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Garbage Can Paradox
A disorderly decision-making process in orderly organization structures

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Keywords
Decision-making; organized anarchy; garbage-can model; organization structure; simulation

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1. Introduction

The garbage-can model is proposed by Cohen, March and Olsen (1972) (CMO) as an extension of organizational decision-making theories, not in opposition to them (March and Olsen, 1986). Classical theories of organizational decision making emphasize decision making as rational on the basis of expectations about the future consequences of actions. The major criticisms of these theories are excessive time and information demands that go beyond human bounded rationality (Simon, 1947; March and Simon, 1958), and the assumption that all participants in an organization share the same goals, or that conflict among them can be managed readily (Cyert and March, 1963). Although bounded rationality and conflict are major phenomena, they do not exhaust the problems involved in matching theories of decision making with many empirical observations, especially in organizations characterized by three general properties of organized anarchy: problematic preferences, unclear technology, and fluid participation (Cohen et al., 1972). Under organized anarchies, organizations can be viewed as the accidental or random confluence of four streams: (1) choice opportunities—occasions which call for a decision, (2) solutions—answers looking for problems, (3) decision-makers—people with busy schedules who might pay attention, and (4) problems—concerns of people within and outside the organization. Thus, decision making occurs in a stochastic meeting of choices looking for problems, problems looking for choices, solutions looking for problems to answer, and decision-makers looking for something to decide.

CMO translate this view into a computer simulation model and examine how decisions are made under organized anarchies. Based on the simulation model, CMO and subsequent studies have assumed that the garbage-can decision-making process works in such a way that the combinations of choice opportunities, problems, solutions, and decision-makers change randomly and, as a result, the decision style of each choice also changes over time. They considered “unsegmented” structures, in which problems, decision-makers, and solutions can move freely among choice opportunities as a condition for that process, i.e., a disorderly decision-making process emerge from disorderly structures (“The widely accepted view” in Table 1).

Recently, some studies cast doubt on this widely accepted view of the garbage-can model. Bendor, Moe, and Shotts (2001) rerun CMO’s simulation model and found that decision-makers and problems move together in a single pack, and that, in unsegmented structures, decisions are made using only one decision style. These findings mean that the combinations of decision-makers and problems do not change and, as a result, decision styles also do not change over time. They regard their findings as an orderly decision-making process. Thus, orderly decision-making processes emerge from disorderly structures ("Retest of Bendor et al. (2001)" in Table 1).

Table 1: Disorderly decision making process and orderly organizational structure

		Organization structures	
		Disorderly (Unsegmented *1)	Orderly (Hierarchical *2)
Decision-making processes	Disorderly (*3)	**The widely accepted view**	**This study**
	Orderly (*4)	**Retest of Bendor et al. (2001)**	

Note: the following will be defined in details later.
*1: The structure in which each problem and decision maker has access to all choice opportunities.
*2: The structure in which accessible choice opportunities differ depending on organizational levels.
*3: The disorderly decision-making processes are defined by "combination change" and "decision style change."
"Combination change" means that the combinations of decision-makers and problems randomly change over time.
"Decision style change" means that decision styles ("resolution," "oversight," and "flight") randomly change over time.
*4: The orderly decision-making processes means that the disorderly decision-making processes are not observed.

In CMO's simulation model, do we not observe the disorderly decision-making process assumed by many existing studies on the garbage-can model? If unsegmented structures do not cause the disorderly decision-making process, what conditions do? This study addresses these questions by examining CMO's simulation model further. Existing studies have not examined CMO's simulation model well. Besides, they, including Bendor et al. (2001), have focused only on unsegmented organization structure. However, CMO's model can be used to explore the consequences of decision-making processes in relatively segmented organizations. It is worth varying structural and other parameters across wide ranges and examining what then happens in CMO's simulation model. This may reveal the real conditions for the disorderly decision-making process.

The simulation of this study shows that it is hierarchical structures that give rise to the disorderly decision-making process ("This study" in Table 1). This study also reveals the boundary conditions for the disorderly decision-making process under hierarchical structures; medium organization size and moderate problem load (moderate solution effectiveness). Besides, this study points out that these paradoxical simulation results— the disorderly decision-making process arising from orderly (hierarchical) organizational structures—are consistent with March and his colleagues' case studies on educational organizations.

