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A SYSTEM-BEHAVIORAL METHODOLOGY FOR BUSINESS POLICY RESEARCH*

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Abstract

A process modeling approach is used to describe three major elements of policy making, namely, the workings of the corporate system of a firm, its representation in Managers' Cause Maps, and the Policy Formation Procedures used by the policy making elite. System Dynamics provides an expert system to aid the construction of the Corporate System. Cause Map and Behavioral Decision Making theory, on the other hand, provides the artificial intelligence (modeling the collective decision making behavior of a senior management) that drives the Corporate System. Potential applications of the methodology are put forward.

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Introduction

The business policy research to be described is based on process modeling.

According to Mohr (1982):

> Process models are little used in organization theory. When they are used, they are often underdeveloped. There is a tendency to present and conceptualize the stages in the process but to omit the forces that drive the movement from one stage to another. The latter, however, are essential . . . . .
>
> Description (of a process) as theory in the more mature sciences has targeted the form, matter, and motion of phenomena, but the kind of description that would seem to have the greatest potential in social science is description of processes--how things are done by people and groups.

The processes to be modeled concern the interaction of the policy making system (describing the beliefs in causality and decision making processes of the dominant policy elite of the firm) and the corporate system (describing the actual operations and activities of a firm). An analogy can be drawn with geological exploration. From scraps of information obtained from test borings and accepted geological theory, the geologist draws a map of the subterranean configurations of old river beds, and etc., that are thousands of feet below the surface. These maps are used by exploration experts to decide on where to drill to maximize the chance of, say, finding oil. If, subsequently, oil is discovered from exploratory drilling, more is learned about the exact nature of the subterrain, leading to a revision of exploration strategy, and so on. Similarly, from scraps of information about operations, customers, suppliers, competitors, government regulations or impending legislation, senior managers piece together "Cognitive Maps"--individual mental maps of their policy domains--which they then use in their policy determinations. The results from implementing these decisions advance the understanding of the firm's operations and environment by the managers, leading to a revision of policies and so on.

Axelrod (1976) has found the decisions by policy makers to be extremely rational within the structure of their "cognitive maps". Unfortunately, these "cognitive maps" often contain gross simplifications of reality because policy makers have more causal assertions than they can handle mentally. The human mind, also, seems incapable of handling causal feedback relations that confound the individual's map.

Group behavior can cause even greater distortions to the accepted "map of causality"--group cause maps of the policy domain--on which the group's decisions are based (Hall, 1981). Furthermore, changes in customer's tastes, the state of the economy, the nature of the competition, and etc., add a dynamic element requiring the maps to be continually updated. But there is a growing concern that senior executives are making important decisions based on out-of-date maps that are gross simplifications of reality and deficient of feedback loops of causality that will create unforeseen deletarious policy side effects and disappointing results.

There seems a general lack of formal methods for handling this problem in private firms that is similar to the military's 'C3I' approach (Communication, Control, Command and Intelligence). A good map is like an insurance policy: when the environment is benign, almost any policy based on the most crude assumptions will be successful, but when the environment is hostile, then survival may depend on having a good map of the policy terrain. The formal map building methodology being developed by the author is based on cause mapping and group behavior theory and computer simulation. It is envisaged that it would complement and not replace existing formal methods such as market analysis, economic forecasting and business policy/strategy formulation. It would focus primarily on (a) helping the organization cope with greater complexity in its domain, (b) finding policies for stability in the face of destabilizing events, and (c) training managers by providing a rich map of their domains that they can use to exploit opportunities and defend against threats as they emerge in 'real' time.

Methodology

To accomplish the task, the author has developed a framework of analysis (see Figure 1) with two distinct submethodologies: (1) to model the corporate system of a firm (e.g., production rates, sales and cash flows), and (2) to model the management policy making system (e.g., the "cause map" and organizational behavior processes--the driving forces used in policy determinations; such as what proportion of available funds/cash flows to devote to different activities).

Figure 1 about here

For modeling the corporate system,[1] Management System Dynamics (Coyle, 1977a; Forrester, 1968; Roberts et al., 1983; Richardson and Pugh, 1981; Lyneis, 1980) and its associated computer simulation languages Dynamo (Pugh, 1983; Pugh and Paton, 1986) provide a ready-made 'expert system'. The steps involved in building such a corporate system model are:

1. From interviews with people in the firm and from industry statistics and company operating reports, an influence diagram, depicting the operations of a company, is put together using the directed digraph method (Axelrod, 1976; Hall, 1978). Note the sign of correlation (+ or -) of each link representing causality in the system.

