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Planning Systems

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Planning systems

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The application of computerized models to planning systems is in danger of falling from favour. The paper analyses the causes of this and identifies the main cause as the use of a mechanistic view of the world. The treatment of humans as machines subject to the laws of cause and effect or as statistical assemblages leads to plans being made for people and not by people for themselves. The paper discusses the pioneering work being done to introduce a methodology which recognizes free will among humans. The planning of production processes, on the other hand, can be treated by a mechanistic model of that system, but currently we have inadequate tools to devise such plans.

Introduction

The trend in the evolution in modern society is to show increasing concern for the welfare of its citizens; this takes a variety of forms, from a comprehensive health service and financial support for the weak to improving the environment and creating a less unequal distribution of wealth.

All of these laudable objectives are constrained by limitations of resources; money, skilled labour, energy and raw materials. The resolution of the conflicting requirements for these resources has driven us to rely more heavily on planning our economies so that surplus wealth generated is used to best effect.

The thesis of this paper is that all planning is concerned with the distribution and allocation of resources. The resources allocated differ in different contexts but there is sufficient commonality of the characteristics of resources to make the study of such a general assertion of value in understanding the problems of planning.

Although society may have concern for its citizens, the results of planning to implement that concern cannot be regarded as wholly successful. There is an ever increasing alienation of people from society and each other and there is increasing doubt whether people are more satisfied with their lives now than in former, less caring, times.

A superficial explanation of this phenomenon argues that planning has become more and more centralized, and hence the organizations to effect the planning have become bigger and more bureaucratic; the ordinary citizen cannot understand the workings of these bureaucratic organizations, and does not trust them. This generates the paradox that the very organizations invented to improve the quality of life are seen by many as a significant factor in reducing it by their regimenting effects.

I believe that the explanation is much deeper than this and this paper is concerned with an analysis which gives a more fundamental explanation of the paradox.

Briefly this arises from a methodology of planning which in turn arises from the current world viewpoint, which has been concerned primarily with gaining control of our production processes. Now that this objective is in sight of achievement and our efforts are turning more consciously to other objectives, our methodology and world view must alter to suit the new objectives.

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The methodology of planning

The current methodology of planning can be described in the following general terms:

(1) The area of study is delimited and defined.
(2) The impact of the environment on that limited area is described.
(3) A model of the system so described is built.
(4) A set of possible actions and procedures are invented and described.
(5) The model is used to predict the behaviour of the system for each member of the set.
(6) Criteria for choosing the 'best' member of the set are invented and applied.
(7) The selected member of the set is implemented.

In different applications of planning the emphases on the phases of this common methodology are often quite different and the methods used to implement them also differ. For example, in a production situation, the area to study is taken without question to be the set of production units under the control of the commercial enterprise, and the environment is taken to be the market for the products of that enterprise; the supply of raw materials (often the product of another enterprise) and the impact on the environment are given much less attention.

In contrast, in urban road planning, a great deal of argument arises about the area of study; it must certainly consider the flow of traffic between locations within the urban area and traffic passing through the area, but should it consider its effect on pedestrian traffic, the spoilation of the pattern of life of residents, the changes it will generate in rail traffic, the architectural heritage which may be destroyed and the enforced reduction in other city amenity plans caused by its cost?

In hospital planning, the dominant elements to be modelled are the consumption of skilled labour and capital equipment to provide the services and so the study centres on trying to resolve the conflict between the value of different health services and their cost. In considering the set of actions and procedures do we include ones that involve training additional staff and if so how do we represent the effect on the community as a whole of this increased deployment of labour – a benefit in health service terms but a disadvantage in terms of the available labour for producing wealth to provide money for that service?

The criteria for selecting the 'best' actions and procedures are also subject to a great deal of debate. Even in the case of a commercial enterprise, where the naïve might imagine that profit will be the sole criterion, in practice, even restricting criteria to profit oriented objectives, there is a great deal of room for argument. Every plan is made in the face of uncertainty about the future environment; on expected states of the environment, a plan may be the most profitable of those considered but, on alternative assumptions about that environment, they can be infeasible leading to bankruptcy. Should we maximize the minimum profit or the expected profit? Should we build in restrictions on the cash flow pattern? Do we consider the total profit over a period and if so over what period?

Even the most hard-headed commercial enterprise has other objectives which are only remotely connected with profit. As examples, firms must be concerned with maintaining a trained labour force during an economically depressed period to be able to produce when the boom comes, the public image of the concern as a good employer will affect its sales among at least a section of the community, a careless spoliation of the environment could evoke legislation which

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might make the production equipment unusable without capital expenditure beyond the means of the company.

For non-commercial enterprises, the concept of profit is a forced one. Attempts have been made to introduce the concept of cost-effectiveness, but this ratio depends on describing the effect in money terms. The means of doing this are certainly not universally accepted.

The planner in social fields is faced with a set of conflicting incommensurable objectives. Hospital services have to be distributed to give easy access by the public, indicating a well distributed set of small hospitals. To offer expensive, but rarely used, facilities, it is cheaper to concentrate the service in a few large hospitals. Should the few requiring the expensive service be ignored for the convenience of the mass of patients? Large hospitals can process more patients per staff employed than a small hospital, but by doing so reduce the level of personal involvement of staff with patients. Should the reduced efficiency be tolerated to give increased involvement between staff and patient?

