Chap. 8

James G. March
Stanford University

Roger Weissinger-Baylon
Director, Center for Strategic
Decision Research

with the collaboration
of Pauline Ryan

Ambiguity and Command

Organizational Perspectives on Military Decision Making

Pitman Publishing Inc.

A Longman Inc. Company

8

Measuring Efficiency in a Garbage Can Hierarchy

KATHLEEN CARLEY

INTRODUCTION

Some organizations seem to be more efficient than others, either overall or with respect to a single type of efficiency. Even within a single organization there may exist a spectrum of inefficiencies, dependent on the way in which efficiency is measured. For example, we can think of an organization as being efficient politically—having staff members working only on those issues that the chief executive officer (CEO) considers to be salient—or we can think of the organization as being efficient structurally—where those in charge have access to all the work done under their ostensible direction, with no blocks in security clearance. Given that there is this spectrum, knowing potential causes of inefficiency may aid the manager in making decisions. Further, when there is a chance to set up an organization, for example, a joint task force or a congressional committee, knowledge of those factors that lead to inefficiency allows the construction of potentially more efficient organizations. Structural features such as size and differentiation, the form of incoming data flows and the criteria used for managerial decisions all vie for the dubious honor of being the "cause" of inefficiency.

Kathleen Carley is Assistant Professor in the Department of Social Sciences at Carnegie-Mellon University.

With ambiguous information flows, as the content and amount of information available on any given issue shifts and is less than complete, preferences over alternatives become problematic, the technology of deciding between alternatives, of making a decision, becomes unclear. As decision making takes on a more tactical flavor, and becomes less routine, those in charge may seek structural means of easing the difficulty of decision making. For example, they might choose a less hierarchical and more fluid notion of participation. This shift, while perhaps easing the burden of decision making, may make the organization less efficient.

Garbage can theory, or the theory of organized anarchies, tries to explain decision making in terms of information, people, problems and other aggregate flows.[1] Handling problematic data flows becomes the key to decision making and, by implication, to organizational success. As Perrow (1977) notes, the processes described in this literature seem curiously divorced from the more familiar hierarchical organizational structures, the phenomena of organizational differentiation and so on. Padgett (1980) argues that this divorce of the aggregate flows from the social structure inhibits the development of managerial implications; for example, this divorce precludes the determination of when to switch from a hierarchical to a more fluid participation structure. I would add to this that the divorce from structure also makes it difficult to construct measures of organizational efficiency, and so to talk about organization success in terms of that efficiency and to analyze managerial approaches vis-à-vis their impact on the organization's efficiency level.

Padgett (1980) showed that it was possible to combine the organized anarchy paradigm with a more classical social structure, a Weberian-type bureaucracy, with the result that it became possible to derive a number of managerial implications. By placing the organized anarchy into a hierarchical structure (although he did not proceed to do so) Padgett made it possible to talk about efficiency both in political and in structural terms. Based on the structure set up by Padgett, several measures of efficiency are developed in this paper. Further, placing the organized anarchy into the hierarchical structure was the key to studying the impact of managerial solutions on the overall efficiency of the organization.

In this paper, an analytic framework for looking at questions of efficiency is presented. This presentation takes the form of describing the underlying parameters and models used in a simulation program, GARCORG, for analyzing the impact of structural, political and managerial changes on the efficiency of the garbage can hierarchy. The following section contains a brief description of organizations as garbage can hierarchies and analytically defines the various flows of concern. Following this, in the third section, there is an analytic discussion of efficiency centering around the development and analysis of various measures of efficiency. Then long-run organizational behavior is analyzed by looking at the limiting behavior of the analytic functions that describe the organizational processes of interest. This paper is not intended as a description of how to use GARCORG, or even of the results that are obtained when using it; rather, it is a description of the underlying models and their analytic long-run behavior.

The symbols used in the analyses are the same as those used in a computer simulation program, GARCORG. Again, this program is based on the analytical measures of efficiency that are developed herein. The symbols are represented by names in bold face type; for example, the number of program chiefs per division is referred to as **PCVs** in the calculations and in the simulation program. Note that the GARCORG program is described in detail in a later chapter, where it is used to look at short-run organizational efficiency.

GARBAGE CAN HIERARCHIES—THE GENERAL MODEL

Some organizations can be thought of as *garbage can hierarchies*—garbage cans because they are organized anarchies with problematic flows, and hierarchies due to the fact that the people who work in the organization are structured in a hierarchical fashion. We can think of an organization as having more of or less of a garbage can nature, depending on the degree to which the following three criteria are met: (1) ambiguous information flows (e.g., amount and content of information varies) (2) ambiguous personnel flows; and (3) unclear decision technology (e.g., changing goals, changing values, changing equipment).

One claim about garbage can hierarchies is that their efficiency has been impaired by having to cope with problematic flows and that, therefore, new strategic styles of decision making may have to emerge. Simulation analysis would allow us to test this and similar claims by, for example, comparing the efficiency level of an organization with more problematic flows to one with less problematic flows. In the following description, I am presenting a set of parameters that allow these criteria to be met to varying extents and a set of models based on these parameters that can be used for measuring an organization's efficiency. A simulation program (GARCORG) based on these parameters has been built. This program can be used, in effect, to see what happens to an organization's efficiency as various flows become increasingly problematic.

Hierarchical Form

The hierarchical form used, like that suggested by Padgett (1980), is set to four tiers. These tiers, in order of descending control, are the following:

1. CEO—chief executive officer
2. AEO—assistant executive officer
3. PC—program chief
4. STAFF—staff members

The chief executive officer (CEO) is ostensibly in charge of an organization which is composed of several divisions. The CEO can be thought of as the president of a company, an admiral, the head of a task force, the commander-in-chief or a different type of executive officer. Note, there is only one CEO.

The assistant executive officer, AEO, is in charge of a division in the organization and oversees numerous programs. The set of assistant executive officers is denoted by **AEOS**. The AEOs can be thought of as the vice presidents of a company, captains, assorted commanders within the task force, or middle-level managers.

Each program is run by its own program chief, PC. The program chiefs can be thought of as middle-level managers, lieutenants, the senate and so on. The set of program chiefs is denoted as **PCV**. Each program chief is in charge of a particular program. A program might be a particular research group, the accounting division, a committee, the selection of an assault team, reconnaissance operations and so on.

Under each program chief are a number of staff members who analyze the information that comes in on a particular issue. Staff members can be thought of as engineers, ensigns and so forth. An issue can be thought of as the state of the hostages in Iran, or the movement of a particular fleet. The point here is that there are four levels in the hierarchy and that we are looking at a company or subset of a company that is under the control, management or command of a single individual.

Note that all the organizations simulated, regardless of the degree they resemble a "garbage can" have a basically hierarchical form in which information comes in at the bottom, is summarized into some form (e.g., a decision) which is then sent up to the next level, where it is again summarized, and so on. In Figure 8.1 the chain of command and flow of decisions in the generic organization is shown graphically.

Issues, Spots in an Organization

The chain of command flows down from the CEO to the staff, whereas decisions flow up from staff members to the CEO. These decisions are based on information that comes in on each of the issues. Associated with each division is a particular set of potential issues **[ISSUE]**. For now, we will assume that this set of issues is time invariant; it does not seem unreasonable to assume that at least in the medium run—e.g., several years—this is in fact the case. Further, this set of issues represents items that are potentially relevant to that division, not necessarily things with which they are currently concerned; therefore, in theory, there could be an infinite number of such issues; in which case the number of potential issues would certainly be fixed.

In each division there are a number of programs being worked on. The number of programs is set equal to the number of program chiefs. Each of the potential issues for the division are potentially relevant to any of the programs. For each program, for each potential issue, there is a particular position, or spot, for a staff member whose job would be to analyze all the information that comes in on that issue. Note, this means that each program has a potential number of staff positions—spots—equal to the potential number of issues per division. In each program some of these issues will be worked on, each by a different staff member. Each staff member analyzes information on only one