2. A system flow diagram is developed from the influence diagram to facilitate programming. This employs control engineering symbols to categorize the conserved subsystems (e.g., inventories and cash balances) and the rates that control the flows in the subsystems.[2] The interconnecting webs of information and decision protocols that determine the activities/rates (the driving forces) in the conserved subsystems, are added.

3. A computer system simulation model is programmed from the system flow diagram using the system simulation language of DYNAMO. This language uses parallel processing (i.e., the order of the computer cards or records is unimportant) and is tailor made to assist this kind of study (e.g., documenting, dimensional checking, loop

analysis and comparative plotting facilities are built in).

4. Computer runs of the model, together with its flow diagrams and documented assumptions, are shown to the potential users who criticize the realism of the results. Changes are made to the model in light of these criticisms (a trivial task with parallel processing, but often, a major operation without this facility). The process is repeated until the opinion of the majority is expressed that the model represents reality for the purpose at hand. Finally, the validation methods appropriate to a System Dynamics model (Bell and Senge, 1980; Forrester and Senge, 1980) can be applied.

Cause Mapping and Policy Making

Whereas the System Dynamics method helps one to capture the essence of the actual workings of the corporate system of a company, the "Cause Mapping" method assists one in modeling the management's collective view of how the corporate system works. The characteristics of the "cause maps" of policy makers have been established by Axelrod (1976) (in particular the ways they differ from the very complex real system they seek to represent). The author has developed an Artificial Intelligence 'process model' of management policy making[3] based on the structure of the accounting/budgeting framework used by a company, together with macro organizational aspects derived from the structure of the firm (its major departments and divisions) and the driving forces of policy formation (e.g., 'equivocality reduction' and group status enhancement; Hall, 1984). The author has been able to demonstrate that with such a model one can predict which policy will be adopted and what the organization will learn from its implementation.

In the next stage of this research, it is proposed to program such a policy and organizational learning model and connect it to the corporate system simulation model. Such a complete system model of a firm has not been attempted before (to the author's knowledge). With the development of micro-computer versions of suitable languages, the application of this technique in situ to firms of all sizes (not just those with access to large main frame computers) is now possible.

The steps involved in modeling the policy making and controlling system are:

1. Construct a Management Cause Map by restructuring the influence diagram using Axelrod's (1976) scheme (i.e., recategorize the concept variables into Policy Variables, Performance Variables and Intervening Variables for each major department or division in the firm and map their interrelations).

2. Conduct an analysis of the Management Cause Map as follows: Trace all paths from primary policy variables to departmental and overall performance variables or goals. Sum the 'negative' signs of correlation of the links along each path to find the path-correlation between policy and performance variables (e.g., an

uneven number of negative link-correlations means a 'negative' overall path-correlation, otherwise the path-correlation is 'positive'). For each set of paths from a particular policy to a particular performance variable, note whether the net policy-performance correlation is indeterminant (N.B., indeterminacy exists when two or more paths have opposing path-correlations, and it infers that the effect of the policy on the performance variable is problematic). Where indeterminacy exists, note the correlation of the shortest path (with fewest links). The policy suggested by the shortest path is a strong candidate for adoption by policy makers to force the issue. If recursive paths (feedback loops) are found, note their path-correlations (polarity). If the polarity is negative, this suggests a tendency for self correction should any variable in the loop change its value. If positive, this suggests the opposite--any change will be amplified. Positive feedback loops are sources of growth, decay and potential uncontrollability (i.e., the system will tend to have a life of its own) and demand special attention, however, as noted before, feedback loops and their associated side effects are not usually apparent to policy making groups.[4]

3. Derive the policies that the management are most likely to adopt from a set of standard policy making procedures supplied in Table 1. These hypothesized procedures--described in detail in Hall (1981)--draw heavily on the seminal work of Cyert and March (1963),

Lindblom (1968), Axelrod (1976) and other decision school theorists who have observed the way managers and groups of managers go about their decision making work. The hypothesized procedures are evoked by the socio-political driving forces associated with subunit (departmental/divisional) status enhancement (or defense against loss of status) (Pettigrew, 1973; Mumford and Pettigrew, 1985; Salancik and Pfeffer, 1977) and the social-psychological driving force associated with the reduction of equivocality threatening confusion and chaos (Weick, 1969; Jung, 1969). The procedures invoke a search of the Management Cause Map for remedial policies. Subsequent learning from the success (or lack thereof) in implementing the policies leads to an updating of the Map, that, in turn will effect the subsequent policies evoked, and so on. The scheme models the continuous process of learning from experience. For an example of this kind of analysis, see Hall (1984).