Of course, the outcome of such conflicts is always a compromise, but for the planner the determination of which compromise, only exaggerates his problem by increasing the set of alternatives to be considered and raising more sharply the problem of 'trade-off' between the objectives. Strictly such trade-offs are impossible to determine, because their existence would demonstrate a method of assigning measures to the objectives which made them commensurate, contrary to assertion. Such trade-offs as can be devised, must be regarded as approximations or conventions to enable progress to be made.

There is a great deal of diversity in the way these and other preliminary questions are resolved before the study starts; there is even ambiguity about the way that is supposed to be resolved.

In a commercial enterprise the situation is fairly clear. Inside such an organization there are groups with conflicting views of the relative importance of different criteria – the production staff concerned with efficient transformation of resources into product, sales staff concerned with availability of product to sell and accountants concerned only with the consumption and production of money. However, such an organization is almost always hierarchical and so ultimately there is one man who determines these relative importances. The resolution of the criteria is contained within the organization and the outside world has little or no say in that resolution.

A nationalized industry operates in a similar manner, except that its sole shareholder, the government, exercises considerably more pressure on the organization than in private enterprise. Its principal effect is to delay the implementation of plans, sometimes to the point that events have matured and give rise to the need to replan.

In social planning, the situation is not so clear. The system consists of the executive organization, national (and/or local) government (which funds the activity), vested interests of various kinds and the general public who are affected by the activity. All these groups have objectives, often conflicting, and there is no hierarchical structure which can be invoked to resolve the conflicts. In its place various mechanisms are used ranging through consultative committees, public enquiries, parliamentary debate, private agreements and unilateral decisions by the executive organization.

The common defect of all these mechanisms is that they cannot contribute early enough to the debate. The executive proposes plans which are debated and amended by the consultation. Often too much is pre-determined by the existence of the plan that the amendments cannot adequately change the course of events. Attempts at consultation before a plan exists are rarely

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successful (and therefore the attempts themselves have become rare) because the other affected parties have not studied the interrelations between the various facets in sufficient detail to make constructive contributions. It is easier to see the defects in a particular proposal than to envisage requirements and constraints for a future situation not yet specified.

Once a plan exists, its creators are forced into a defensive position and overcoming the resistance to it becomes one of their objectives.

The foregoing comments have been criticisms of the current practice of planning. They accept the methodology of planning and merely point to some of the difficulties of implementing that methodology in practice. We now turn to a critique of the methodology itself.

Critique of the methodology

Many practitioneers of planning may not recognize their own activities as conforming to the pattern described above. In some cases, this is because the model used is so crude or so ingrained into our way of describing a situation that we confuse a description of the model with a description of the real world.

In others, the mechanism for searching the alternatives is so dependent on the structure of the model that we use, the model is hidden within the search apparatus. We even go so far as to describe the search process as the model, e.g. an l.p. model of a system is really a search mechanism (almost universally based on the simplex algorithm) of a model of a system subject to only linear constraints using a choice criterion based on a linear function of the same variables we use to describe the constraints.

Even if the model is overtly present, our present limited understanding of the means of undertaking large-scale searches, often strongly influences our formulation to take advantage of some particular structure that does lend itself to an efficient search. In many cases, the number of possibilities we would wish to test far exceeds the number we can afford to search and the scope of the study is thus reduced.

However, this does not constitute the main criticism of the methodology. It is merely a current technical limitation on our ability to implement it.

The current methodology stems directly from the classical scientific method which postulates a hypothesis, explores its consequences and verifies (or otherwise) these by experiment and continues this cycle until a hypothesis is found which does explain the real world. This can be put in other words: a model is built of some part of the real world, predictions are made from that model and then verified by experiment. This model is then incorporated into larger models of larger parts of the real world until we have the ability to make a coherent consistent model of any part of the real world.

Planning just consists of this process where we use models that have so long passed the test of experimental verification that the repetition of the verification is pointless. We then take the bold step of believing that the amalgamation of models of parts of the real world can be used to predict the behaviour of systems which have never existed before.

Planning is the application of the scientific method without the experimental verification. Of course, it is possible to regard the implementation of the plan adopted as an experiment but few planners do so regard their activities in this tentative light.

There is a historic precedence for this shortcut – in engineering design. The engineer builds a model, on paper or to scale, experiments with it to make compromises between cost and

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performance and builds the full scale object. The main ingredients of the planning process are all present – the model, the criteria of success, the search for the best, the implementation.

This process has been remarkably successful, particularly in comparison to the success of our planning activities; it requires us to determine the differences between the cases to explain the differing successes.

First, the scale of even the largest engineering project is such that the consumption of resources is such a small proportion of the total available that they can be regarded as interchangeable through the medium of money. The 'cost' of the project is reduced to a single variable. In national planning, often all of a given resource is consumed and changes in the demand for it reverberate into another problem area. Resources cannot be interchanged without incurring an unknown cost outside the system under study.

Secondly, the required minimum performance of the engineering system is determined for the designer and there is little further advantage in over-performance. The objectives become constraints and the whole exercise is reduced to minimizing cost, subject to constraints. In planning, the required performance of the system it is not predetermined and 'trade offs' between different performance characteristics, albeit ill defined, are presumed to exist.