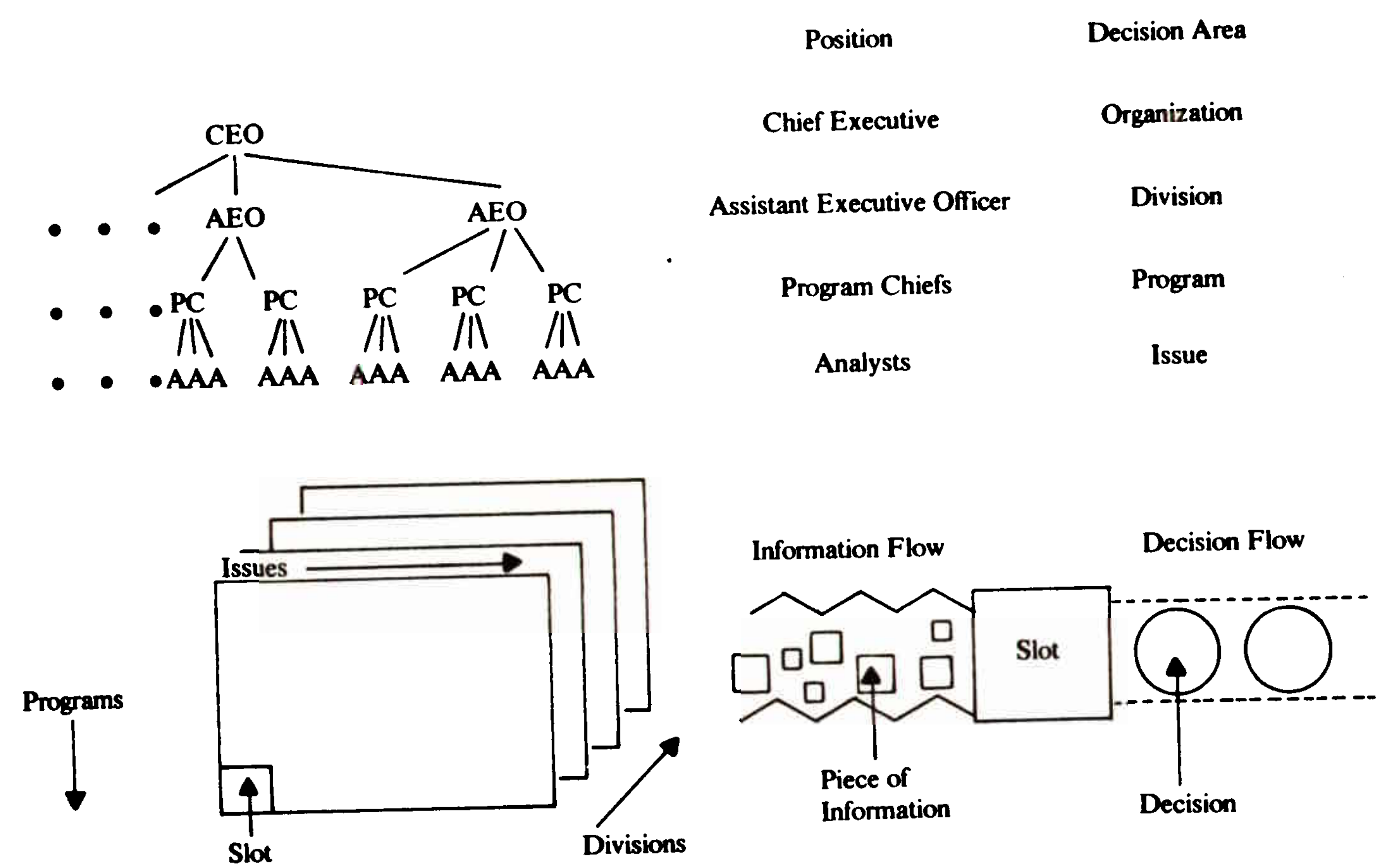

Figure 8.1 Chain of command.

issue at any one time. The same issue may be worked on by different staff members for different programs. Similarly, there may be some issues that are not being worked on at all.

The matrix **ANM** is a representation of whether or not there is a staff member in a particular spot, for a particular program. It describes which issues are being worked on by which staff member. Let **ANM** be a three-dimensional matrix whose dimensions are the number of AEOs in the organization, by the maximum number of program chiefs under any one AEO, by the number of potential issues available per division. Now, each element of **ANM**—($\mathbf{ANM}_{spi}$)—is assigned a value as follows (where the index for **AEOS** is **s**, for program chiefs is **p**, and for issues is **i**):

[1] $\mathbf{ANM}_{spi} = 1$
if there is a staff member working on issue (i) under program chief (p) who is working under AEO (s);

[2] $\mathbf{ANM}_{spi} = 0$
if there is no staff member working on issue (i) under program chief (p) who is working under AEO (s).

Note, each cell in the **ANM** matrix, in effect, represents a *spot* in the organization, an issue that may need to be analyzed. Into each of these spots, for each issue, information comes in, whether or not there is a staff member there to deal with it. When there is an analyst in the spot, the information that comes in is analyzed and decisions are based upon it (see Figure 8.1).

Models of Alternative Information Flows

The information that comes into each spot is characterized by the amount of information that comes in, $\mathbf{AMOUNTINFO}_{spi}$, and the content (or quality) of that information, $\mathbf{CONTENT}_{spi}$. There are many ways in which these parameters can be modeled, some deterministic and others stochastic. Herein, those models implemented in GARCORG are presented. These models allow the user to choose either a stochastic or a deterministic process.

MODELING AMOUNT OF INFORMATION

To create a range of mechanisms, the amount of information coming into a spot, $\mathbf{AMOUNTINFO}_{spi}$ is allowed to be constant, increasing or random. The first two of these are deterministic models, and the third is stochastic. In all cases, in GARCORG the option chosen first sets the initial amount of incoming information $\mathbf{AINIT}_{spi}$ per spot and then uses an algorithm for updating the amount of information available to that spot each time period $\mathbf{AMOUNTINFO}_{spi}(\mathbf{t})$.

In GARCORG when the option chosen is *constant*, at time $\mathbf{t} = 0$, the initial amount of information coming into each spot in the organization, $\mathbf{AINIT}_{spi}$ is chosen at random from a uniform distribution over the integers 0 to 100. During each of the following time periods the amount of information remains constant:

$$\mathbf{AMOUNTINFO}_{spi}(t) = \mathbf{AINIT}_{spi}.$$

In GARCORG when the option chosen is *increasing*, at time $\mathbf{t} = 0$, the initial amount of information coming into each spot in the organization, $\mathbf{AINIT}_{spi}$, is chosen at random from a uniform distribution over the integers 0 to 100. During each of the following time periods the amount of information increases. The user can choose a linear increase, with **B** as the rate of increase,[2] in which case

$$\mathbf{AMOUNTINFO}_{spi}(0) = \mathbf{AINIT}_{spi}$$

and

$$\mathbf{AMOUNTINFO}_{spi}(t + 1) = \mathbf{AMOUNTINFO}_{spi}(t) + \mathbf{B}.$$

Therefore,

$$\mathbf{AMOUNTINFO}_{spi}(t) = \mathbf{AINIT}_{spi} + \mathbf{Bt}.$$

Or the user can choose an exponential increase, with a modulation of **B**, in which case

$$\mathbf{AMOUNTINFO}_{spi}(0) = \mathbf{AINIT}_{spi}$$

and

$$\mathbf{AMOUNTINFO}_{spi}(t+1) = \mathbf{AMOUNTINFO}_{spi}(t)e^{(t/B)}.$$

In GARCORG when the option chosen is *random*, at time $\mathbf{t} = 0$, the initial amount of information coming into each spot in the organization, $\mathbf{AINIT}_{spi}$, is chosen at random from a uniform distribution over the integers 0 to 100. Each time period thereafter the amount of information per spot is again chosen at random from a uniform distribution over the integers 0 to 100.

MODELING CONTENT OF INFORMATION

To create a range of mechanisms, the content of information coming into a spot, $\mathbf{CONTENT}_{spi}$, is allowed to be constant, or to have an increasing or decreasing average. Note, content is always modeled as a stochastic process; however, sometimes the mean is constant over time, and sometimes it is moving. In all cases, in GARCORG the option chosen first sets the initial average content of incoming information $\mathbf{CINIT}_{spi}$ per spot, and then uses an algorithm for updating the average content of information available to that spot each time period $\mathbf{AMOUNTINFO}_{spi}(t)$, and for determining the actual content per piece of information coming into the spot.

One difference between content and amount of information is that content is defined as a percentage with a 0/1 range, whereas amount is defined as a positive integer. Note, each piece of information that comes into the organization has a unique content. Further, each spot in the organization has an average content for all information that comes in to it. The value of a particular piece of information is chosen at random from a uniform distribution centered about the mean and scaled to lie between 0 and 1. The width of this distribution is chosen at random from a uniform distribution 0 to 100 and scaled to lie within the range −0.25 to +0.25. As will be seen later, when discussing the probability of having a staff member in a spot, only the mean content of information affects this likelihood.

In GARCORG when the option chosen is *constant average*, then at time $t = 0$, the initial average content of information coming into each spot in the organization, $\mathbf{CINIT_{spi}}$, is chosen at random from a uniform distribution over the integers 0 to 100 and then scaled to lie in the interval 0 to 1.

In GARCORG when the option chosen is *moving average*, then at time $t = 0$, the initial average content of information coming into each spot in the organization, $\mathbf{CINIT_{spi}}$, is chosen at random from a uniform distribution over the integers 0 to 100 and then scaled to lie in the interval 0 to 1. During each time period after this the average content moves.