2. Existing garbage-can studies: The widely accepted view and its recent critique

2.1 What is the garbage-can model?

The garbage-can model is a model of decision-making in organized anarchies; that is, in situations that do not meet the conditions for more classical models of decision-making in three important ways: problematic preferences, unclear technologies, and fluid participation (Cohen et al., 1972). First, preferences are often problematic. It is difficult to impute a set of preferences to the decision situation that satisfies the standard consistency requirements for a theory of choice. The organization operates based on various inconsistent and ill-defined preferences. Second, technology is often unclear. Although the organization manages to survive and even produce, its own processes are not understood by its members. It operates based on simple trial-and-error procedures, the residue of learning from the accidents of past experience, and pragmatic inventions out of necessity. Third, participation is often fluid. Participants vary in the amount of time and effort they devote to different domains; involvement varies from one time to another. As a result, the participants in any particular type of choice change capriciously. No single participant dominates the choice in all its phases.

Assuming this type of decision situation, an organization can be viewed as a collection of choice opportunities looking for problems, problems looking for choice opportunities in which they might be aired, solutions looking for problems to which they might be the answer, and decision-makers looking for choice opportunities that should be made.

Choice opportunities: The "garbage cans" in the garbage-can model are such choice opportunities as contract meetings, budget committees, and compensation decisions. These choice opportunities are occasions when an organization is expected to produce behavior that can be called a decision. These arise regularly and collect decision-makers, problems, and solutions.

Problems: Problems are the concerns of people with access to decision. They may involve things such as logistics, resource allocation, or scheduling. They may involve issues of lifestyle, the frustrations of work, and group relations within the organization. In CMO simulation model, problems are characterized by the amount of energy required to solve them (problem's load) and by their access to choice opportunities being restricted by organizational structure ("access structure").

Decision-makers: Decision-makers devote their energies to making choices. They are involved in one choice opportunity at any one time, but they move from one choice opportunity to another. In CMO simulation model, decision-makers are characterized by their energy (ability to solve problems) and by their access to choice opportunities being restricted by organizational structure ("decision structure").

Solutions: Solutions are answers to problems that may or may not have been recognized. In CMO simulation model, they can be characterized by the resources they provide to decision-makers who are trying to make choices. More specifically, solutions are a type of coefficient that operates on the decision-makers' energies to determine the amount of effective energies.

CMO assume that a decision is made whenever the decision-makers present at a choice opportunity (aided by whatever solutions are available) have enough energy to overcome the load of problems that are present. By their definition, decision does not always mean "resolution," and there exist "oversight" and "flight" as other types of decisions.

Resolution: There are problems associated with a choice opportunity, and the decision-makers attached to the choice bring enough energy to meet the demands of those problems. The choice is made and the problems are resolved.

Oversight: Sometimes a choice opportunity arrives and no problems attach themselves to the choice. All the problems in the system are attached to other choices. In this situation, a choice is made with minimum time and energy. It resolves no problems.

Flight: Sometimes a number of problems have been associated with a choice opportunity for some time. Since they collectively exceed the energy of the decision-makers attached to the choice, the choice is not made. When another choice opportunity becomes available, the problems leave the initial choice to attach themselves to another. After the problems are gone, the original choice is made. It resolves no problems.

2.2 The widely accepted view and recent critique on garbage-can model

CMO translated the ideas noted above into an explicit simulation model, and examined the decision-making behavior using many output numerical data. However, their simulation results are so complicated and confusing that the subsequent studies, including that of the original authors, have referred mainly to the following two implications. First, decision-makers, problems, and solutions move around choice opportunities, and their combinations change randomly in the decision-making process ("combination change"). Second, decisions are made depending on timing and, therefore, decision styles randomly change over time ("decision style change"). Decisions are sometimes made by resolution, but also by oversight or flight. As CMO state, "A major feature of the garbage can process is the partial uncoupling of problems and choices. Although decision-making is thought of as a process for solving problems, that is often not what happens. Problems are worked upon in the context of some choice, but choices are made only when shifting combinations of problems, solutions, and decision-makers happen to make action possible. Quite commonly this is after problems have left a given choice arena or before they have discovered it (decisions by flight or oversight)" (p.16).