Third, in engineering, the models used are based on well-established laws of behaviour and can be trusted to predict with accuracy the outcome of proposed designs. The choice of design is made on the best predicted behaviour and this is likely to be close to the best actual behaviour.

In contrast, planning uses models which are not so well established and for which predicted and actual behaviour are liable to differ significantly. Of course, in both cases, it is not possible to know that the choice has lead to the best actual behaviour because in neither case have we actually made an alternative design or implemented an alternative plan. However, the designer can be assured that implemented design will be as good as predicted, the planner cannot.

Fourth, and most important, the engineer is dealing with a system of passive objects assembled in a new way. The behaviour of the system is determinate and predetermined. There is no variability in its performance, albeit we may have difficulty in calculating it. The system is mechanistic and can be described by a set of values for certain variables. In contrast, the planner works in a world of uncertainty and cannot describe the effects of this uncertainty except in uncertain terms. He cannot accurately describe the outcome of his system by a few fixed values.

The planner has adopted the methodology from a deterministic science and its application by engineers to mechanistic systems and added features which attempt to take account of uncertainty. I believe these attempts to be ill-founded and that nothing short of a new methodology and new concepts to give us a grasp on a world of uncertainty, will establish social planning as a worthwhile exercise.

The nature of uncertainty

It may come as a surprise to hear of uncertainty raised as a new significant problem. In many peoples' minds, uncertainty has been successfully incorporated into our methodology by the concepts of probability theory which in its modern form has been with us for over half a century.

However, the frequency theory of probability does not make any radical inroads into the central tenet of a deterministic world viewpoint. This simply asserts that the future will be like

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the past. What happened in certain circumstances in the past will occur again when those circumstances reoccur in the future. The problem in deterministic science is to unravel what are the relevant circumstances about the past that caused the happening, so that we may recognize their reoccurrence and predict the reoccurrence of the happening.

Frequency theory is applied when we have to admit failure – that we cannot isolate all the relevant circumstances and have to describe a set of circumstances and ask what can happen. The answer is that many things can happen, but that in the occurrence in nature of that set of circumstances, the relative frequency of the individual members of that set has a stability which endures through time. We observe that in the past, the relative frequencies have had certain values; we assume or predict, that those relative frequencies will occur in the future.

Thus the frequency theory of probability merely extends the principle of determinism – to enable us to continue to maintain a mechanistic world view. It transfers attention from the individual happenings to a set of them and for this entity it reasserts the law of determinism. For that set and the frequency function derived from it, we make certainty statements – the mean has this value, the standard deviation that value and ever more shall do so.

It is true that a frequency theory description does not allow us to predict which happening will occur because we cannot predict which member of the set will occur. Indeed we introduce the concept of independent random variables as a means of separating the future from the past and it was a significant step forward in our description of the real world to see part of our future not determined by our past. It partially broke the stranglehold of a deterministic view which denied the possibility of free will.

However, it is not an adequate theory to explain free will. It allows us to recognize that we cannot see the connection between the past and the future – it does not assert that they are independent, only that we cannot see the dependence. There is no place for human free will to influence the future except through the mechanism of cause and effect. It is a theory that does not allow anything *new* to happen only the reoccurrence of some unpredictable happening from the past.

Some schools of thought believe that there *is* nothing new to happen. It is only the chance common occurrence of events which has not happened before, that gives the illusion of something new. Change takes place by a sort of generalized evolutionary process. They produce examples which show a new idea was thought of over a century ago and are delighted if an even earlier exposition of the idea can be produced. They quote well-known tags such as 'history repeats itself'.

The evidence seems against them. What explanation is there on this theory, based on such random concurrences, of the epochs of relative stagnation and those with a high level of innovation – the Renaissance and the post-war technological revolution, for example? Why do problems which constantly face groups of people without a successful solution, suddenly become solved when another group (or most likely a single man) become faced with it?

It is much more flattering to man and therefore more acceptable to him, to believe that the individual man makes some contribution which, recognizing the opportunity afforded by the circumstances, chooses a course of action which does create something new. This choice or decision is a creative act which separates the past from the future so that 'it can never be the same again'.

Of course, viewed from afar this can still be viewed as an inevitable trend. If this one man had

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not created the step forward, some other man would have faced the problem and taken the step. In such a vast system as all of human affairs, the combination would be almost certain to occur.

However, to the planner worrying about the renewal of the city centre or the state of the ambulance service, it is no consolation to know that ultimately his and similar problems will be solved by some accident. He wants the accident to happen to him.

It may seem to be wandering rather deep to be discussing free will, but without the concept of free will, man must be treated as everything else in deterministic science – as a machine.

If man is treated as a machine, social systems being an aggregate of men must be a machine. Conversely, if we apply a methodology for studying social systems derived from the study of machines we treat a social system as a machine and it parts, men, must be machines.

It is the obstinate refusal of men to believe this and their actions to refute the assertion that destroys the validity of plans made for social systems based on a mechanistic world view. Until we have a methodology which accepts the non-mechanistic nature of man, our planning of social systems will continue to go awry.