4. The Policies that it is predicted will be used to dispel the symptoms of problems can now be compared with the actual management policies chosen in similar circumstances. This will provide a rough check of the credance of the model. The policies so chosen can be used to drive the Corporate System simulation model. If the results are counter-intuitive, further investigation can be undertaken to find the cause.

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Table 1 about here

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Potential Developments and Applications

Corporate system models are used for a different purpose (namely to aid the management on a journey of discovery into the policy areas of the organization) and hence, complement other techniques that are oriented more to prediction, forecasting and strategy analysis. Some of the potential developments and applications of this technique are as follows:

Intuitive-Logical Policy Analysis

The insights generated by experimenting with a corporate system simulation model lead to the identification of the factors causing unsatisfactory behavior and to the derivation of policies logically (albeit intuitively) to prevent the deterioration of the system's performance (see for example, Nord, 1963; Packer, 1964; Roberts et. al., 1968; Hall, 1976). This is one of the more conventional uses of corporate system simulation. For example, with the aid of a corporate system model, the change in fortunes in a magazine publishing company was explained and a policy for survival devised (Hall, 1976)[5]. It became evident that information critical to the survival of a magazine (such as the turnover of regular readers) was not being supplied by the company's information system or recognized in policy making. The method could be used for Critical Success Factor analysis (Hall and Munro, 1986) leading to the formulation of more sensible policies.

Stability Analysis

The feedback loop structure of a system model will determine its dynamic stability (or lack thereof): how the system will react to external disturbances and its own controls. Coyle (1977a: Ch. 7 and 8) presents a loop analysis method based on tabulating loop polarity, gain, number of pure integrations and length of exponential delays. A better understanding of the causes of instability (e.g., combinations of phase shift due to delays or integrations, and loop gain) can be derived, leading to prescriptions (e.g., changes in gain or delays, or "short circuiting" offending loops and their implications for policy change) to remedy the situation.

Day (1982) has shown that the simple feedback structures embodied in self-organizing systems, such as firms and their markets, when certain critical values of parameters are approached, can produce wild fluctuations and chaotic results. Similarly, the unusual and sudden changes in the basic behavior of a positive feedback loop (also found in self-organizing systems such as firms and their markets) has been demonstrated by Rahn (1982). Although the study of chaos is relatively new, it does not take much imagination to perceive the potential use of system modeling to warn organizations when their markets are becoming chaotic or their own internal policies are leading them into a 'zone of chaos.'

These studies of chaos suggest that organizations can suddenly encounter periods of great turbulence for reasons that are difficult to ascertain. The consequent internal political activities set in motion can compound the situation by favouring the conditions for internecine warfare and vaccilating strategies from which the organization may not recover.

Again it would seem that the System Dynamics methodology could come to the rescue here, since it is a particularly apt technique for modeling complex interactive feedback systems and analyzing them for stability in the face of uncontrollable external variability. From such a study it is usually possible to demonstrate the effects on the system of, say, a proposed compromise agreement, and devise policies for the organization that are "robust"--i.e., reduce the destabilizing effects of the compromise on the system (Sharp, 1977). It offers a way for putting control back into the system.

Clearing House for Values

Organizations tend to be made up of individuals or groups vying with each other for status and power over resources (Pettigrew, 1973). The competition can become very intense and potentially damaging to the organization as a whole. System models can be used to demonstrate the effect of unilateral actions by any individual or group on the others. It can provide a means for clarifying issues and a stimulus to searching for creative policies that will simultaneously satisfy several contending forces. For example, Coyle (1977b) was able to show with the aid of a simple corporate system model of an international mining company that the natural policies being pursued by both the parent company and its more independent subsidiaries were mutually harmful. Policies simultaneously beneficial to both were generated by the analysis.

Without a well informed board of directors, who is to supervise the management? Roos and Hall (1980) using influence diagramming, have shown that a viable role for the evaluator of an organization is to uncover the power strategies used by managers to acquire excess resources.