Besides, subsequent studies by the original authors insist that this decision-making process can typically be observed in unsegmented structures where there are no limits on movements of problems, solutions, and decision-makers (Cohen et al., 1976; March and Olsen, 1986; March and Olsen, 1989). As stated by March and Olsen (1986), "In the absence of structural constraints within a garbage-can process, solutions are linked to problems, and decision-makers to choices, primarily by their simultaneity" (p. 17).

The widely accepted view of the garbage-can model is that unsegmented (disorderly) structures lead to the disorderly decision-making process, which are defined by "combination change" and "decision style change" (cf. "The widely accepted view" in Table 1). In fact, standard textbooks on organization theory (Hatch, 1997; Scott, 2003; Daft, 2004) and many academic articles (Grandori, 1986; Pinfield, 1986; Levitt and Nass, 1989; Mezias and Scarselletta, 1994) reflect the implications stated above.

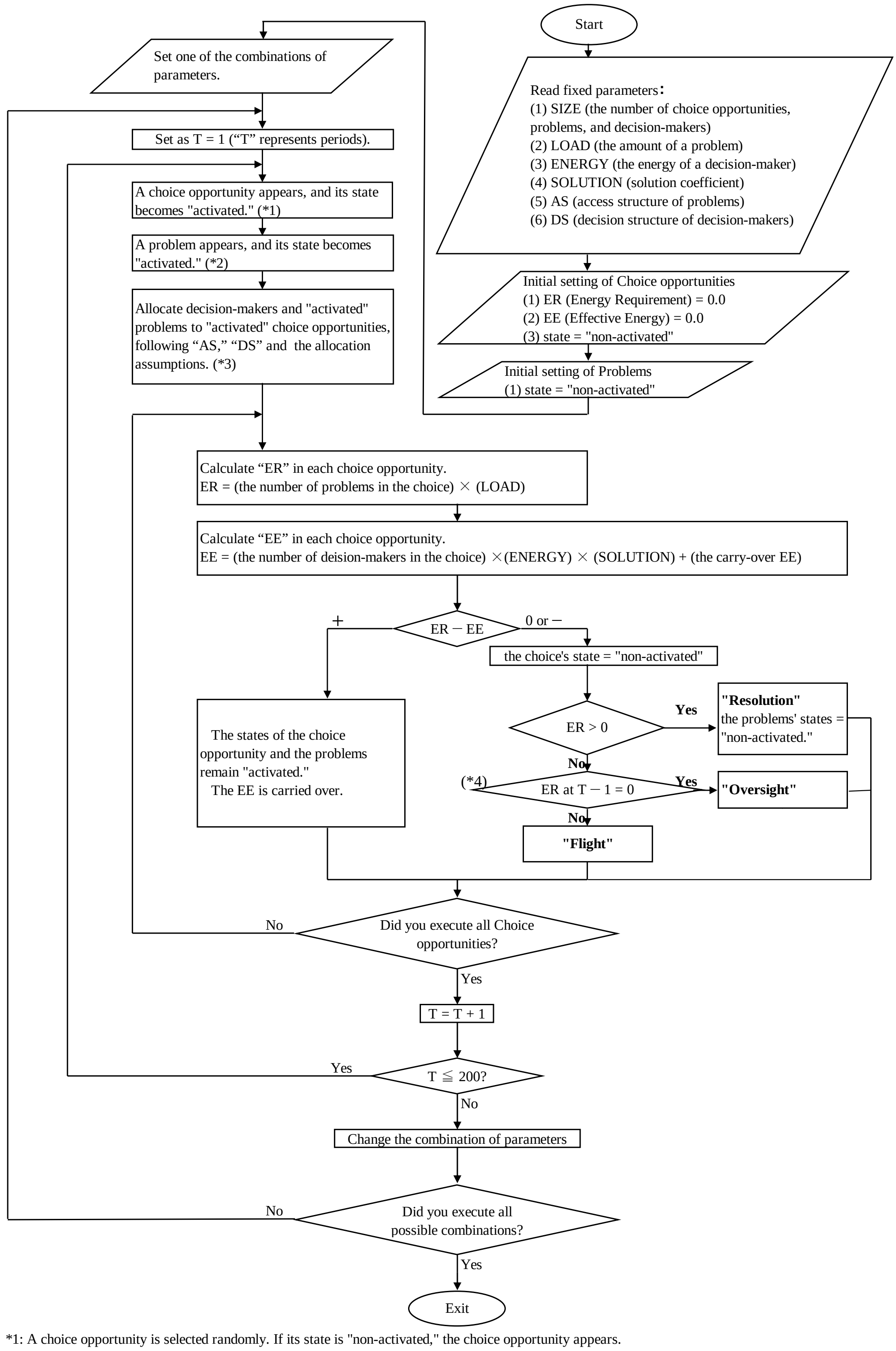
Recently, CMO's simulation model has been rerun and examined, and the widely accepted view has encountered criticism. Bendor et al. (2001) rerun the simulation model and discover that its decision-makers (and sometimes problems) move together from choice to choice, in unsegmented structures; that is, the combinations of decision-makers (or problems) do not change randomly over time. Besides, they point out that all decisions are made using only one decision style ("resolution" or "flight") through a simulation run; that is, decision styles do not randomly change over time. These findings are strikingly different from the disorderly decision-making process assumed by the widely accepted view. Bendor et al. (2001) conclude that, although CMO's simulation model has been supposed to represent disorderly decision processes, it generates an incredible degree of order, even in the prototypical unsegmented case. According to Bendor et al. (2001), unsegmented organizational structures cause the orderly decision-making processes (cf. “Retest of Bendor et al. (2001)” in Table 1).

