inputs are infrequent and tend to reflect policy alternatives making the models more indicative.

The people who were responsible for building these models had a variety of backgrounds and a description of them might give some insights into the different types of skills which Industry would like. One senior man who led a team and was responsible for planning and financial models learned a great deal about Operations Research while working for a nationalised industry. His view of Operations Research is extremely wide and he feels that he is studying the total operations of the whole business and can deal with any level of the system. Too many people feel happy in only dealing with the detail; but it is little use suboptimising on the detail if the total pattern is wrong. A second senior manager did not know much mathematics and computing but understood well what was practically possible. He was a charismatic leader of a team of young graduate specialists that he inspired. A senior computer manager was originally a chemist and gained valuable experience from an attempt to implement a management information system that failed. It was found that in critical places the manual system was more adaptable and could outperform a computer system.

Teams of systems analysts were recruited internally using aptitude tests which were very satisfactory in indicating who would be good but not so accurate in predicting who would be bad. The team leaders were very keen to recruit internally but it could be argued that recruitment of graduates might have brought more vision, drive and insight, and have been helpful in developing new ideas and approaches.

The model of pollution in the River Tees was developed by a mathematician in co-operation with the local authorities. The model shows the effects of putting effluent into the Tees at various places and heights of tides and its movement until it finally flows out into the sea. The model of the para-Xylene plant was started when an older man was asked to study the flow of information around the plant. There was so much information per week that the majority of it had to be discarded so that the remainder would be useful. Recipients of this information, at various levels in the plant, then wanted some rules on how they should act on the information and this required the development of a model. It is important, when briefly reviewing these models, not to underestimate the difficulties and the skills required. The models must communicate with top management and skill is needed to ensure that they do. Graduates with some knowledge and technical skill were recruited to work on models for research and development. They also needed a knowledge of "real life" situations and an ability to apply their knowledge in a practical way.

Long-term planning models are only indicative and require a lot of intuition in their construction and interpretation. They reached their peak some years ago when a model of the division's future was built which gave a basis for management decisions on alternative future policies. After that time, there was a reaction against these types of model because of their intractability but they are now coming back into favour in a simplified format as it is realised that planning requires a basis of hard facts.

A valuable member of the team was an accountant who developed a financial model of large companies; he became interested in planning for the future as well as accounting for the past. There is a need for accountants to build bridges with other areas and to be more concerned with the future rather than just the past. Simple predictive models have a value in dramatising situations and may catch the attention of management who might then be persuaded to take an interest in more complex models.

7. The Value of Models

There is no doubt that the continuous short term plant models are useful. Weekly and monthly models are increasingly being used by non-experts. Instead of asking specialists to sort the problem out for them, non-specialists are going straight to the computer and interpreting the answers for themselves. The longer term models are of less use but they have given management an enhanced viewpoint of what is going on, caused more interaction with the accountants, and improved communications with head office.

8. The Graduate Personel required by Industry

I do not feel it is up to me to tell the Universities what they should teach, nor do I think the wishes of industry should be the sole criterion of what is taught in Computer Science departments. There is an educational and social requirement that cannot be related directly to the needs of industry. However, it might help you to get a better balance in your courses if I stated the sort of qualities I would like to see in a young graduate recruited into the Central Investigation Department of the Petrochemicals Division.

He should have:-

(1) Some sound relevant basic technical knowledge.

(2) A deep understanding of people and how they feel and operate.

(3) An ability to learn how to design systems, how to choose the best of many alternative systems, and how to integrate it in sensible human terms with the people on the job.

(4) A drive to apply his knowledge in industry. (Industry is, after all, providing a service for society and it is respectable and right to wish to apply knowledge in that field; it is also as intellectually stretching and as difficulty as University work).

(5) The ability to synthesise as well as analyse, to take risks and a willingness to question the system. The capacity to develop a feel for the overall picture of the industry and thus be able to undertake a total systems approach.

Discussion

Professor Seegmüller : You listed among the things that can aid the modelling process Behavioural Science. Can you give examples of how it can help?

Dr. Youle : I will take some examples from my experience at ICI. The first one was at a Staff Development Programme in which we met in unstructured groups. This made me realise you can get more out of people in a "think" department if the hierarchy is not too obvious.

Secondly, behavioural scientists have helped me personally to get better team work in groups to which I belong by loosening up the personal relationships and removing negative influences. The paper by Mangham, Shaw and Wilson (1971) describes these ideas in more detail.

Professor Page : But would a degree in Behavioural Science give the sort of expertise you require?

Dr. Youle : I do not know, but the behavioural scientists I have been talking about had no such degree. They learnt their expertise on the job.

Dr. Parnas : Is the material we have been talking about actually taught on any University Behavioural Science course?