The user can choose an increasing, a decreasing or a mixed increasing and decreasing average content of information. The moving average is linear, with a rate of change of $\mathbf{Bt}^3$. In order to insure that the content level does not exceed 1 or decrease below 0 at time **(t)** such that the average content has reached 1/0, the rate of change becomes 0. This provides a ceiling/floor effect.[4] This whole process occurs once each time period.

Following is a brief description denoting, not the algorithm used in making a decision, but the kinds of organizational components that are important in the making of that decision, and that might impair the efficiency with which decisions are made. No decision algorithm is given as such. This is not a discussion of *how* managers decide; rather, it is a discussion of the kinds of organizational features, both structural and political, that impair the manager's ability to make decisions by constraining the flow of information.

I would like to suggest that efficiency, at any level, may be affected by the size of the subordinate staff; for example a commander who directs four lieutenants may be more efficient than a commander who directs two lieutenants, or one who directs 30. The overall size of the organization **[SIZE]**, and its level of differentiation **[DIF]**, correspond to the size of the subordinate staff. Note, in the four-tier structure, size is the sum of 1 (for the CEO) plus the number of AEOs **[AEOS]**, plus the number of program chiefs per AEO, plus the number of staff members per program chief per AEO. Mathematically,

[3]
$$\mathbf{SIZE} = 1 + \mathbf{AEOS} + \sum_{s=1}^{\mathbf{AEOS}} \mathbf{PCV_s} + \sum_{s=1}^{\mathbf{AEOS}} \sum_{p=1}^{\mathbf{PCV_s}} \sum_{i=1}^{\mathbf{ISSUES}} \mathbf{ANM_{spi}} .$$

Differentation, the spread of the organization, at any level is the ratio of personnel at that level to personnel at the next lower level.[5] For now, we will measure differentiation **[DIF]** as the ratio of program chief managers to staff personnel:

[4]
$$\mathbf{DIF} = \frac{\sum\limits_{s=1} \mathbf{PCV_s}}{\sum\limits_{s=1}^{\mathbf{AEOS}} \sum\limits_{p=1}^{\mathbf{PCV_s}} \sum\limits_{i=1}^{\mathbf{ISSUES}} \mathbf{ANM_{spi}}} .$$

THE PROGRAM CHIEF'S DECISION

Each program chief makes a recommendation to the AEO on his program based on the analyses, of all the staff members under him, for only those issues to which he has access. Thus, there are as many recommendations to the AEO as there are programs. Structurally, the program chief's decision (i.e., his recommendation) is dependent on the number of analysts he has working under him and, therefore, the number of issues he has to consider. There are at least three structural aspects of the organization that might impair the program chief's efficiency: (1) the size of the organization; (2) the level of differentiation; and (3) the program chief's access to work done ostensibly under his control.

Mathematically, program chief access **[PCACCESS]**, is defined as a three-dimensional matrix with the same dimensions as **ANM**. **PCACCESS** describes which issues are accessible by which program chiefs. Let **PCACCESS** be of the same dimensions as **ANM**. Here, each element of **PCACCESS**—(**$\mathbf{PCACCESS_{spi}}$**)—is assigned as follows:

[5] $\mathbf{PCACCESS_{spi}} = \mathbf{1}$
if program chief **(p)** working under AEO **(s)** has access to issue **(i)**;

[6] $\mathbf{PCACCESS_{spi}} = \mathbf{0}$
if program chief **(p)** working under AEO **(s)** does not have access to issue **(i)**.

There are many reasons why a manager might not have access to work done by one of his subordinates. For example, he may not have the right security clearance, he may not have enough technical expertise to evaluate a subordinate's work or the subordinate may not finish the analyses by the time the manager needs to make his report. It would seem that lack of access would lead to inefficiency; whether or not this is true, at the organizational level, is something that the proposed simulation program, GARCORG, could be used to study.

THE AEO'S DECISION

The AEO basically makes one recommendation to the CEO for each of the programs under his jurisdiction, based on all the analyses of all the staff members in all the programs under him for those issues to which he has access.

The AEO is thought to have access to all information that any of his immediate subordinates, the program chiefs, have access to. As long as one program chief under his direction has access to information on issue **i**, the AEO has access to issue **i**. AEO access is thus, logically, the *anding* of the access of the subordinate program chiefs. A result of this process is that access for a particular AEO is identical for all program chiefs under him.

The matrix **SACCESS** describes which **AEOS** have access to which issues. **SACCESS** has the same dimensions as **ANM**, and each element ($\mathbf{SACCESS}_{s \cdot i}$) is assigned as follows:[6]

[7] $\mathbf{SACCESS}_{s \cdot i} = 1$
if AEO (s) has access to issue **(i)**;

[8] $\mathbf{SACCESS}_{s \cdot i} = 0$
if AEO (s) does not have access to issue **(i)**.

Like the program chief's decision, we expect that the AEO's decision is affected by the size and differentiation of the organization, as well as by his access structure. To distinguish the AEO from the program chief, and to denote the increased authority of the AEO and the increasing strategic and unstructured nature of the decisions made at this level, the AEO decision process is seen as being affected by the AEO's saliency structure. Saliency for the AEO can be thought of as the degree to which the AEO thinks that the issue is important, relevant or central to the decision.

Like access, AEO saliency **[ASALIENCE]** is defined mathematically in terms of a matrix. **ASALIENCE** describes whether or not AEO **(s)** thinks that issue **(i)** is salient for program **(p)**. **ASALIENCE** has the same dimensions as **ANM**. The elements ($\mathbf{ASALIENCE}_{spi}$) are defined as follows:

[9] $\mathbf{ASALIENCE}_{spi} = 1$
if AEO **(s)** considers issue **(i)** to be salient to program **(p)**;

[10] $\mathbf{ASALIENCE}_{spi} = 0$
if AEO **(s)** does not consider issue **(i)** to be salient to program **(p)**.

The saliency variable can be used to represent the degree of belief in that issue. The point of distinction being made is that program chiefs are viewed as making primarily programmed decisions, as having to make reports on x, whereas, the AEOs are viewed as making less structured decisions in which they can trade off various aspects, various pieces of information. Another interpretation of the saliency vector for the AEO might be the relevance of the issue to the perceived political objective.

THE CEO'S DECISION

The CEO makes a final decision regarding each of the programs, based on the analyses of all the staff members in the entire population. The CEO is presumed to have complete access to information on all issues. Like the program chiefs and the AEOs, the CEO is presumed to have his decision-making behavior affected by the size and differentiation of the organization. Complete access means that lack of access cannot make his behavior less efficient. Like the AEO, however, the CEO makes decisions in which the information he receives is weighted by a particular level of salience. CEO saliency **[PSALIENCE]**, like AEO saliency, can be thought of as the CEO's belief in the issue, the perceived relevance of that issue and so on. As with AEO saliency, the purpose of CEO saliency is to distinguish the subjective availability of that information. One might think of CEO saliency as the relevance of the information to the actual political objective.

Mathematically, CEO salience **PSALIENCE** is a matrix of the same dimensions as **ANM**, and it describes which issues the CEO considers to be salient to which programs. Which issues the CEO considers to be salient to which programs vary over time. At a specific time, the elements of **PSALIENCE** (**$PSALIENCE_{spi}$**) are defined as follows:

[11] **$PSALIENCE_{spi}$** = 1
if the CEO considers issue **(i)** to be salient to program **(p)**;

[12] **$PSALIENCE_{spi}$** = 0
if the CEO does not consider issue **(i)** to be salient to program **(p)**.

Personnel Transfers—Moving Staff Members through Spots

The main difference between this proposed model and that suggested by Padgett (1980) is that in my model organizational membership is not fixed. Staff members can be transferred into and out of any particular spot. Such transfers can be thought of as hiring or firing personnel or simply as moving them from one job to the next. Recall that a staff member's presence in a particular spot means that there is a staff member analyzing a particular issue, under a particular program chief, in a particular division.

There are many reasons for transferring staff members about. For example, the staff member may be incompetent, he may be needed elsewhere, there may be nothing to do in the job and so on. If the efficiency of an organization is affected by what kind of jobs are being done, as well as by who is doing which job and how well that job is performed, then criteria that affect the jobs being done may affect organizational efficiency. Further, whether or not someone is doing a particular job, and whether or not there is a staff member in a particular spot, affects whether or not the analysis of the corresponding issue is available for upper level management when they are making decisions.

In this paper, the effect of three different personnel transfer criteria on organizational efficiency are examined. These criteria are amount of information, content of information and saliency of information:

- *Amount:* Staff transfers are made on the basis of whether or not there is anything for staff members to do, that is, whether or not there is any or enough information coming in on the issue of concern. In the hostage situation in Iran, for example, as more information on the hostage situation came in, a possible solution arose, which was to use the MH-53 helicopter which then necessitated the need to find assault pilots.