In CMO’s simulation model, do we not observe the disorderly decision-making process assumed by the widely accepted view? What conditions cause the disorderly decision-making process, if unsegmented structures do not? This study addresses these questions by examining CMO’s simulation model further. Regrettably, CMO’s simulation model has not attracted the attention of organization theorists, and it has not been thoroughly examined across a wide range of parameters’ space, such as solution coefficient. Besides, most of the attention to the garbage-can model in the literature emphasizes unsegmented structures (c.f., Takahashi, 1997), although CMO’s simulation model can treat several more structured cases, such as hierarchical and specialized. Exploration of garbage-can decision-making processes in highly structured organizations has hardly begun (March and Olsen 1986; March, 1994). In addition, CMO tried to explore how different structures produce different decision-making styles and problem solving performance, but this resulted in hardly a satisfactory examination. CMO analyzed the effects of organizational structure extensively, using many output numerical data such as problem latency and activity, but they did not examine the simulation processes directly. Generally speaking, multiple simulation runs of the same model may differ from each other, due to differences in initial conditions and stochastic events, and the results are, therefore, often path-dependent. To understand the results often requires understanding the details of the history of a given run (Axelrod, 1997). The pitfall in analyzing the simulation results only by output numerical data is misreading the real simulation processes. Therefore, this paper varies structural and other parameters across wide ranges, visualizes the simulation processes, and examines what happens in the model.

3. Simulation model and design

3.1 Simulation model

We can reconstruct CMO’s simulation model precisely because CMO state the source code in their appendix. The following model rebuilds CMO’s model as accurately as possible (some alterations are noted later). The model’s flow chart is drawn in Figure 1.



*1: A choice opportunity is selected randomly. If its state is "non-activated," the choice opportunity appears.
*2: A problem is selected randomly. If its state is "non-activated," the problem appears.
*3: The choice opportunity closest to a decision (ER - EE is minimal) is selected.
*4: At the first period or in the case of the choice activated newly, "ER at T - 1" is zero.

Figure 2: The flow chart of the simulation model.