Dr. S. Andersen : Sociology is taught didactically and not learnt. Such courses do exist at the Tavistock Institute in the U.K. and at such places as Dexler University, Pennsylvania, U.C.L.A., Case University and Carnegie-Mellon in U.S.A. However, you will find that teaching such subjects are a challenge to a University departments' authoritarian attitudes and this challenge must be faced if the students are not to find your teaching inconsistent.

Dr. Youle : There is a distinction between teaching and learning here: creating a need to know and then studying real life problems may be the answer.

Professor Wolbers : Is it possible to teach the qualities you require in industry or is a person born either with or without them?

Dr. Youle : The qualities can be developed and enhanced and can certainly be killed.

Professor Seegmuller : Could you expand on what you mean by knowledge in this context?

Dr. Youle : For particular jobs it is necessary to have particular skills. People who can get a job done smoothly are also required. In addition to detailed technical knowledge a basic core of persuasiveness is important.

Professor Page : In our teaching we cover some of the areas that you have mentioned and some that you have not; for instance Systems Analysis. It is often suggested that the Universities should teach such topics, do you agree?

Dr. Youle : Yes, knowledge of systems engineering is of key importance.

Professor Page : Do you prefer giving the skills in an environment of doing the job rather than in the class room environment with artificial teaching aids?

Dr. Youle : I am a great believer in training on the job.

Dr. Cowie : Do you consider that most of industry has the talent available for internal development? Will you be able, in the future, to rely on internal training when the problems will become more complex and the methodologies more developed or will you have to rely more on the Universities?

Dr. Youle : If the talent is not internally available then you can always get help from local Universities and Polytechnics. We will probably have to rely more, in the future, on the Universities and there is also a need for better trained people to start off with.

Professor Dijkstra : The jokes that you told were at the expense of Universities and the way in which you identified people in what you said seemed to suggest a profound distrust, in the business circles, of technical competence particularly with references to Universities. One of the greatest difficulties of industrial activity is to exploit competence. I had hoped that this was getting better but it appears that it is not. You talk about the 'real life' problems as if they existed only in a business context and not in the Universities.

Dr. Youle : I share your worry about the use of technical competence in industry and I said that top management sometimes tend to undervalue it; this is wrong. There is a need in industry to apply knowledge to real world situations. The problems dealt with in the Universities are concerned with real life seen through analytical eyes but in industry the individual must be prepared to apply his own knowledge in the pragmatic real life situation.

Professor Dijkstra : Universities are involved in the conscious development and refinement of applicable methodologies as well as the search for truth. The whole purpose of this research is to produce something useful and the power of this is undervalued by industry.

Dr. Youle : Universities should increasingly be a source of applicable knowledge; then industry will be increasingly ready to use that applicable knowledge. A great deal of interchange of views and mutual argument is needed to bring this happy situation about, and at present industry tends to deny what the Universities strogly affirm, namely that applicable methodologies are being produced.