- *Content:* Staff transfers are made on the basis of whether or not the job is worth doing, that is, whether or not the information coming in on the issue of concern has a particular level of quality. In the Grenada crisis, for example, the lack of current up-to-date maps of the area created the need for staff members to do reconnaissance and develop or find maps of the area.
- *Saliency:* Staff transfers are made on the basis of whether or not the job a staff member is or will be doing is considered important to the CEO. For example, various commanders, or even entire units, may be moved about on the basis of whether or not their position is considered politically viable by the commander-in-chief.

These criteria are discussed in the following chapter, as they are the ones which are implemented in the simulation model, GARCORG. Finally, there are two other parameters that characterize the transference process— threshold and delay period. The threshold is simply the level of "*x*" that is needed before a staff member is transferred in/out of a spot. There is no threshold for the criteria saliency, as saliency is modeled as a binomial variable—*yes* salient, or *no* not salient. There are, however, thresholds for content and amount of information, as these are modeled as discrete flows. For the criterion amount, this threshold is denoted by **THA**, and for the criterion content it is denoted by **THC**. The delay period is the number of time periods that the criterion is met before a staff member is transferred in/out of a particular spot, **R**.

So whether or not there is a staff member in a particular spot is dependent on the personnel transfer mechanism. When the personnel transfer criterion is set to amount or content, the personnel transfer decision involves a comparison with a threshold. For simplicity, at this point we will assume not only that the same type of criterion is used for in transfers as out but also that the threshold level for transferring someone into a spot is equal to that for transferring someone out of a spot[7]. Setting these thresholds equal to each other produces a general threshold—**THA** for amount and **THC** for content.

Thus, if the personnel transfer criterion is amount, then if for **R** consecutive time periods,

[13] $[\mathbf{AMOUNTINFO_{spi}} > \mathbf{THA}] \rightarrow \mathbf{ANM_{spi}} = 1,$

or else, if for those **R** consecutive time periods,

[14] $[\mathbf{AMOUNTINFO_{spi}} \leq \mathbf{THA}] \rightarrow \mathbf{ANM_{spi}} = 0.$

Similarly, if the criteria is content, then if for **R** consecutive time periods,

[15] $[\mathbf{CONTENT_{spi}} > \mathbf{THC}] \rightarrow \mathbf{ANM_{spi}} = 1,$

or else, if for those **R** consecutive time periods,

[16] $[\mathbf{CONTENT}_{spi} \leq \mathbf{THC}] \rightarrow \mathbf{ANM}_{spi} = 0.$

Whereas, when the criterion is saliency, there is no threshold per se; rather if for **R** consecutive time periods,

[17] $[\mathbf{SALIENCE}_{spi} = 1] \rightarrow \mathbf{ANM}_{spi} = \mathbf{1},$

or else, if for those **R** consecutive time periods,

[18] $[\mathbf{SALIENCE}_{spi} = 0] \rightarrow \mathbf{ANM}_{spi} = \mathbf{0}.$

MEASURES OF EFFICIENCY

Four measures of efficiency will be presented—two structural and two political in nature. These four measures—E1, E2, E3, and E4—are based on the program chiefs' access structure, the AEOs' access structure, the salience of the issues to the AEOs and the salience of the issues to the CEO, respectively. Each of the efficiency measures is a time average.

The first two measures, E1 and E2, are structural; that is, they are gaged relative to inherent access structure of the specific organization under study. Structural inefficiencies may be difficult to eliminate without altering the structure of the organization. The second two measures, E3 and E4, are political in nature; that is, they relate to specific executives (the AEOs and the CEO) working in the organization and not to the organizational structure. Political inefficiencies may be difficult to eliminate without altering the political impressions of the executives. In both cases, it would be expedient in the short run if one could find a managerial solution for decreasing these inefficiencies, for example, by altering the personnel transfer mechanism.

All four measures—E1, E2, E3 and E4—are normalized measures of rising efficiency, with a range from 0 to 1. When multiplied by 100, they can be thought of as the percentage of that type of efficiency achieved by the organization. Essentially, these measures are normalized by the organization's size so that they are comparable across organizations. These measures are referred to as measures of rising efficiency, as a 0 represents total inefficiency and a 1 represents perfect efficiency. Each of the four measures is a moving time average; that is, they measure how efficient that particular garbage can hierarchy was on average, up to the time period chosen.

All four measures are based on a comparison between a valuation of a particular spot and whether or not there is actually a staff member in that spot. All four measures of efficiency are essentially measuring the prevalence of *bad spots* in the organization. We can think of a *bad spot* as a spot in the organization where the person making the decision does not have access to, or does not consider salient, the issue.

E1: Structural Efficiency—Program Chiefs' Access

Structural efficiency relative to the program chiefs' access structure is essentially measured by a counting procedure, which looks for staff members in inaccessible spots. This procedure counts for each time period, the number of staff members in the entire organization that are analyzing the information that comes in on a particular issue; such that the issue is not accessible by the program chief under which the staff member is working. When this count is divided by the number of time periods, it yields a 0 to 1 measure of inefficiency; dividing by time gives the average number of structural inefficiencies that occur over time due to the program chiefs' access structure. Subtracting this from 1 produces the measure E1.

Let **TIME** be the number of time periods for which the simulation was run or, alternatively, for which one has data. Then, given this and the fact that a logical operator used on a matrix operates element by element, we are ready to look at the mathematical definition of E1. E1 as presented here ranges from 0 to 1 and thus needs to be multiplied by 100 to turn it into a percentage.

[19]

$$\mathbf{E1} = 1 - \frac{\sum_{t=1}^{TIME} \dfrac{\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (ANM_{spit} > PCACCESS_{spi})}{\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (PCACCESS_{spi} = 0)}}{TIME}$$

E2: Structural Efficiency—AEO's Access

Structural inefficiencies can also occur at the AEO's level, in a manner similar to that in which they occur at the program chief level. Structural inefficiency relative to the AEO's access structure is measured via a counting procedure. This procedure counts, for each time period, the number of staff members in the entire organization who are analyzing the information that comes in on some issue, where the AEO above that staff member does not have access to the issue on which that staff member is working. Knowing the nature of this matrix, we can now understand the mathematical definition of E2. Again, like **E1**, the measure ranges only from 0 to 1.

[20]

$$\mathbf{E2} = 1 - \frac{\sum_{t=1}^{TIME} \dfrac{\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (ANM_{spit} > SACCESS_{spi})}{\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (SACCESS_{spi} = 0)}}{TIME}$$

E3: Political Efficiency—Assistant Executive Officer

One way in which political efficiency can occur at the AEO's level is for there to be staff members working on issues that the AEO does not consider to be salient for the program whose program chief that staff member is under. Like structural inefficiency, political inefficiency can be measured via an accounting mechanism. This mechanism simply counts the number of such staff members working on issues that are not salient to the AEO. Note, AEO's salience changes with time. Given this, E3, with a range of 0 to 1, is measured as follows:

$$[21] \qquad E3 = 1 - \frac{\displaystyle\sum_{t=1}^{TIME} \frac{\displaystyle\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (ANM_{spit} > ASALIENCE_{spit})}{\displaystyle\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (ASALIENCE_{spit} = 0)}}{TIME}$$

E4: Political Efficiency—Chief Executive Officer Salience

Similarly, at the top executive level, political inefficiency arises when there is a staff member working on an issue that the CEO does not consider germane to that program. Like the previous measures, E4 measures this type of inefficiency via a counting procedure. This procedure counts, for each time period **(t)**, the number of staff members in the organization that are analyzing the information that comes in on issue **(i)** for program **(p)**, such that the CEO does not consider issue **(i)** to be salient to program **(p)**. Thus, E4 is a time average of this count: political inefficiency relative to political salience is the average over time of the number of staff members analyzing nonsalient issues in that organization. Given this, we can state that

$$[22] \qquad E4 = 1 - \frac{\displaystyle\sum_{t=1}^{TIME} \frac{\displaystyle\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (ANM_{spit} > PSALIENCE_{spit})}{\displaystyle\sum_{s=1}^{AEOS} \sum_{p=1}^{PCV_s} \sum_{i=1}^{ISSUE} (PSALIENCE_{spit} = 0)}}{TIME}$$

LONG-RUN EFFICIENCY

This section is divided into two parts. The first contains a mathematical analysis of the four measures of efficiency relative to each of the personnel transfer criteria suggested in the second section. This analysis is done in terms of the probabilities of the underlying comparisons. This analysis is summarized in Tables 8.5 and 8.6. The second part contains an analysis of the effect of changing the delay period, **R**, on whether or not there is a staff member in a particular spot.

Spot Filling as Independent of Spot Valuation

Central to each of the four measures of efficiency suggested previously is a comparison of a particular valuation of an issue against whether or not there is a staff member working on that issue **ANM**. Specifically, each measure of efficiency **(E)** is a function of the form

[23] $\mathbf{E} = \mathbf{f}(\mathbf{ANM} > \mathbf{VALUATION})$.