Before we describe the real attempts to break away from a mechanistic world view, we must discuss two other attempts to amend our present view to include men in systems. Both of these are idealistic theories meaning that they are based on an idealistic philosophy (the supremacy of ideas over matter) rather than a materialistic philosophy. It is not surprising that the grafting of these two elements founded as they are on an opposing philosophy to that of the mechanistic one has not been very fruitful or widely accepted.

Subjective probability

The first of these is the theory of subjective probability. The theory of frequencies already discussed implies (to use the statistician's language) the specification of a reference set. Assertions are made about the properties of members of this reference set. In many practical applications, such a reference set is comparatively easy to define although many of the paradoxes of statistics hinge on an unconscious change of the reference set. But in some situations, a reference set, a collection of like circumstances, is difficult to define. For example, what are the like circumstances to be considered if we wish to discuss the probability of an Arab–Israeli war breaking out? Previous states of tension between Arabs and Israelis? Or states of tension between any two neighbouring states? Or any two states? Over all recorded history, or just this century, or since the emergence of super-powers?

Subjective probability theory claims that it is still possible to speak of the probability of this event, but that the probability is an entirely new concept distinct from the frequency concept and not dependent on a reference set. It is a measure of the belief that an individual has in the possible occurrence of the event. It can be different for two individuals and hence the adjective 'subjective'.

Now there can be no doubt that individuals do hold beliefs of this kind and hold some strongly and others less so. For any two beliefs a rank order may exist. This is a long way from meeting the requirements for a measure to exist.

To make subjective probability a useful concept, we require a calculus and this requires a measure which in turn requires additional assumptions about the relations between our beliefs. The axiomatic development of subjective probability then finds a set of relations

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which will lead to a measure of belief and hence to a calculus of subjective probabilities which, we are all pleased to find, obey the same laws of combination as frequencies.

The crucial point is whether our beliefs do follow these axioms. The subjective probabilists then put a twist to the argument. A rational man would accept these axioms (the definition of rational) and hence a rational man accepts the conclusions from them; it follows that since man likes to be rational, he should accept the subjective probability theory. We move from a descriptive theory of how man does behave to one of how man should behave – a prescriptive theory.

The argument is dangerous, because if man does not have a pattern of beliefs consistent with subjective probability laws, then it follows that man is not 'rational'. Of course, the whole analysis is a tautology because 'rational' is used in a special sense and the argument pretends it is used in the layman's sense of a coherent, consistent set of beliefs and actions – a much wider definition. The argument exploits the emotive majorative implications of the word rational.

Can it be an accident that subjective probabilities follow the same law as frequencies? Why can two individuals have different strengths of belief in the possibility of a given future event? The answer may lie in their different past experiences and so it seems reasonable that the relevant selection of these form their reference sets – different reference sets give different probabilities. The only difference between subjective probability and frequency would lie in the ill-defined nature of the reference set in the former case.

If the difference does not depend on past experience, then it remains to explain where it comes from. It implies the idea springs to the mind independently of the real world – an idealistic standpoint which throws no light on the differences.

Such a world view looks at a system from the outside and requires to know what will happen to it. The beliefs of men inside the system are only relevant to predicting how men will act because of their beliefs. Subjective probability says nothing about this.

Subjective probability has a long history stretching back into the eighteenth century, but even the modern post-war revival of this idea has remained the playground of the academic and has not found more than lip service among practical people. This is commonly attributed to the admitted difficulty of elucidating probability values in practical problems but the real objection to it is its passive, introvert nature. It emphasizes what the real world may do to the observer, and not what the observer can do to change the outside world. It makes no contribution to the problem of free will.

Utility theory

A related idea that has sprung into popularity in social planning and, indeed, in all decision making is the concept of utility. This relates to what a man hopes will happen rather than to what he believes may happen. It is concerned with attempting to force onto a common scale his various objectives, i.e. it is a general theory of how to find trade-offs between objectives. It is even more overtly idealistic than subjective probability theory, because the trade-offs are supposed to be discovered by questioning men about their preferences in hypothetical situations they have not yet experienced – but only imagine.

The axiomatic approach has also been used to justify utility theory. The axioms are taken to define a 'rational' man and then, because this should make a 'logical' man behave as if he believes in utility, 'rational' men should behave so. It is hailed as an escape from mechanism,

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but on the contrary sustains and re-emphasizes the mechanistic viewpoint. If a man is 'rational' he cannot escape the consequences of his consistent rationality and all other men knowing his start point can predict his actions, i.e. can treat him as a machine subject to the laws of cause and effect, obedient to his own imposed laws of behaviour.

Utility theory is dependent on some description of uncertainty. The classic method of determining a utility measure uses the indifference principle. Select two outcomes which, in the view of the subject whose utility is being measured, represent the worst and best outcomes possible. The utility of any third outcome lies between the values for these which we can take without loss of generality as 0 and 1 respectively. Offer as an alternative to the third outcome, one in which the best has a probability of p of maturing and the worst a probability of $1-p$. The value of p for which the subject is indifferent to the two choices gives the utility measure of the third outcome.

This procedure has several difficulties. It may be that a subject has such an aversion to uncertainty that irrespective of the value of the third outcome he prefers it to any value of p (except 0 or 1). Thus all outcomes become divided into good and bad. Yet given two outcomes (with no uncertainty) one is preferred to the other. This violates the transistive property of indifference essential to construct a measure.