Crisis Simulation

The Limits to Growth (Forrester, 1971; Meadows et. al., 1972) simulations of the collapse of the world are supposed to have had a profound effect on the thinking of statesmen. It has been suggested that a similar simulation of the collapse of a firm could have the same effect on its management (Hall, 1979). The use of such a model could facilitate the changes in values, attitudes and orientation associated with a crisis (Turner, 1976) before, rather than after, the onset of the crisis.

Weick (1969) has suggested that the selection and retention processes of organizational adaption are driven by the need to reduce equivocality and not necessarily to optimize per se. In a crisis situation, the procedures for reducing equivocality tend to become political--the dominant group prescribes a policy most in line with its interests (Hall, 1981; Pettigrew, 1973).

The lack of attention to both complexity and novel alternatives in the deliberations of an organization during a threat have been noted by Staw, Sanderlands and Dutton (1981):

> ...search for information may change as a threat develops, from an initial flurry when a threat is recognized, to a low point as channels become overloaded, and on to a second peak as decisions are confirmed or implemented. However, throughout these changes in information search, the number of genuinely new or novel alternatives considered by the organization may still be relatively low. Even when search is increased, information received is likely to be similar to that of the past, due to heavy reliance on standard operating procedures, previous ways of understanding, or communication that is low in complexity...(p. 513).

Alternatively, crude and emotive arguments based on simplistic assumptions hold sway and complexity and uncertainty are assumed away (Steinbrunner, 1974). The chance of selecting an inappropriate policy is obviously increased by such primitive group processes. As Pettigrew (1974) puts it:

> For organizations as for groups and individuals, extreme situations provide the opportunity for learning which will only be taken up if the participants have the capacity to unravel what has been experienced from what has been learned, and the motivation to do the after-the-fact reflection and analysis which will disentangle the noise of the experience from the message of learning (p. 7).

Corporate System Modeling could be invaluable in a crisis situation (particularly when survival is at stake) by reducing the equivocality surrounding the problem (an essential step in coping) yet aiding in the construction of a rich map of the policy terrain with which to search for a safe passage. It becomes a part of the organizational process for learning to cope with an uncertain and threatening situation. Using a system model in this way as an organizational intervention tool would seem to provide a fruitful field for future action research and a potentially important extension of analytical methods in organizational and policy issues. Hall and Menzies (1983) have reported on the successful application of such a model in saving a distinguished sports club from collapsing in its centennial year. Such an analysis leads naturally to the identification of the vunerabilities and the associated information that is critical to the survival of the organization.

Efficient Policy Generation

Nelson and Krisberg (1974) have shown that a search algorithm, such as Bandler's (1971) Razor Search Program, can be used in conjunction with a system simulation model to generate more complex policies for managing the system. The policies so generated exhibit not only more policy variables in tandem but also in sequence (e.g., adopt policy A for so many months and then switch to policy B). The Razor Search Program has the capability to search for an optimum value of some objective function in the kind of discontinuous solution space associated with system models. Setting the weight to the criteria of an objective function does, however, pose a problem since managers can rarely agree on the relative merits of achieving various goals. Experimenting with different goals weightings can help the management team clarify their collective objectives (Keloharju, 1982). A systematic procedure for model simplification by removing links in the model that do not significantly alter its behavior has also been devised (Keloharju and Luostarinen, 1982; Keloharju, 1983).

Policy Training Aid

A Corporate System Model can be turned into a game using GAMING-DYNAMO (Pugh-Roberts, 1984) or reprogrammed in FORTRAN by using the translation facilities of DYNAMO II/F to produce a FORTRAN module to which subroutines controlling the game and generating reports can be added (see, for an example, Hall, 1974; Hall and Lai, 1984). The participants in the game make decisions or set policies and receive feedback of the results. In the process, they can gain a better understanding of the sensitivity (or lack thereof) of the corporate system to changes in policies, and learn to incorporate more complexity into their policy determinations. The game can also be used to demonstrate or study decision making behavior and organizational learning such as the inability to perceive recursive paths of causality.

Summary

This paper has attempted to develop a methodology for business policy research based on the notion of Process modeling. The workings of the Corporate System (turning inputs into outputs), Management Cause Maps (the management's collective representation of how the Corporate System works) and the Policy Formation procedures (whereby problems are recognized and the Cause Maps searched for solutions) are described in process form. It is suggested that System Dynamics be used as an expert system to aid the construction of the Corporate System. Cause Mapping and Behavioral Decision Making theory, on the other hand, can be used to provide the artificial intelligence to model of the way a group of managers might seek to understand and control the Corporate System. Such a model, it is suggested, can provide the driving force of action, learning and adaption in a particular corporate environment. Lastly, potential applications of the methodology have been put forward.