When looking for the expected value of each of the measures of efficiency, we must be concerned with the expected value of these comparisons. Further, since this is an element-by-element comparison, we can look at the comparison being made for a single spot ($\mathbf{ANM_{spi}}$) and generalize to the other spots. Note that the form of the comparison being made is the same for all spots. Further, since all five of the relevant matrices consist of just 0s and 1s, then

[24] $E\{\mathbf{ANM_{spi}} > \mathbf{VALUATION_{spi}}\} = 1 - E\{\mathbf{ANM_{spi}} = 1 \ \& \ \mathbf{VALUATION_{spi}} = 0\}$.

When **ANM** is independent of the comparison matrix,

[25] $E\{\mathbf{ANM_{spi}} > \mathbf{VALUATION_{spi}}\} = 1 - Pr(\mathbf{ANM_{spi}} = 1) \times Pr(\mathbf{VALUATION_{spi}} = 0)$.

The personnel transfer mechanism always affects whether or not there is a staff member in a particular spot, $\mathbf{ANM_{spi}}$. The question is, does it affect the other matrices? As we shall presently see, the answer is no—that is, not in such a way as to make these dependent on which spot which staff member is in ($\mathbf{ANM_{spi}}$). Thus, for our purposes, **ANM** and these other matrices are independent.

It turns out that under all of the personnel transfer mechanisms suggested, these matrices are, in fact, independent. This independence arises from the way in which the personnel transfer mechanisms affect these matrices. The personnel transfer mechanism always affects whether or not there is a staff member in a particular spot ($\mathbf{ANM_{spi}} = 1$) at any particular time greater than the delay ($\mathbf{t} > \mathbf{R}$). The program chiefs' access structure (**PCACCESS**), the AEO's access structure (**SACCESS**) or AEO's salience (**ASALIENCE**) are exogenous variables; that is, they are not affected by the personnel transfer mechanism chosen. Therefore, **ANM** is independent of **PCACCESS**, **SACCESS**, and **ASALIENCE**.

While it also turns out that **ANM** is independent of **PSALIENCE**, the reasoning behind this is not quite as straightforward. Now, when the personnel transfer mechanism is based on either the amount of information (**AMOUNTINFO**) that comes in on a particular issue at time (**t**) or the content of that information (**CONTENT**), the personnel transfer mechanism does not affect political salience (**PSALIENCE**). Therefore, under these two mechanisms **ANM** is independent of **PSALIENCE**.

It turns out that even when the personnel transfer mechanism is based on political saliency, $\mathbf{ANM_{spi}}$ is independent of **PSALIENCE**. For at time (**t**) efficiency is calculated first and then staff members are transferred. That is, where **ANM(t)** is the value of **ANM** after it is updated using the information gathered during period **t**, then

[26] $\mathbf{ANM(t)} = \mathbf{f}(\mathbf{PSALIENCE(t)})$

and

[27] $E\{\mathbf{E4(t)}\} = 1 - E\{\mathbf{ANM(t-1)} > \mathbf{PSALIENCE(t)}\}$.

Even though **PSALIENCE** is not independent of **ANM(t)**, it is independent of **ANM(t − 1)**. Recall that **PSALIENCE(t)** is independent of **PSALIENCE(t − 1)** as **PSALIENCE** for any particular spot is reassigned randomly each time period.

Given these considerations, equation 19 is valid for the following analysis. Therefore, let us consider the value of the resulting five probabilities: *Pr*(**ANM** = 1), *Pr*(**PCACCESS** = 0), *Pr*(**SACCESS** = 0), *Pr*(**ASALIENCE** = 0) and *Pr*(**PSALIENCE** = 0).

There are an infinite number of ways to model each of the five main probabilities mathematically. Some of these models are independent of the staff members' location, spot, ($\mathbf{ANM_{spi}}$), others are not. When the staff members' locations are homogeneous, the comparisons are independent of location and can thus be pulled outside of the corresponding sums. As the counting procedures produce a normalized output, these sums without the internal comparison are 1. That is, when *Pr*(**ANM** = 1) and the **VALUATION** matrices—*Pr*(**PCACCESS** = 0), *Pr*(**SACCESS** = 0), *Pr* (**ASALIENCE** = 0) and *Pr*(**PSALIENCE** = 0)—are independent of the staff members' position (the spot **spi**), then the expected value of each measure of efficiency is found by

[28]
$$E\{\mathbf{E}\} = \mathbf{1} - \lim_{\mathbf{TIME}\to\infty} \sum_{t=0}^{\mathbf{TIME}} \frac{Pr(\mathbf{ANM} = 1) \times Pr(\mathbf{VALUATION} = 0)}{\mathbf{TIME}}$$

In this study, such homogeneity is assumed to be the case, therefore, the form of the above equation suffices to define the efficiency of the organizations. Exactly how these five probabilities are measured will be discussed in the next five subsections. How the corresponding matrices are modeled in the simulation program GARCORG is also discussed. Numerical examples are drawn from the data used in the simulation analysis in a later chapter. The effect of the personnel transfer mechanism on this probability is also discussed in the case of the likelihood of having a staff member in a particular spot.

Transfers—Probability of a Filled Spot

The probability of having a staff member in a particular spot $\mathbf{Pr(ANM_{spi} = 1)}$ is dependent on the personnel transfer mechanism. If for all spots (**spi**) the flow on which the personnel transfer criteria is based is deterministic, and if after a deterministic number of time periods there are no changes in the **ANM** matrix, the final personnel transfer decision for each of the spots will have been made. For example, if the criteria is amount, and the amount of incoming information is constant, then after **R** time periods there will be no changes. On the other hand, if the flow on which the personnel transfer criteria operates is stochastic, then the expectation of whether or not there is a staff member in a particular spot can be modeled as a Markov process.

As previously mentioned, there is a plethora of ways in which the probability of having a staff member in a particular spot could be modeled. The important thing to note here is that whether or not there is a staff member in a spot depends on the criterion used for transferring personnel. The three criteria discussed analytically here are amount of information, content of information and political saliency.

TRANSFER CRITERION IS AMOUNT OF INFORMATION

Constant Under this option, **AMOUNTINFO** is fixed for all time periods. In this case, after **R** time periods, all the personnel transfer decisions will be made in one fell swoop. Until **t** > **R**, until the first delay period is over,

[29] $\mathbf{ANM} = \mathbf{ANMINITIAL}.$

And, at time **t** = **R**, if

[30] $[\mathbf{AMOUNTINFO}_{spi} > \mathbf{THA}] \rightarrow \mathbf{ANM}_{spi} = 1$

or if,

[31] $[\mathbf{AMOUNTINFO}_{spi} \leq \mathbf{THA}] \rightarrow \mathbf{ANM}_{spi} = 0.$

Hence, for any time **t** > **R**,

[32] $\mathbf{ANM(t)} = \mathbf{ANM(t = R)}.$

On average, for all spots combined, after **R** time periods,

[33] $Pr(\mathbf{ANM} = 1) = Pr(\mathbf{AMOUNTINFO} > \mathbf{THA}).$

In GARCORG, this is interpreted as

[34] $$Pr(\mathbf{ANM} = 1) = \frac{100 - \mathbf{THA}}{101}.$$

Increasing Amount In this case, since the amount of incoming information for each issue is increasing, eventually a staff member will be transferred into every spot. Eventually, **Pr(ANM** = 1) = 1. When this occurs depends on the threshold and the rate of increase; that is, the maximum amount of time that it will take for **ANM** to reach steady state is simply the threshold divided by the rate of increase **B** plus the delay period:

[N + E] $MAX\mathrm{t} = (\mathbf{THA} \div \mathbf{B}) + \mathbf{R}.$

Recall that for a linear change the amount of incoming information is found to be some base amount plus a fixed increase (**AINIT** + **Bt**) from the initial amount of information **AINIT**. Thus, for cases of fixed increase, the time by which all of the personnel transfer decisions are made for a particular spot, where the matrix of such time is ***M*t**, is found by using the following equation:

[35] $$M\mathbf{t} = \mathbf{R} + \frac{\mathbf{THA} - \mathbf{AINIT}}{\mathbf{B}}$$

Since the for **AINIT** are chosen randomly from the uniform distribution over the integers 0 to 100, the average value of **AINIT** is 50. Then, on average, at most 25% of the spots will be unfilled at time **t** = 0, and only 1% will take the full maximum time periods to be filled.

Random Amount In this case, since the amount of incoming information for each issue is determined each time period in a stochastic fashion, for any given spot staff members will keep being transferred in and out. Recall that the stochastic process used was one where, for each time period, the amount for each issue is rechosen at random from a uniform distribution over the integers 0 to 100. This is the same as having a mean that is constant over time at 50 pieces of information. In this case, the value of the amount of information can be described as a base (**AINIT**) plus a choice from a zero mean distribution (**C(t)**).