As noted above, CMO's simulation model consists of choice opportunities, problems, decision-makers, and solutions. The number of choice opportunities, problems, and decision-makers are set by the parameter of SIZE. The initial states of choice opportunities are "non-activated (closed)." There are no problems and decision-makers' energies in each choice opportunity at the initial phase; that is, energy requirement (ER) and effective energy (EE) are zero. The initial states of problems are also "non-activated (latent)." Problems are characterized by the amount of energy required to solve them (LOAD). The abilities of decision-makers to solve problems are determined by ENERGY. The solution coefficient, set by SOLUTION, operates on the decision-makers' energies to determine the amount of effective energies.

This study focuses in particular on the parameters of organizational structure: access structure of problems (AS) and decision structure of decision-makers (DS). Access and decision structures are a list of choice opportunities to which the problem or decision-maker "has access." As shown in Figure 2, these structures are of three types: (1) Unsegmented (each problem or decision-maker has access to all choice opportunities), (2) hierarchical (the number of accessible choice opportunities differs depending on organizational level: the higher the level, the more the accessible choice opportunities), and (3) specialized (each problem or decision-maker has access to only one choice opportunity).

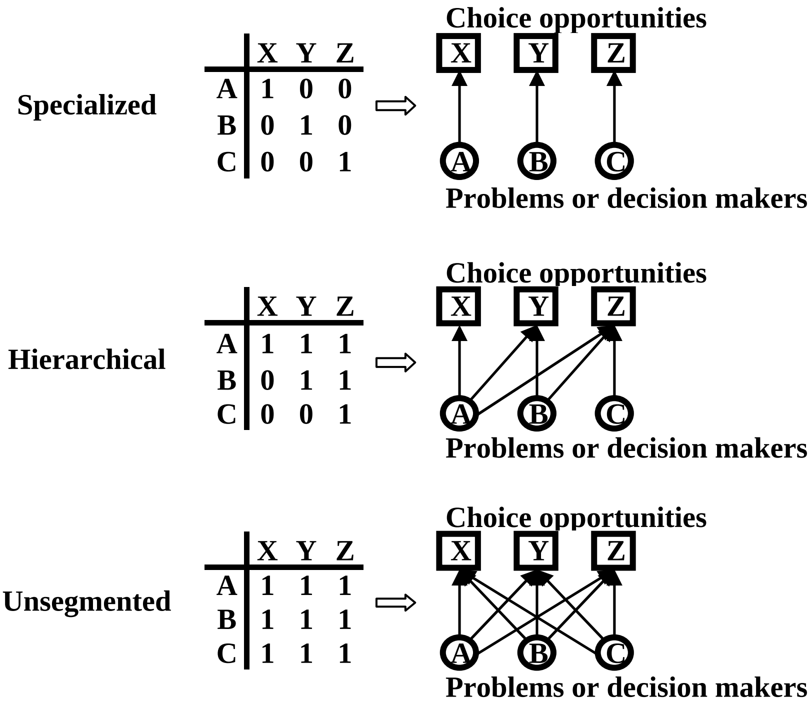


Figure 2: The three types of organizational structures. Consider that there are three choice opportunities (“X,” “Y,” and “Z”) and three problems or decision-makers (“A,” “B,” and “C”). In the matrices on the left side, “1” represents the problem (or decision-maker) who has access to that choice opportunity. In the figures on the right side, arrows indicate that the problem (or decision-maker) can take part in that choice opportunity.

In each parameter setting, the simulations are conducted according to the following rules:

(1) A choice opportunity is selected randomly. If its state is “non-activated (closed),” the choice opportunity emerges and its state becomes “activated (open).” A problem is also selected randomly. If its state is “non-activated (latent),” the problem emerges and its state becomes “activated.”

(2) Activated problems are attached to activated choice opportunities by the following rule. First, activated problems judge which activated choice opportunities are accessible, based on access structure. Second, they calculate required energy and effective energy in each activated and accessible choice opportunity, and move to the choice opportunity closest to a decision (the deficit energy is minimal).

(3) Decision-makers are attached to activated choice opportunities in the same way. First,

decision-makers judge which activated choice opportunities are accessible, based on decision structure. Second, they calculate that required energy and effective energy in each activated and accessible choice opportunities, and move to the choice closest to a decision (the deficit energy is minimal).

