SYSTEM DYNAMICS: A NEW MANAGEMENT TECHNIQUE

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Greece stands on the threshold of becoming a new member of the EEC. Opinions are mixed as to the effect of this move on the future of our business. However, it is commonly agreed by both sides, for and against our membership, that the future of our industries will be threatened by our continued lack of interest in adopting the new management techniques, which are so widely applied throughout the other member states. Recent study[1] shows that there are numerous opportunities to apply these techniques, and to adopt a new "management philosophy".

The purpose of this paper is to demonstrate some highlights to the discerning manager of the relatively new technique of system dynamics, which has been applied by industries over the last 20 years, both in the United States and Europe.

We shall refer first of all to the concept of a "systems approach", and how system dynamics can be used to tackle complex socio-economic problems.

Finally, a brief description will be given of some of the work carried out in the System Dynamics department of Bradford University in England.

A "systems approach"

Over the centuries, management has been regarded mainly as an empirical art. But within the last thirty years the need for professional management has been recognised, and methods have been developed to deal with top management problems. To develop the status of a profession, management must discover the underlying principles which unify its separate aspects. The manager must learn to combine his experiences with the new management techniques for explaining and solving problems as they arise. Only then will the next generation of managers be true professionals.

The task of the "new" management is to interrelate the flow of information, materials, manpower, money and capital equipment so as to achieve a higher standard of living, stability of employment, profit to the owners and rewards appropriate to the success of the managers.

In the past, with management considered more of an art than a profession, education and practice have been highly fragmented. Manufacturing, finance, distri-

bution, organisation, advertising and research have too often been viewed as separate skills and not as part of a unified system[2].

Nowadays, the manager should tackle problems on the basis of the "systems approach". This is a methodology which attempts to be rational and objective – much like the scientific method – in approaching complex problems. This approach, at first applied successfully in military, industrial and managerial contexts, has now become firmly embedded in every other discipline, particularly those which try to describe or predict observable phenomena[3].

A system approach in management involves the study of a firm in its totality so that the man and material resources of the firm can be organised to realise the firm's overall objectives as efficiently as possible. This approach is now becoming essential because of the role of automation and the potential of competitors.

To understand the system approach, we must first be clear about the meaning of the word "system". The notion of systems has been assigned a variety of meanings. One common definition is:[4]

"... a grouping of parts that operate together for a common purpose"

An automobile is a system of components that work together to provide transportation. An example of a very complex system is our economy. Its components work together to produce, distribute and consume goods and services.

In its broadest and most general sense, "systems" refers to a way of thinking. It concentrates on the analysis and design of the whole, as distinct from the parts. It implies that the whole is more than merely of sum of its parts, and that the parts acquire certain characteristics due to their existence in the whole. It tries to understand how system components interact with one another, what relationships are desirable and how they might be attained.

It should be clear that systems vary widely in scope and complexity and that all systems can be regarded as subsystems of a larger system.

An important step in the systems approach is the development of models[3]. Models are attempts to imitate a situation, and to understand complex relationships within that situation. By referring to models, one can obtain valuable insights into the behaviour of a system. The development of models is a sophisticated combination of art and science.

For determining the behaviour of complex systems we need to use the methods of simulation.

In business, simulation means setting up in a digital computer the conditions which describe company operations. On the basis of the descriptions and assumptions about the company, the computer then generates the resulting charts of information concerning finance, manpower, product movement, and so on. Different management policies and assumptions about conditions of the market can be tested, to determine their effect on the success of the company.

Many techniques have been employed to construct simulation models (such as input-output analysis and econometric models) for complex socio-economic systems.

We shall refer here to the System Dynamic Techniques which we believe overcome some of the limitations of other existing techniques. It is a technique which can be a valuable aid to any manager who believes in the concept of a systems approach.

System Dynamic Technique

System Dynamic modelling, developed by Professor Forrester of M.I.T., is a methodology that deals with deterministic, dynamic, nonlinear, closed boundary systems. Its initial application in 1958 was to the study of the behaviour of industrial systems where the shorterm dynamic of production rates and inventory levels were analysed. Forrester expounded his system dynamic techniques is his books "Industrial Dynamics"[5] and "Principles of System"[4]. More recently, he has applied his modelling methods to longer-term problems of the city and to the problems of world growth. Forrester is currently developing a dynamic model of the U.S. economy. Dennis Meadows[6] has developed a similar world model in his books "Limits to Growth" and "Dynamics of Growth in a Finite World".

S.D. is concerned with the application of the principles of systems theory and control theory to socio-economic systems. S.D. is perhaps best described in terms of the backround threads on which it is built:[7] traditional management of social systems, feedback theory, and computer simulation.

Traditional management is the process used to govern social systems through history. Based on observation and judgment, it has great strengths. But it also has serious weaknesses.

Feedback theory or cybernetics is a body of methods and principles developed during the last 100 years dealing with how decisions, and the way they are embedded in information channels, cause the dynamic behaviour of systems.

Computer simulation allows one to determine the time-varying behaviour implicit in the complex structure of a system.

S.D. starts from the practical world of normal economic and political management. It doesn't begin with abstract theory nor is it restricted to the limited information available in numerical form. Instead it uses the descriptive knowledge of the operating arena about structure, along with available experience about decision making. Such inputs are augmented where possible by written description, theory and numerical data. Feedback theory is used as a guide for selecting and filtering informations to yield the structure and numerical values for a computer simulation model.

Generally speaking, S.D. is conceived as an approach of studying the behaviour of systems over time in terms of feedback loop systems to show how the interrelationship of policies, decision, structure and delays influence the systems growth and stability[5].

It has a twofold objective:[8]

(a) explaining the system behaviour in terms of its structure and policies;

(b) suggesting changes to structure, policies or both which will lead to an im-

provement in the behaviour.

S.D. is applicable to managerial problems which have a systematic interrelationship, where the past influences the future and where changes through time of interest.

The largest group studying S.D. techniques is probably at M.I.T. (U.S.A.). However, Bradford University is certainly the major institution studying the technique in Europe.

It was established in 1970, and directed by Dr. R.G. Coyle. It is primarily concerned with the application of system dynamics to the redesign of managed – particularly business – systems.

Various studies have been carried out covering different aspects of business. The mining industry has been closely examined, as have chemical, oil[9], paper[10 11 12], electricity[13] and cementproducing[14] industries, and shipping and ship-building[15]. Besides any such specific studies, a number of projects of a more general nature have been carried out, covering points such as capacity planning[16], investment and corporate and financial planning[17], inflation accounting[18].

As can be seen from the studies undertaken, S.D. can be applied to a wide range of situations. Our experience to date suggests that the S.D. approach has a number of features that make it useful for tackling management problems, particularly of a strategic nature.

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