In this case, the probability that there is a staff member in a particular spot can be modeled by a Markov process based on the probability of transferring in a staff member and the probability of transferring out a staff member. Let the probability of transferring a staff member into a spot be denoted by $\mathbf{H}^R$, where **H** is the probability that the criterion will be above the threshold for transferring into a spot at a particular time. Similarly, let the probability of transferring out of a spot be denoted by $\mathbf{F}^R$, where **F** is the probability that the criterion will be below the threshold for transferring out of a spot at a particular time. Since the threshold for transfers into a spot is equal to that for transfers out of a spot,

$$[36] \quad \mathbf{H} + \mathbf{F} = 1$$

As long as neither of these probabilities goes to zero, a steady state equilibrium is reached where

$$[37] \quad Pr(\mathbf{ANM} = 1) = \frac{\mathbf{H}^R}{\mathbf{H}^R + \mathbf{F}^R}$$

or in reduced form,

$$[38] \quad Pr(\mathbf{ANM} = 1) = \frac{1}{1 + (\mathbf{F} \div \mathbf{H})^R}.$$

Thus,

$$[39] \quad \mathbf{H} = Pr(\mathbf{AMOUNTINFO} > \mathbf{THA}) = (100 - \mathbf{THA}) \div 101$$

and

$$[40] \quad \mathbf{F} = Pr(\mathbf{AMOUNTINFO} \leq \mathbf{THA}) = (1 + \mathbf{THA}) \div 101.$$

Therefore,

$$[41] \quad Pr(\mathbf{ANM} = 1) = \frac{1}{1 + ((1 + \mathbf{THA}) \div (100 - \mathbf{THA}))^{\mathbf{R}}}.$$

Note, if **R** is 1, then equation 41 reduces to equation 39—that is, choosing the option *random* produces the same effect as choosing the option *constant*, on average.

TRANSFER CRITERION IS CONTENT OF INFORMATION

Constant Average Similarly, when the personnel transfer criterion is content, and the content of incoming information changes over time, staff members will keep being transferred to the same spot. Like the case of random amounts of information, the case where the average content of the information is constant inhibits the user from achieving a state where no staff members are transferred. Since content is always modeled as a stochastic process, the probability that there is a staff member in a particular spot can be modeled by a Markov process, as was done for the amount of incoming information when it was modeled as random. As before, there is a particular probability of a staff member being transferred into a spot (**H**) and of being transferred out of a spot (**F**). Since the content is chosen from a mean centered distribution, where the mean is drawn at random from a uniform distribution over the integers 0 to 100, scaled to lie between 0 and 1

$$[42] \quad \mathbf{H} = Pr(\mathbf{CONTENT} > \mathbf{THC}) = (1 - \mathbf{THC}) \div 1.01$$

and

$$[43] \quad \mathbf{F} = Pr(\mathbf{CONTENT} \leq \mathbf{THC}) = (0.01 + \mathbf{THC}) \div 1.01.$$

And

$$[44] \quad Pr(\mathbf{ANM} = 1) = \frac{1}{1 + ((0.01 + \mathbf{THC}) \div (1 - \mathbf{THC}))^{\mathbf{R}}}.$$

The threshold, **THC**, has a range of 0 to 1. Placing these limits into equations 42 and 43 limits **H** and **F** to

$$[45] \quad \text{if } \mathbf{THC} = 1, \text{ then } \mathbf{H} = 0 \text{ and } \mathbf{F} = 1$$

and

$$[46] \quad \text{if } \mathbf{THC} = 0, \text{ then } \mathbf{H} = 0.99 \text{ and } \mathbf{F} = 0.0099.$$

In the first case

$$[47] \quad Pr(\mathbf{ANM} = 1) = 0,$$

and in the second case

$$[48] \quad Pr(\mathbf{ANM} = 1) \rightarrow 1.$$

Moving Average When a moving average type is chosen using GARCORG, the user can choose to have the average increase linearly, decrease, or a mixture of the two. Note, as the average content for any particular issue increases, new staff members are transferred in, and the staff size approaches its maximum; that is,

$$[49] \quad [\mathbf{B} > 0] \rightarrow \lim_{\mathbf{T} \to \infty} Pr(\mathbf{ANM} = 1) = 1.$$

Similarly, when the option chosen is decreasing, then as the average content for any particular issue decreases, staff members are transferred to other programs or even divisions, and the project grinds to a halt as the staff size approaches 0; that is,

$$[50] \quad [\mathbf{B} < 0] \rightarrow \lim_{\mathbf{T}\rightarrow\infty} Pr(\mathbf{ANM} = 1) = 0.$$

The probability of a staff member being in a particular spot is still modeled as a Markov process, such that the probability of being transferred changes over time. Recall that the stochastic process used to calculate content, in effect, creates a mean centered distribution where the mean is equal to **CINIT** plus a rate of increase (**Bt**). Thus,[8]

$$[51] \quad \mathbf{H} = \frac{1 - (\mathbf{THC} - \mathbf{Bt})}{1.01}$$

and

$$[52] \quad \mathbf{F} = \frac{0.01 + (\mathbf{THC} - \mathbf{Bt})}{1.01}.$$

Therefore,

$$[53] \quad Pr(\mathbf{ANM} = 1) = \frac{1}{1 + ((0.01 + \mathbf{THC} - \mathbf{Bt}) \div (1 - \mathbf{THC} + \mathbf{Bt}))^{\mathbf{R}}}.$$

TRANSFER CRITERION IS CEO SALIENCY

Criteria salience when the transfer criteria is political salience, the only thing that will affect whether or not there are staff members in a particular spot is the level to which the CEO's salience is set (**PSP**). Recall that political salience is a stochastic process; that is, at any time period salience is reassigned to each spot at random. However, the level of salience (**PSP**) as defined by the user determines the fraction of issues which will be considered salient. Thus, the probability of there being a staff member in any spot can be modeled as a Markov process such that

$$[54] \quad \mathbf{H} = Pr(\mathbf{PSALIENCE} = 1) = \mathbf{PSP} \div 100$$

and

$$[55] \quad \mathbf{F} = Pr(\mathbf{PSALIENCE} = 0) = (100 - \mathbf{PSP}) \div 100,$$

in which case,

$$[56] \quad Pr(\mathbf{ANM} = 1) = \frac{1}{1 + ((100 - \mathbf{PSP}) \div \mathbf{PSP})^{\mathbf{R}}}.$$

Valuation—Probability of a Bad Spot

The probability that a spot is bad is based on the valuation measure. Herein, four such measures have been proposed: (1) program chief access; (2) AEO access; (3) AEO saliency; and (4) CEO saliency. The first two of these can be thought of as structural valuation measures having to do with the organizational structure; and the second two can be thought of as political valuation measures having to do with the personnel preferences and political structure.

PROGRAM CHIEF ACCESS

The probability that any particular program chief does not have access to the information on a particular issue, *Pr*(**PCACCESS** = 0), is a function of both the number of potential issues that the program chief might have access to (**ISSUE**) and the specified access structure. Four such structures are considered: *total*, *random*, *specialized* and *quasi-specialized*. This probability is computed for a single organization as the average, over all of the program chiefs in the organization, of the percentage of potential issues that each of them do not have access to. When several organizations are looked at, this probability is just the average over the organizations of each of their individual averages.

For a particular organization,

$$[57]\quad Pr(\mathbf{PCACCESS} = 0) = \frac{\sum_{s=1}^{\mathbf{AEOS}} \sum_{p=1}^{\mathbf{PCV}_s} \sum_{i=1}^{\mathbf{ISSUE}} (\mathbf{PCACCESS}_{spi} = 0)}{\mathbf{ISSUE} \times \sum_{s=1}^{\mathbf{AEOS}} \mathbf{PCV}_s}.$$

Given the particular access structures, this form can be reduced.

Total Access When the access structure is one of total access, then every program chief has access to every issue; therefore,

$$[58]\quad Pr(\mathbf{PCACCESS} = 0) = 0.$$

Random Access When the access structure is random, then the probability that a program chief does not have access to any particular issue is dependent on the characteristics of the random distribution. In GARCORG, a uniform white noise source is used; that is, 1s and 0s are distributed with equal likelihood over the access structure. Under these conditions,

$$[59]\quad Pr(\mathbf{PCACCESS} = 0) = 0.5.$$

Specialized Access For specialized access structures, the calculations become more complex. In GARCORG, each program chief has access to as many issues as every other program chief (**I** issues). However, no two program chiefs have access to information on the same issue. Further, each division has as many potential spots for staff members, as many issues to be worked on as the next (**ISSUE**). This reduces equation 57 to

$$[60] \quad Pr(\mathbf{PCACCESS} = 0) = \frac{(\mathbf{AEOS} \times \mathbf{ISSUE}) - \mathbf{I} \times \sum_{s=1}^{\mathbf{AEOS}} \mathbf{PCV}_s}{\mathbf{AEOS} \times \mathbf{ISSUE}} .$$

The structure of the organization, its size and its differentiation level affect this calculation. One has to take into account the total number of program chiefs (**NUM PC**), the number of AEOs (**AEOS**) and the information on issues. For an example of the range available, refer to Table 8.1, where the data for the organizations simulated in a later chapter are gathered.