It is not clear what kind of probability is envisaged for the fictitious uncertain outcome. If it is a frequency concept, then the subject is invited to imagine an indefinite succession of such choices; if he actually experienced such an indefinite succession his preference would certainly change during the succession. To give a homely example, if the outcome is that he acquires a drinking vessel and he most dislikes those made of pottery and best likes those made of glass, what is his utility for a pewter pot? The first imaginary choice may be confused by his desire to own a pewter pot as well as his pleasure in drinking from it. By the second imagined choice he already owns a pewter pot. In due course, he becomes embarrassed by all the pewter pots he owns and wants no more, however pleasant drinking from it will be (he can already choose to drink from one anyhow).

Every experience changes a man and every invitation to imagine an experience involves him in imagining the change the experience would induce in him. A frequency concept of probability requires not just an imagined reaction to an outcome by himself but by a whole succession of imagined changed selves generated by the imaginary experiences. Would the average man even understand the invitation?

Thus the kind of probability involved is unlikely to be frequency. If it is a subjective probability, it must be his own probability. He is invited to imagine that his subjective belief in which outcome will be actually presented to him has the nominated value and then to imagine what his preference would be under these hypothetical circumstances. His actual subjective belief depends on his trust in the inviter to actually give him the alternatives under the stated conditions; but he knows the inviter has no intention of actually offering him anything.

Such experiments in the mind offer no guarantee as to the subject's reaction when faced with a similar real choice; we all know from bitter experience than men do not always act as they say they will. Thus even if the utilities of the men in a system are known, it does not allow valid or accurate predictions to be made about the behaviour of the system.

Probability is also involved in dealing with utilities of conditional outcomes. If some plan can give rise to different outcomes 'by chance', then the utilities to a man of those outcomes must be combined to give *a* utility to the plan. The probability weighted average (the expected

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value) of the component utilities is taken and the 'rational' man is supposed to accept the plan with the greatest expected utility.

Once again it is difficult to envisage either form of probability as relevant to the man's objective. Even the professional planner does not make such a succession of plans that he can be content that his success rate, over the whole set of plans that he makes, is fairly high. Indeed, *his* utility is not relevant; it is no consolation to the subjects of one of his plans that other plans have been much better. The failure of his plan is what concerns them and the plan is for them, not to gratify the ego of the planner. Arguments that it is the process of planning which is all important do not impress those who suffer from the bad products of planning.

If it is not the utility of the planner which matters, whose utility does matter? Being a subjective, a personal, thing people within a system are bound to have different utilities.

To make an objective comparison of plans one measure is required and some combination of the constituted utilities of its components must be formed. Any average is quite inappropriate as it is difficult to see what it means. It is not the utility of some mythical average person. Such a concept would involve imagining the imaginations of an imaginary person – a feat which defies imagination!

The combination must recognize the conflict that lies inside the system and determine how it will be resolved; this involves the imposition in part or in total of one view upon the others. It raises a deep philosophical problem of how to ascribe a purpose to an organization. It will be distinct from the purposes of its human components and may not be calculable from these alone. It may be a figment of our minds; merely the invention of an external observer to explain the behaviour of some organization or system. Yet each individual human being knows he has a purpose and he is just a system of parts. What characteristics of a system are necessary for it to have consciousness and thus be aware of its own purpose?

Neither of these palliatives to our world view throw any light on this problem.

Ackoff's proposals for a new methodology

This, of the recent work known to me, is the most systematically developed. Ackoff starts from the observation that our present mode of thought only became universally accepted since the Renaissance. Before that argument was based on appeal to authority, loose analogies, arbitrary classification of facts and empirical rules. As it has not existed for all time, it need not exist for all future time and we should study the causes of its origin which may give a clue to the possible nature of its successor.

Ackoff argues that the present mode of thought arose out of the realization that mastery of the inanimate world was within human power and evolved to its present form to obtain that mastery. He analyses the present mode of thought into four elements.

(*a*) Things are understood by dividing them into parts and studying the parts.

(*b*) These parts are things which can be divided, but there must be an end to this subdivision. The world is made up of atomic (or basic) elements which cannot be further subdivided.

(*c*) If the properties of the atomic elements are understood, those of collections of them can be understood and so on to the whole world.

(*d*) The properties of an element is a description of its behaviour expressed by statements of cause and effect.

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The idea of atomic elements is more far-reaching than the familiar atoms of matter and each subject of study has its own atomic elements, which may not be so regarded by another subject. Thus in economics the basic element is an 'economic man', who however, in so far as he corresponds to a typical man, is regarded by an anatomist as composed of basic elements such as bones, nerves and tissue. To the biologist, tissue is composed of cells which are his atomic elements. Divide a cell into parts and it has no life. It becomes the province of the chemist.

The atomic concept in our thinking is an inevitable consequence of the method of analysis; it provides an escape from an infinite process.

The third component implies that the whole is no more than the sum of its parts; that the relations between its parts are no more than necessary to provide each of them with an environment. It is from this idea that isolated systems arise as the ideal subject of study.

The fourth and most important component is the law of cause and effect which gives the deterministic flavour to all our thought and is the reason that Ackoff christens our mode of thought as the *machine age* mode. Applied to the inorganic world, it was a powerful way of thinking to master the problems of production and to give us the understanding and insight necessary to invent the machines to achieve that mastery.