NOTES

1. A corporate system is defined here as an organizational entity that is capable of being managed in such a way that, at the very least, it is self-regulatory.

2. Standard modules of typical configurations are available to assist the construction of the System Flow Diagram (see Wolstenholme and Coyle, 1983).

3. A policy is defined here as an important decision resulting from group processes within the organization and not imposed from above or without (as for example, a president or receiver empowered to make sweeping changes unilaterally). It may or may not be tied to a strategy or long-term master plan for the organization. In fact the natural policy making process (e.g., raising prices to offset short-run profit shortfalls) may systematically subvert a strategy

(e.g., to produce a low priced product for mass sale). This interplay of natural policy process and strategy raises some interesting questions for business policy research.

4. To examine this phenomenon, students in classes studying decision making participated in a magazine publishing game (Hall, 1974; Hall and Lai, 1984). Working in teams and assuming the roles of managers of the departments of a magazine publishing company, the participants (over 200) made decisions and received feedback from a computer simulation model that simulated 20 years of operations spread over a 10-week period. After instruction in cause mapping (Axelrod 1973, Hall 1978), they were asked to draw the perceived relationships in the computer model. Few were able to discern any of the six feedback loops built into the model. Nor could the participants interpret the meaning of such loops in causality when made aware of their presence. This is consistent with the observations of Axelrod (1976).

5. Subsequent correspondence and interviews with the presidents of five leading national and international magazines gave the impression that the availability of this strategy was not generally appreciated. All the presidents expressed the belief that the number of editorial pages was not directly related to the amount of advertising, although the plots of editorial versus advertising pages (using data they furnished) cast serious doubt on this statement. Most used separate companies to handle their

subscription sales and had little idea about the churning effect of subscribers described by such statistics as the percentages of trial and regular subscribers renewing their subscriptions. Yet small changes in these percentages can have dramatic effects on the long term success and viability of the magazines. It is perhaps not surprising that most have since gone out of business.

6. A project is underway to build a simulation version of the policy making processes of an organization and use it to drive a corporate system model. It is intended to examine the budget planning process, for example, in detail—e.g., how many cycles through the budget were required before an acceptable decision was found, was it necessary for dominant coalition to force a decision, what did the organization learn from the results and how did this effect subsequent decisions?

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FIGURE 1 - Framework of Analysis