Quasi-Specialized Access For a quasi-specialized program chief access structure, the calculations depend on the degree of overlap. In GARCORG, each program chief has access to as many issues as every other program chief (**I** issues). However, each program chief shares a certain number of these issues with another program chief (**OVERLAP**). Otherwise, the situation is set up identically to the way it was set up for specialized access. Thus,

$$[61] \quad Pr(\mathbf{PCACCESS} = 0) = \frac{(\mathbf{AEOS} \times \mathbf{ISSUE}) - (\mathbf{OVERLAP} + (\mathbf{I} - \mathbf{OVERLAP}) \times \sum_{s=1}^{\mathbf{AEOS}} \mathbf{PCV}_s}{\mathbf{AEOS} \times \mathbf{ISSUE}} .$$

In GARCORG, for a quasi-specialized access structure, **I** is set to 3, and the degree of overlap (**OVERLAP**) to 2; hence,

$$[62] \quad Pr(\mathbf{PCACCESS} = 0) = \frac{(\mathbf{AEOS} \times \mathbf{ISSUE}) - (2 + \sum_{s=1}^{\mathbf{AEOS}} \mathbf{PCV}_s)}{\mathbf{AEOS} \times \mathbf{ISSUE}} .$$

For an example of the available range, refer to Table 8.2.

AEO ACCESS

Recall that AEO's access is just the anding over the program chief access structure of those program chiefs under that AEO. Thus, the probability that

Table 8.1: ***Pr*(PCACCESS = 0)** Under Specialized Access

STRUCTURE	NUM PC	I	AEOS	ISSUE	Pr(PCACCESS = 0)
small differentiated	7	2	3	8	0.4167
small undifferentiated	5	2	2	8	0.375
large differentiated	34	2	8	12	0.2917
large undifferentiated	11	3	3	12	0.0833

Table 8.2: ***Pr*(PCACCESS = 0) Under Quasi-Specialized Access**					
STRUCTURE	**NUM PC**	**1**	**AEOS**	**ISSUE**	**Pr(PCACCESS = 0)**
small differentiated	7	3	3	8	0.625
small undifferentiated	5	3	2	8	0.5625
large differentiated	34	3	8	12	0.625
large undifferentiated	11	3	3	12	0.6389

no AEO has access to a particular issue is equivalent to the probability that no program chief has access to a particular issue.

AEO SALIENCE

AEO salience is assumed to be distributed randomly. For any particular issue, whether or not the AEO considers it to be salient is redetermined each time period. However, the user sets the level of saliency (**ASP**); that is, the user sets the percentage of issues which the AEO will consider salient each time period.[9]

[63] ***Pr*(ASALIENCE** = 0) = 1 − (**ASP** ÷ 100).

CEO SALIENCE

CEO salience is assumed to be distributed randomly. For any particular issue, whether or not the CEO considers it to be salient is redetermined each time period. However, the user sets the level of saliency (**PSP**); that is, the user sets the percentage of issues which the CEO will consider salient each time period.[10]

[64] ***Pr*(SALIENCE** = 0) = 1 − (**PSP** ÷ 100).

Summarizing and Combining Filled and Bad Spots

The following tables summarize the predicted long-run efficiency in terms of the foregoing subsections. By way of example, exact values are also calculated for the long-run levels of these likelihoods, based on the parameters used in the simulation analysis in a later chapter. These values are listed in brackets "[ ]." In Table 8.3, the parameter values used in that simulation analysis are listed.

Table 8.3: Simulation Parameters	
PARAMETER	*VALUE*
delay period **R**	3
amount threshold **THA**	25
amount rate of change **B**	3
content threshold **THC**	
content rate of change **B**	0.01
CEO saliency level **PSP**	50%
AEO saliency level **ASP**	50%

In Table 8.4, the likelihoods that there is a staff member in a particular spot, relative to the three personnel transfer mechanisms (or criteria), are summarized. Note, none of the parameters, other than those listed, affect the ***Pr*(ANM = 1)**, the likelihood of there being a staff member in a particular spot.

In Table 8.5, the relationship between relevant GARCORG parameters and the associated underlying probabilities are summarized. None of the parameters other than those listed affect these probabilities. For both the probability of **PCACCESS** and that of **SACCESS**, the predicted values for the four different organizational structures simulated are presented. These are small differentiated (SY), small undifferentiated (SN), large differentiated (LY) and large undifferentiated (LN).

In Table 8.6, the relationship between various parameters in GARCORG and the predicted long-run efficiency values are summarized. Note, the values listed for efficiency are the expected values. For the structural measures of efficiency, data for the four different organizational structures simulated are presented, and all organizations are assumed to be quasi-specialized. These are small differentiated (SY), small undifferentiated (SN), large differentiated (LY) and large undifferentiated (LN). In most cases, what is presented is the long-run efficiency value.

Table 8.4: GARCORG and ***Pr*(ANM = 1)**

PARAMETER AND HIRING/FIRING MECHANISM (HF)	***Pr*(ANM = 1) =**
HF = AMOUNT, AMOUNT is	
constant	$(100 - \mathbf{THA}) \div 101$ after $\mathbf{t} = \mathbf{R}$ [0.7426]
linear	1 after $\mathbf{t} > \mathbf{R} + (\mathbf{THA} + \mathbf{B})$ [1 after $t > 12$]
random	$1 \div (1 + ((1 + \mathbf{THA}) \div (100 - \mathbf{THA}))^{\mathbf{R}})$ [.96]
HF = CONTENT, CONTENT is	
constant	$1 \div (1 + ((0.01 + \mathbf{THC}) \div (1 - \mathbf{THC}))^{\mathbf{R}})$ [0]
increasing	$1 \div (1 + ((0.01 + \mathbf{THC} - \mathbf{Bt}) \div (1 - \mathbf{THC} + \mathbf{Bt}))^{\mathbf{R}})$ [1 after $\mathbf{t} > 26$]
decreasing	$1 \div (1 + ((0.1 + \mathbf{THC} - \mathbf{Bt}) \div (1 - \mathbf{THC} + \mathbf{Bt}))^{\mathbf{R}})$ [0 after $\mathbf{t} > 26$]
HF = SALIENCY, CEO SALIENCE	
PSP level	$1 \div (1 + ((100 - \mathbf{PSP}) \div 100))^{\mathbf{R}})$ [0.5]

Table 8.5: GARCORG and Underlying Probabilities

PARAMETER	*PROBABILITY*
Program Chief access and AEO access	*Pr*(**PCACCESS** = 0) = *Pr*(**SACCESS** = 0)
total	0 [no effect due to structure]
specialized	1 − ((**I** × **NUM PC**) ÷ (**AEOS** × **ISSUE**))
SY	[0.4167]
SN	[0.375]
LY	[0.2917]
LN	[0.0833]
quasi-specialized	1 − ((**OVERLAP** + (**I** − **OVERLAP**) × **NUM PC**) ÷ (**AEOS** × **ISSUE**)) [1 − ((2 + **NUM PC**) ÷ (**AEOS** × **ISSUE**))]
SY	[0.625]
SN	[0.5625]
LY	[0.625]
LN	[0.6389]
random	0.5 [no effect due to structure]
AEO salience	*Pr*(**ASALIENCE**) = 1 − (**ASP** ÷ 100)
ASP 50%	[0.50]
CEO salience	*Pr*(**PSALIENCE**) = 1 − (**PSP** ÷ 100)
PSP = 50%	[0.50]

With regard to Table 8.6, having a total program chief access structure is clearly the most efficient. However, a random program chief access structure leads to a more efficient organization than either a specialized or a quasi-specialized access structure.