However, Ackoff argues that its application outside that field, where uncertainty holds sway has lead to our present difficulties. In particular, it leads to a view that everything including man is a machine. This attitude has become all pervasive, often in very subtle ways. It extends beyond the idea that a man employed to screw nuts on to a motor car chassis is a machine, used because no other machine can be invented which is as cheap or efficient as a man.

We have seen examples of how the idea has penetrated our thoughts; our attempts to explain uncertainty through idealistic theories still retain the idea of man as a machine through the introduction of concepts of rationality.

Ackoff's suggested methodology simply consists of inverting each component of the machine age methodology.

(*a*) Things are understood by recognizing that they are a part of something bigger.

(*b*) The process is terminated when the thing is everything.

(*c*) If the relation between the thing and all its fellow members of that thing which contains it, are understood, then it is understood.

(*d*) The relations between things are explained by the inverse law to cause and effect. Effects cannot occur unless certain conditions are satisfied.

Ackoff has christened this mode of thought *systemic*. It escapes from determinism by replacing the law of cause and effect by one merely prohibiting some relations; by concentrating on relations between parts rather than the inner workings of the parts it enables the whole to be greater than its parts.

The machine age mode of thought gave birth to the procedure for study of systems in three phases: (*a*) analysis, (*b*) description of parts, (*c*) synthesis, which together form the theoretical wing of the classic scientific method and corresponds to model building in planning.

Under the systemic mode of thought these phases are inverted: (*a*) synthesis, (*b*) description of relations, (*c*) analysis.

It is interesting to note that Ackoff applied the machine age procedure to derive his suggestion. Mode of thought was divided into its four components, which were described with very little

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reference in the descriptions to the other parts; the synthesis consists of the conclusion that all men are treated as machines.

Of course, none of the parts of the Ackoff's methodology are new. Each has arisen independently many times before. The *systems* approach has become almost mandatory now in many fields. If we see a man delving into the innards of his car, he is no longer 'tinkering with the carburettor' but is 'adjusting the fuel intake sub-subsystem of the power unit subsystem of his trackless locomotion system'. Of course, he still just checks that the needle valve is not stuck, that the petrol line is not choked and the float is not punctured.

The word system has attracted such a majorative appeal that even data processers who are concerned with a well structured arrangement of their data takes this systematic arrangement as elevating their activity into systems analysis.

The idea of concentrating on the relations between parts had some popularity two decades ago under the name 'black box' theory. In practice, this frequently degenerated into a branch of statistical regression theory. It became discredited because it was applied to deterministic systems and more powerful conclusions could always be made by dissecting the black box and looking at its internal structure and men trained in the machine age mode of thought always wanted to so dissect their black boxes.

The newness of the systemic approach lies in the combination of these ideas and applying them in the appropriate circumstances, in particular in systems involving men as components. The central element is the abandonment of the law of cause and effect. This destroys the validity of the whole planning methodology which hinges on predicting the behaviour of the system and assigning a measure of worth to that behaviour. Within the Ackoff framework a plan cannot be designed to achieve a given objective; instead it must be designed to *prevent* some undesirable behaviour. It is far easier to get a consensus of what is *not* desirable than to focus on a commonly accepted positive requirement. The planning process is not conceived as analysed into two parts – make a plan and implement it, but rather as a continuous process of adaption with the dominent emphasis being on the relation between the plan and its execution. The plan is now regarded as a social experiment and its design objective is to give the greatest flexibility so that the participants have a framework which facilitates changes in any direction they wish to take.

Ackoff in his book *Redesigning the future* illustrates the consequences of his ideas on a range of social problems and although many of these applications produce proposals which do not appeal to machine age minds they, considered as a set, do offer promise of an escape from our present social dilemmas.

They certainly illustrate that successful plans cannot be made for people but rather they must be made by people for themselves. It shows how planning can be relegated to a technical rôle of just providing a framework for a system of people to adapt as they require.

Ackoff's theory is not without its defects. He claims that it is a teleological system which recognizes that some systems have purpose but is rather unconvincing about the distinctions between an objective imposed on a system by an external observer, an objective invented by an external observer which explains the behaviour of the system and an objective set by the system itself. He sheds no light on how a system is conscious of itself and regulates its own behaviour to achieve a self-imposed objective. Much of this is related to his uncritical acceptance of probability as the means to describe the kind of uncertainty generated by abandoning the law of cause and effect.

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He has an optimistic belief that the conflicting objectives of people within a system can be resolved by the invention of new arrangements that generate a collaborator's surplus. In so far as his proposals give impetus to discover these new arrangements it is to be applauded, but there are conflicts which arise from such diametrically opposed views that compromises will only generate further conflicts on how, for example, to share the collaborator's surplus.

Shackle's theory of decisions

In his book *Time, order and decision in human affairs*, Shackle sets out the complete account of his work over the last twenty years on these topics. His central theme is that a decision involves an act of imagination – it is a creation which, however slightly, alters the course of history. If the decision is a conclusion which would be reached by all men then no decision is involved. This viewpoint eliminates at one stroke the controversy that is periodically raised in O.R. circles on the rôle of O.R. in decision making. The extreme form is illustrated by the situation that there are two proposals; the O.R. man shows that one will create £1M of wealth for the organization and the other will lose £1M. The managing director is asked to make a decision on which proposal to follow. Who makes the decision, the O.R. man who discovered the worth of the two proposals, or the M.D. who actually made the choice? Shackle's claim is that neither did, because no decision is involved. All men faced with that situation will take the same choice.