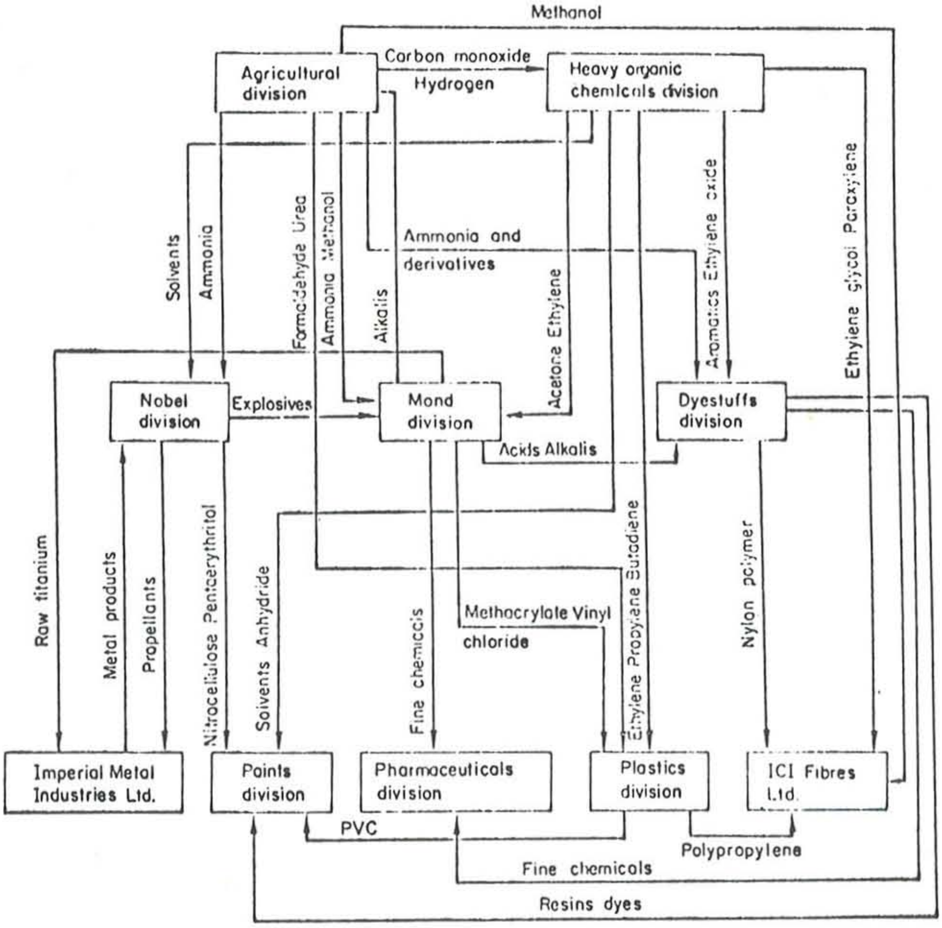

FIG. 1. *The administrative division of I.C.I. showing major material flows.*

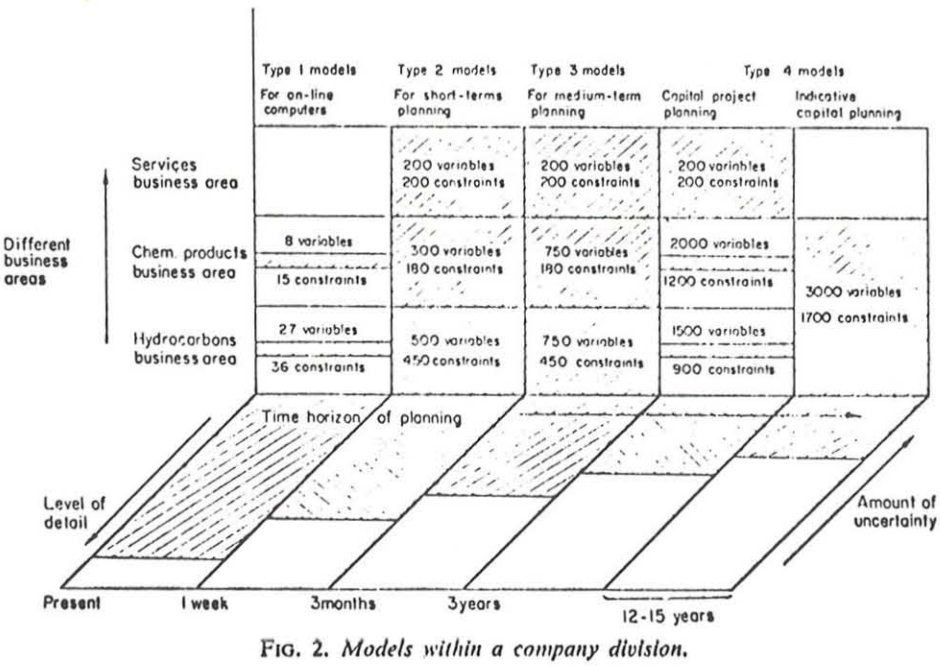

FIG. 2. *Models within a company division.*

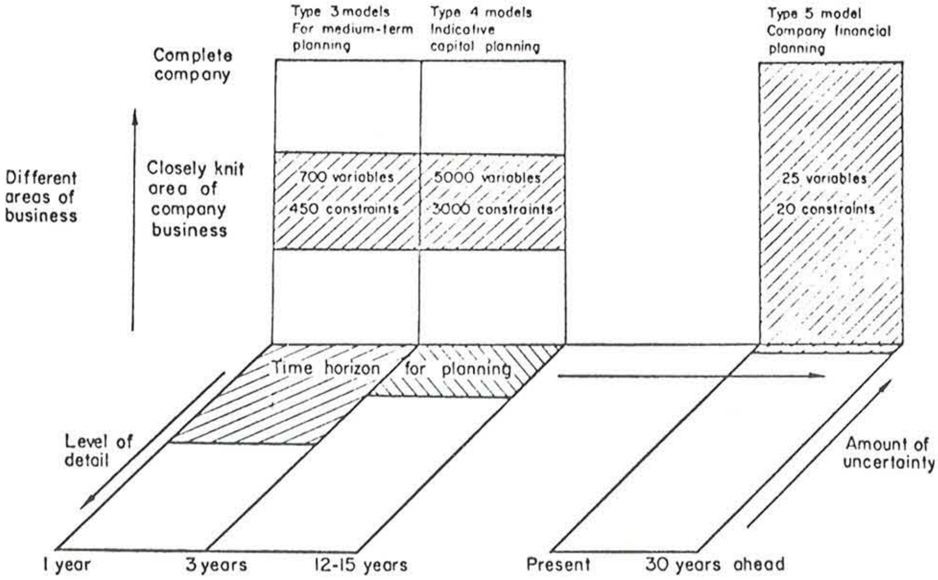

FIG. 3. *Models outside a single division.*

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