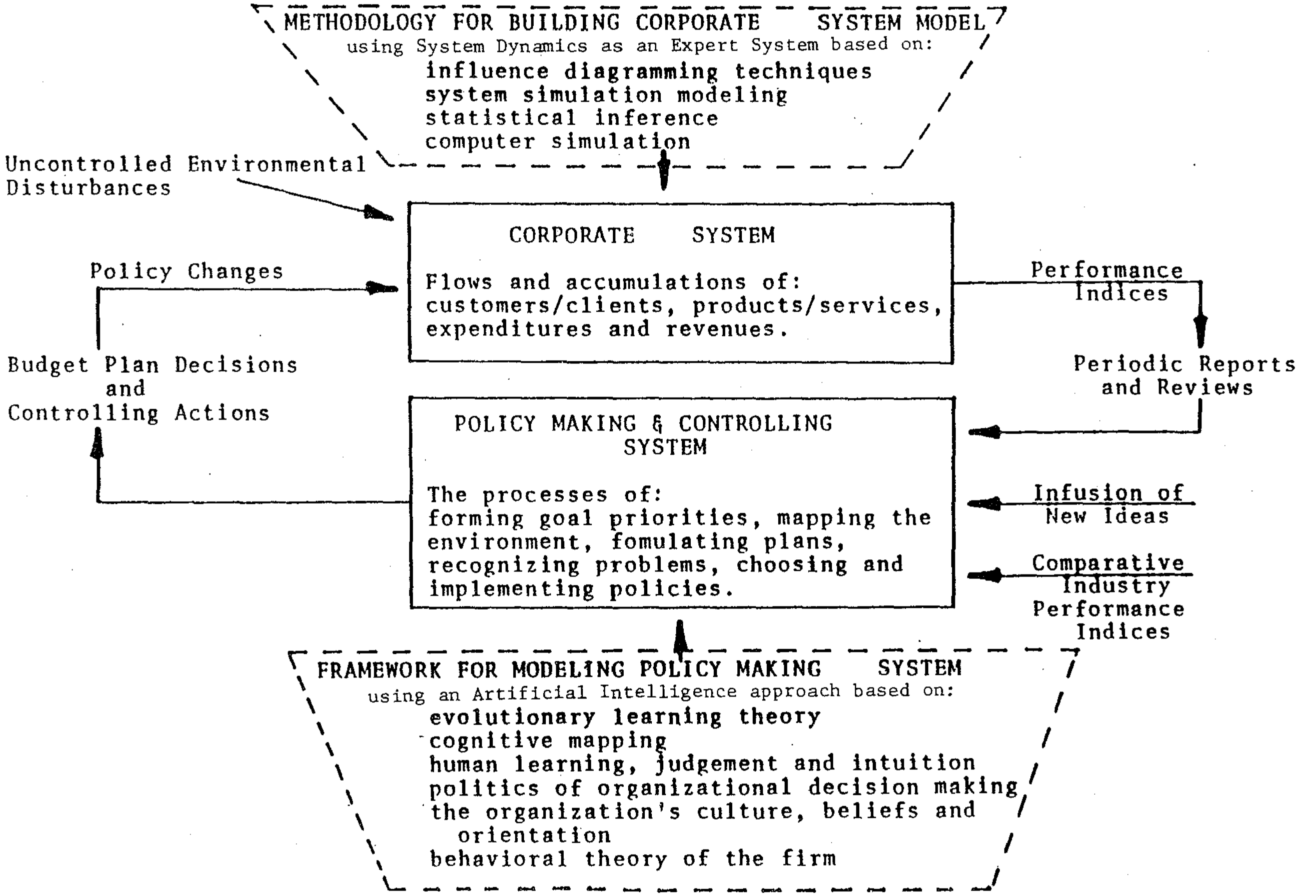

TABLE 1 - Standard Policy Making Procedures based on Organizational Behavior Assumptions

Driving Forces	The procedures evoked by the driving force
TO FORMULATE BUDGET PLANS	
Reduce the uncertainty of producing unsatisfactory financial results at year end.	Construct a budget plan using the structure of the financial accounts as the basis of the plan.
Reduce ambiguity about the assumptions to be used for computing each line of the budget.	Estimate each budget item using clearly established relationships retained from past experience. If these relationships are unclear, use simple forecasts based on extrapolating past results.
TO RECOGNIZE PROBLEMS	
Reduce disagreement in recognizing problems.	Compare the results computed by the budget with the organization's expectations for each goal. Identify shortfalls and surpluses in achieving the goals. These define the organization's problems.
Reduce uncertainty and disagreement in diagnosing the cause of problems.	Use standard financial procedures to compute operating ratios and growth rates of items in the proposed budget. Compare with previous year's figures to identify the symptoms of the problem.
TO CHOOSE REMEDIAL POLICIES	
Seek to increase subunit status or defend against threats to it.	Each subunit evokes preferred policies to dispel the symptoms of the dissatisfied goals using its retained map of causality.
Minimize inter-group conflict.	A search is made for acceptable policies that do not violate subunit goals.
Bring closure to the policy process when inter-group conflict cannot be avoided.	Select policies that meet the goals of the politically powerful subunits at the expense of the politically weak.
Bring closure to the policy process when choosing among several competing policies.	Choose the policy most frequently used before.
Bring closure to the policy process when indeterminancy exists.	Evoke policies that attend to the dissatisfied goals one at a time.
Bring closure to the policy process when indeterminancy exists under stressful conditions.	Choose the policy based on the most simple and direct argument offering immediate tangible results.
Avoid uncertainty concerning the reaction of the organization's environment to its actions.	Make only small incremental changes to the policy variables chosen for implementation and wait for feedback of results before making further changes.
Bring order to planning and coordinating the proposals of subunits.	Enter the authorized changes to policy variables into the budget and recompute the shortfalls and surpluses.
	Repeat the process until all problems are solved or no solution can be found.
TO MAKE THE PLAN WORK	
Reduce the uncertainty of not meeting budgeted targets.	If the target is being under subscribed and slack resources exist, invoke a slack reduction program (e.g., cut production costs).
Reduce the uncertainty associated with over achieving targets.	If the target is over subscribed, invoke a slack absorption program (e.g., increase discretionary expenditures on promotion, or research and development).
Reduce the uncertainty of negative reactions to policies that manipulate slack.	Control internal variables only (i.e., do not change variables that affect the environment, such as prices if at all possible).