If the M.D. takes other factors into account (for example the loss-making proposal may allow diversification into a new, potentially lucrative field) and takes the worth of these other factors into account in his decision then he has made a meaningful decision. If the O.R. worker imagined these possibilities and incorporated them in his analysis, then in so far as that imagination was not common property among all men, the O.R. man has effectively made the decision.

This emphasis on man's imagination of what is possible makes subjective probability an inappropriate approach to the uncertainty of the future. Shackle replaces it with the concept of *surprise*. A man who has learnt nothing from his experience is not surprised at anything that happens. He has no concept of the relations between happenings and cannot understand how a prediction could be made that something is impossible. He believes in magic.

A man of more imagination can see connections between things and his reaction to some proposal about the future will be extreme surprise. He believes it is impossible. Others he can see no argument to refute and they are consistent with everything he knows about the world. They generate no surprise. There can be many outcomes which have this property and all will be said to have a value of zero of a measure of surprise. Yet other outcomes are not ruled as impossible, but the man cannot understand how they might come about, he would have some surprise if they occurred. Moreover, the surprises that the man imagines he would feel if either of any two outcomes actually occurred can be ranked by him. This, with a transitive property, allows a measure of surprise to be generated in the classical fashion.

This simple inversion of the invitation to man to consider the future – not how likely he feels an outcome may be but how unlikely or surprising it would be – has far-reaching consequences.

First, each outcome can be considered independently of all others. The fact of the existence or not of other outcomes which might be considered, does not alter the opinion about *this* outcome. One of the difficulties of subjective probability (that it is distributed) disappears. Subjective probability accepts that something must happen and shares belief between the set of

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outcomes presented as covering everything that can happen. If it is realized that another outcome is possible, then all the probabilities must be adjusted, because their sum must still represent certainty. The laws of combination of surprise are quite different from those of subjective probability and of frequency so it is without doubt a distinct concept from them.

Another feature of surprise is that it accepts indifference about a set of outcomes as the norm and not as a special degenerate case. An important difference comes when we consider the combination of surprise about two outcomes. Shackle's analysis demonstrates that the temporal order of these outcomes is important. In subjective probability we can speak of the two probabilities for two independent events and the probability of the joint event as their product regardless of the timing of these events. In surprise theory, we have a conditional surprise of one event A given the occurrence of a *previous* event B but not of B given A which is temporal nonsense. The theory makes clear the double level of imagination involved, for this conditional surprise involves imagining the level of surprise the observer will imagine in the future about A when B has occurred.

Now, any theory must also describe the interest to the observer of any outcome as well as his belief in its possible occurrence and the two must be combined in some way. Shackle's method of combining things does not involve any averaging process, but a focusing process so that at various stages in the reduction just two cases are singled out as most interesting. For example, if the outcome of a plan depends on a set of future events, then considering the set of events of zero surprise, those events which give the worst and the best outcomes are selected or chosen as foci. This can be repeated for each set of assumptions with a common measure of surprise.

Now a principle must be introduced that enables a balance to be made between a good outcome under future circumstances with a high measure of surprise and a less desirable outcome under circumstances with a lower measure of surprise. Once again a principle of indifference is applied to define a *neutral* outcome.

The whole theory is a descriptive one giving a formalized procedure of how men actually take decisions which for students of the actual practice of decision makers has a familiar ring about it. The process involves the successive rejection for consideration of sets of cases until just two cases remain. This reduction is a common place device among real decision makers who otherwise get confused by a welter of different cases.

Another attraction of the theory is that the focusing process makes the precise values of surprise unimportant. The focus chosen is invariant over a widespread of values and so the practical difficulty of precise measurement of utility or subjective probability is avoided.

However, the main attraction centres on the positive contribution to the decision taking played by man's imagining of the possible future. It is the closest we have got to a practical incorporation of the rôle of free will in such activities.

This short account does less than justice to Shackle's work which should be read to give a fuller understanding of its importance.

But, the theory is a personalized one describing the rôle of an authoritarian decision maker and throws little light on how decisions can be taken in social planning situations with many potential decision makers not hierarchically organized.

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Howard's meta-game theory

If in a planning situation everyone had identical beliefs about the future and identical views about the desirability of possible outcomes, then any one could be taken, indifferently, to represent them all. Thus it is the conflict of ideas which constitute the complication in the multi-person situation. As part of a study of economic behaviour, Von Neuman & Morganstein studied a formal theory of games. Games are themselves formal models of conflict situations and through this theory it was expected to gain some understanding of human behaviour.

In one sense, the theory was a great success in generating a brilliant example of mathematical elegance. In another sense it was a disaster because it generated several paradoxes about the commonly held ideas of 'rational' man. Perhaps this may be more significant as the resolution of these paradoxes will have far-reaching implications for an understanding of human behaviour.

A game consists of two or more players each allowed to make moves in succession according to a set of rules which change the state of a system (of cards, chess pieces or the like) and rules to give a termination of the game. Rewards are presented to each player after each move according to the state of the system. Each player makes moves to maximize his total reward which generally will reduce the rewards to others.