Effect of Delay Period, R

The delay period, **R**, is the number of time periods that the transfer criterion has to be met in order to transfer a staff member. Examples include the number of "goofups" someone gets before he is demoted or the number of times a particular skill is required before someone who has that skill is hired. In the simulation analysis presented in Chapter 9, **R** is set to 3. The exact effect that **R** will have on the measures of efficiency is dependent on the model used for the probability that there is a staff member in a particular spot (*Pr*(**ANM** = 1)). Now, unless this probability is defined stochastically, the size of **R** serves only to delay the time at which all the transferring in and out will occur, but it will not have an effect on whether or not the changeovers occur. In such cases, the larger **R** is, the longer it takes the system to reach its final state, but that state remains the same. However, when this probability is defined stochastically, **R**

Table 8.6: GARCORG and Expected Efficiency

PARAMETER AND HIRING/FIRING MECHANISM	*EXPECTED EFFICIENCY*					
	E1 = E2				*E3*	*E4*
	SY	*SN*	*LY*	*LN*		
HF = AMOUNT, AMOUNTINFO is						
constant	0.536	0.582	0.536	0.526	0.629	0.629
linear after t>12	0.375	0.4375	0.375	0.3611	0.5	0.5
random	0.4	0.46	0.4	0.387	0.52	0.52
HF = CONTENT, average CONTENT is						
constant 1 after t>3	1	1	1	1	1	
increasing after t>26	0.375	0.4375	0.375	0.3611	0.5	0.5
decreasing after t>26	1	1	1	1	1	1
HF = SALIENCE						
CEO SALIENCE **PSP** level [50] **ASP** level [50]	0.688	0.719	0.688	0.681	0.75	0.75

has a more complex role. Recall in the Markov examples suggested in the last subsections that

$$[65]\quad Pr(\mathbf{ANM} = 1) = \frac{\mathbf{H}^{\mathbf{R}}}{\mathbf{H}^{\mathbf{R}} + \mathbf{F}^{\mathbf{R}}}.$$

Differentiating this with respect to **R** gives

$$[66]\quad \frac{d}{dR}[Pr(\mathbf{ANM} = 1)] = \frac{(\mathbf{F} \div \mathbf{H})^{\mathbf{R}} \times ln(\mathbf{F} \div \mathbf{H})}{[1 + (\mathbf{F} + \mathbf{H}^{\mathbf{R}})^2}.$$

Thus, when the probability of transferring a staff member out of a spot is greater than the probability of transferring someone into a spot, then (**F** > **H**)—an increase in the delay period (**R**) results in a decrease in the probability that there is a staff member in a particular spot (Pr(**ANM** = 1)). And, as the probability of transferring a staff member into a spot increases over the probability of transferring a staff member out of a spot, an increase in **R** results in an increase in (Pr(**ANM** = 1)). This is represented pictorially in Figure 8.2.

SUMMARY

Combining the organized-anarchy model and the more familiar social-structural model led to several results. First, this combination provides a

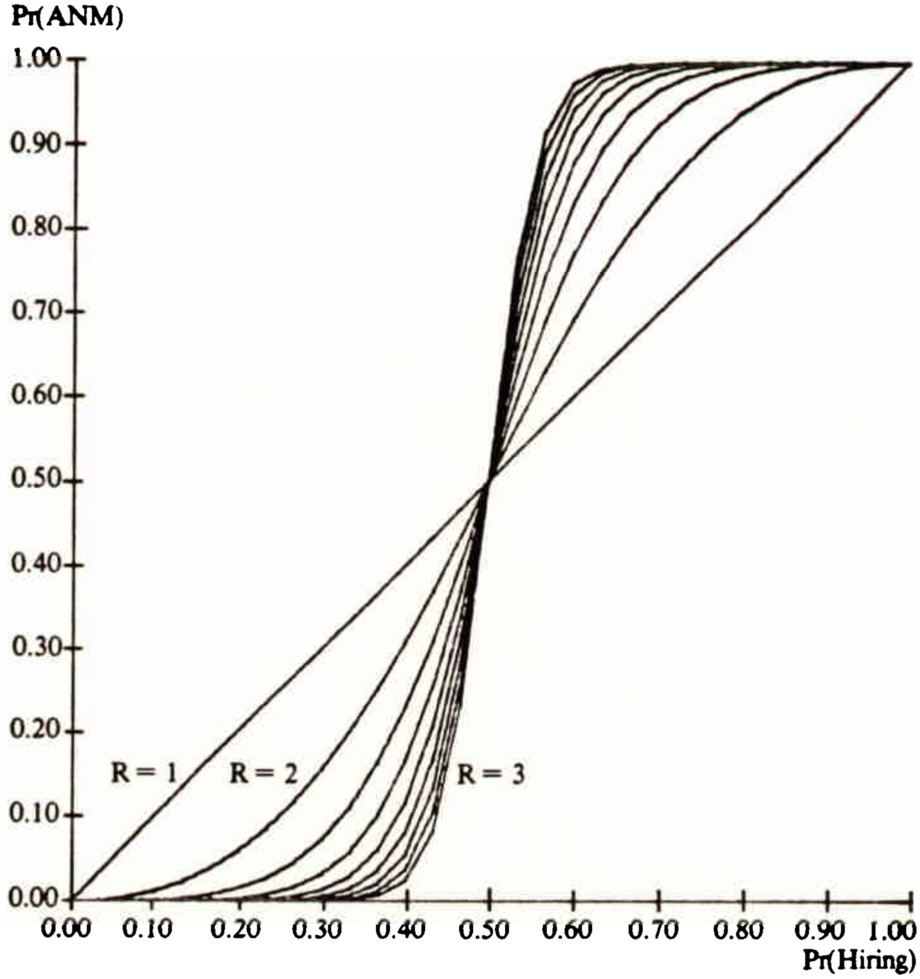

Figure 8.2 Altering the delay period. The effect of changing **R**, the grace or delay period for hiring and firing, on the value of **PR**(**ANM**). Recall that **PR**(HIRING) + **PR**(FIRING) = 1.

framework in which the garbage can hierarchy can be viewed as "one type of organization" relative to other organizations. That is, organizations are seen as being more garbage-can-like the more ambiguous the flow of information, the flow of personnel and the decision technology. Herein, a set of models for information flow (content and amount), personnel flow (personnel transfer mechanisms) and aspects of the decision technology (access structures and saliency) are presented. In the GARCORG program the user can set these parameters as desired; this allows one to test theses about, for example, whether or not "garbage can hierarchies" are more or less efficient than other organizations, or which problematic flows have the highest impact on efficiency.

A second item due to the combination of the anarchy model and the hierarchy model is the development of the notion of *spots* in the organization. In specific, the notion of *bad spots* in an organization has been presented. A *bad spot* is basically a position or job that does not contribute to the overall effectiveness of the organization, a spot that has a negative valuation on some criteria. There are many ways in which a spot can be *bad*. Herein, two different types of criteria for *bad spots* have been suggested—structural ineffectiveness (measured as lack of access) and political ineffectiveness (measured as lack of saliency).

A final result due to placing the organized anarchy within the hierarchical structure is that it creates a framework in which efficiency can be measured. Herein, inefficiency has been defined in terms of having staff members working in bad spots. This is just one way in which efficiency could be modeled. Alternate measures might be percentage of decisions that are pushed up to the CEO for final approval, time before a decision is made and so on. The point here is that although placing the organized anarchy into a hierarchical structure admitted the possibility of measuring efficiency, the measure of efficiency chosen determines the nature of the results.

NOTES

1. The term *garbage can hierarchies* was coined by Cohen, March and Olsen (1972) to describe organizations where the goals and technology are unclear.

2. In GARCORG, **B** is set to 3; however, this can be changed at the user's discretion.

3. Note, in GARCORG, the level of change **B** is set internally to 0.01 when the *increasing* option is chosen and to −0.01 when the *decreasing* option is chosen. However, this can be changed by the user.

4. For a more detailed description, the reader is referred to either the GARCORG program or the paper by Padgett (1980).

5. Differentiation is a measure of the spread of the organizational hierarchy. There are many potential measures, of which this is just one. Another might be the number of branches.

6. Note, the AEO (**s**) has access to issue (**i**) just in case at least one of the program chiefs (**p**) under AEO (**s**) has access to issue (**i**). A result of this is that the AEO access structure is identical vis-à-vis the program chiefs. The "*" indicates that for all program chiefs under AEO (**s**) for issue (**i**), **SACCESS** is set as indicated. In other words, the "*" indicates identity across that dimension.

7. Note, in the simulation program different transfer criteria can be used for bringing staff members in than are used for transferring staff members out. Also, the in-transfer threshold can be set independently of the out-transfer threshold in GARCORG.

8. Recall that content is never allowed to go outside the range 0 to 1. Therefore, if the sum of **Bt** and **THC** is greater than 1, the content level for that issue is set to 1 if **B** is positive, and 0 otherwise.

9. Note, the user is asked for a percentage and can give any number between 0 and 100 for **ASP**. To convert **ASP** into a percentage for this analysis, simply divide it by 100.

10. Note, the user is asked for a percentage and can give any number between 0 and 100 for **PSP**. To convert **PSP** into a percentage for this analysis, simply divide it by 100.

REFERENCES

Cohen, R. M., March, J. G., and Olsen, J. P. "A Garbage Can Model of Organizational Choice." *Administrative Science Quarterly* 17 (1972): 1–25.

Padgett, J. F. "Managing Garbage Can Hierarchies." *Administrative Science Quarterly* 25 (1980): 583–604.

Perrow, Charles. "Review of Ambiguity and Choice in Organizations." *Contemporary Sociology* 6 (1977): 294–298.