The first brilliant step was to reduce this extensive form of description to a canonical form. This involves consideration by each player of his possible strategies, each of which is a set of rules for determining his succession of moves. The reward obtained for each strategy depends on strategies of his opponents. All games are now reduced to an equivalent game of one move choosing a strategy. A value is attached to each strategy being the minimum reward as the opponents range over their strategies. The best strategy is that which maximizes this value. In a two person game with perfect information and no random element in which the rewards sum to a constant for every outcome (taken without loss of generality as zero) (e.g. chess) then the players will choose strategies that give a common solution to the game.

The second step was to deal with uncertainty which is represented by frequencies. If instead of choosing a strategy, each player chooses a set of frequencies one for each strategy, and in a succession of plays of the game chooses from his strategies with these frequencies, then once again a unique max–min value is assignable to the game and no player can gain more reward on average than this value (for one player and its negative for the other).

When we relax the restriction to two players or the zero sum constraint the difficulties begin. In n-person games the possibility of coalitions arises; the method of allocating the joint reward among the coalition is not prescribed by the rules of the game and has to be agreed by the members before coalescing. Prescriptive rules of how this should be done must be added before analysis is possible.

In non-zero sum games, the validity of 'rational' behaviour of the players is thrown in doubt. Games have been invented in which the rational principle of maximizing expected reward lead players into disadvantageous strategies. The most famous of these, the prisoner's dilemma, in which an agreement to collaborate leads to better rewards (actually less punishment) for both players than that obtained by the rational principle. The quirk of this particular game is that it can be regarded as transformed into another game in which the decision to be taken is whether to honour the agreement. This was exactly the same characteristics as the first game, so the dilemma infinitely regresses through a succession of such games.

Howard has made a significant methodological advance by his theory of metagames ('The

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paradoxes of rationality'). He recasts the formulation of game theory as the determination of an equilibrium in which no player departs from the chosen strategy (or randomized choice of strategy) for fear that the reaction of the opponents will worsen his reward. For two person zero sum games this equilibrium is unique. For other games it may not exist or may not be unique. In the latter case, the principles of rationality are not sufficient to identify the actual outcome of the game.

Howard makes the observation that in real world situations with a game-like structure, the rules are never as clear cut as in formal games; there is an ambiguity of what game is being played. He mirrors this in formal games by constructing a series of *meta-games*.

The first meta-game is one in which one player regards his strategy response to a strategy choice by his opponent(s) as merely a move in a game and for this game he applies game theory to create a strategy (which thus consists of a strategy for strategy choices). Each player can behave thus and every meta-game so constructed can be regarded as a game to which the 'meta-orizing' process can be applied. Thus an infinite tree of meta-games is generated.

The equilibrium principle is then applied to the tree of games and various kinds of meta-stability are defined. These meta equilibria are reached by the application of a meta rationality principle. In this way, man's rationality can be restored and the paradoxes explained.

The exponential growth in the size of the system as the tree is developed is so great that a complete analysis of the situation is quite beyond our reach. Howard sets himself a much reduced target – to find out if any state of the system is in any form of equilibrium.

This he terms *meta-game analysis*. Now the theory takes a subtle twist. It moves from being a prescriptive theory – rational man ought to play games like this – to a descriptive theory – real men faced with this game will behave like this.

The best short description of meta-games analysis is that it is a formalized simulation of the game where the arguments for and against a change of strategy which go on in the minds of the players are imagined (or deduced from their beliefs) and the moves repeated until an equilibrium is found. Since the technique is simulation oriented it is applied to discover, given assumptions about beliefs, the actual likely behaviour in a specific game-like situation. It has already been applied in the analysis of international political conflict and of industrial conflicts. It would seem to be a natural extension to apply it to discover the equilibrium states for any social system.

The basis of any agreement hinges on a belief that any attempt to gain a more satisfying outcome for one party might invoke a response from another party which could result in a less satisfying outcome. This is the basis of Howard's game theory and is, as practical politicians know, also the basis of settlement of a political conflict. Social conflicts are similar to and often are indistinguishable from political conflicts.

Conclusion

This paper has not been concerned with the detailed mechanism of planning systems since its premise is that the methodology applied to inanimate systems such as production planning is inappropriate to social planning.

An analysis of the defects of our current mode of thought about such problems and the new proposals about alternative modes of thought all lead to a confirmation of this premise.

Planning must be regarded as an evolutionary process in which the execution of the plan is

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regarded as an experiment and in which study of the results of the plan and its execution and change are more intimately connected than in the adaption of the classical method of science.

Any method which tries to predict the results of a plan is forced to work with the imaginings of the observer about the imagined desires of the people within the system and this is such an insecure basis for prediction that an experimental approach is inescapable.

Of course, the radical change to our mode of thought advocated here will not come quickly and the old mode of thought will still be appropriate for the situations for which it was evolved Even within social planning, problems of the allocation of material resource have to be solved and the techniques developed for these will still be required, but now imbedded in a different overall strategy.

In such a short and inadequate account of these ideas, many imperfections can be found and criticisms are bound to arise. Some of these will be well founded but many will be found to derive from a failure to escape from machine age thinking. If the paper arouses interest and discussion I shall be well content.

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