(4) The energy requirement (ER) of each choice opportunity is calculated as follows.

ER = (the number of problems in the choice) × (LOAD)

(5) The effective energy (EE) of each choice opportunity is calculated as follows.

EE = (the number of decision-makers in the choice) × (ENERGY) × (SOLUTION)
+ (the carry-over EE from the previous periods)

(6) If ER minus EE is equal to or less than zero, the choice is decided and becomes "non-activated (closed)." However, if ER minus EE is greater than zero, the result is the opposite. In this case, the choice remains "activated (open)," and EE is carried over to the subsequent periods.

(7) This rule induces three types of decisions. If the choice opportunity that has problems is decided (EE > ER > 0), the decision is made by "resolution." In this case, problems in the choice opportunity are resolved and become "non-activated." In addition, the decision is made even if the choice opportunity has no problems (ER = 0). CMO consider two such types of decisions. The first is "oversight," which is made before problems appear in the choice opportunity; that is, ER in the previous period = 0 (however, in the first period, or in the case of a new activated choice, which is equal to zero). The second is "flight," which is made after all problems in the choice opportunity have left, that is, ER at the previous period > 0.

3.2 Some alterations of CMO's simulation model

We made a few minor alterations due to some technical problems; although the simulation model described so far rebuilt the CMO simulation model as correctly as possible. First, when examining the source code, we came across a strange setting. The initial value of the ER of choice opportunities was set at 1.1, as if there were problems in the choice opportunity from the beginning. Thus, we changed this value from 1.1 to 0.0.

Second, the original model consists of 20 periods of time. All choice opportunities and problems emerge in the first 10 periods, and no new ones are introduced in the last 10 periods. However, it is more natural to consider that choice opportunities and problems continue to be introduced into an organization. Besides, it would be more enlightening to run the model for longer periods with the continuing entry of problems and opportunities. Therefore, we alter the entry rules and add the re-activated rules of choice opportunities and problems.

3.3 Simulation design

We conducted 50 simulation runs for each combination of the following parameters.

1) Organizational structures: (AS and DS); unsegmented, hierarchical, and specialized
2) SIZE: (the number of choice opportunities, problems, and decision-makers); from 3 to 23
3) LOAD: from 1 to 10
4) SOLUTION: from 0.1 to 1.0
5) ENERGY: from 1 to 10

As shown in EE's equation, the effects of ENERGY are almost the same as those of SOLUTION. In the following, the cases in which ENERGY is kept at 1, and the other parameters (organizational structures, SIZE, LOAD, and SOLUTION) are changed, will be reported.

We set the periods for each run at 200, and analyzed the last 100 periods. This was because the first 100 periods was a start-up phase, and because the stable pattern of the simulation process could be analyzed by considering a longer time frame, such as 100 periods.

4. Simulation results

We will show in this section that it is not unsegmented or specialized structures, but hierarchical ones, that give rise to the disorderly decision-making process. Moreover, we will show that disorderly decision-making process are particularly common in moderate LOAD, SOLUTION, and SIZE.

4.1 Unsegmented structures

Table 2 shows how many times each decision style is dominant in each simulation run under unsegmented structures. When the proportion of a decision style in the total number of decisions is equal to or more than 50%, the style is dominant in that simulation run. Table 2a shows the number of cases in which any decision style is not dominant among 50 simulation runs. If "decision style change" could be observed, there should be no dominant decision styles. Therefore, this case indicates “decision style change.” Tables 2b, 2c, and 2d show the number of cases in which “resolution,” “oversight,” and “flight,” respectively, are dominant.

In most cases under unsegmented structures, one of the three decision styles always gains a majority (Table 2a); that is, unsegmented structures do not lead to “decision style change.” “Resolution” tends to be dominant under light LOAD and effective SOLUTION (Table 2b); on the other hand, “flight” tends to be dominant under heavy LOAD and ineffective SOLUTION (Table 2d). “Oversight” fails to obtain a majority in many parameter settings (Table 2c).

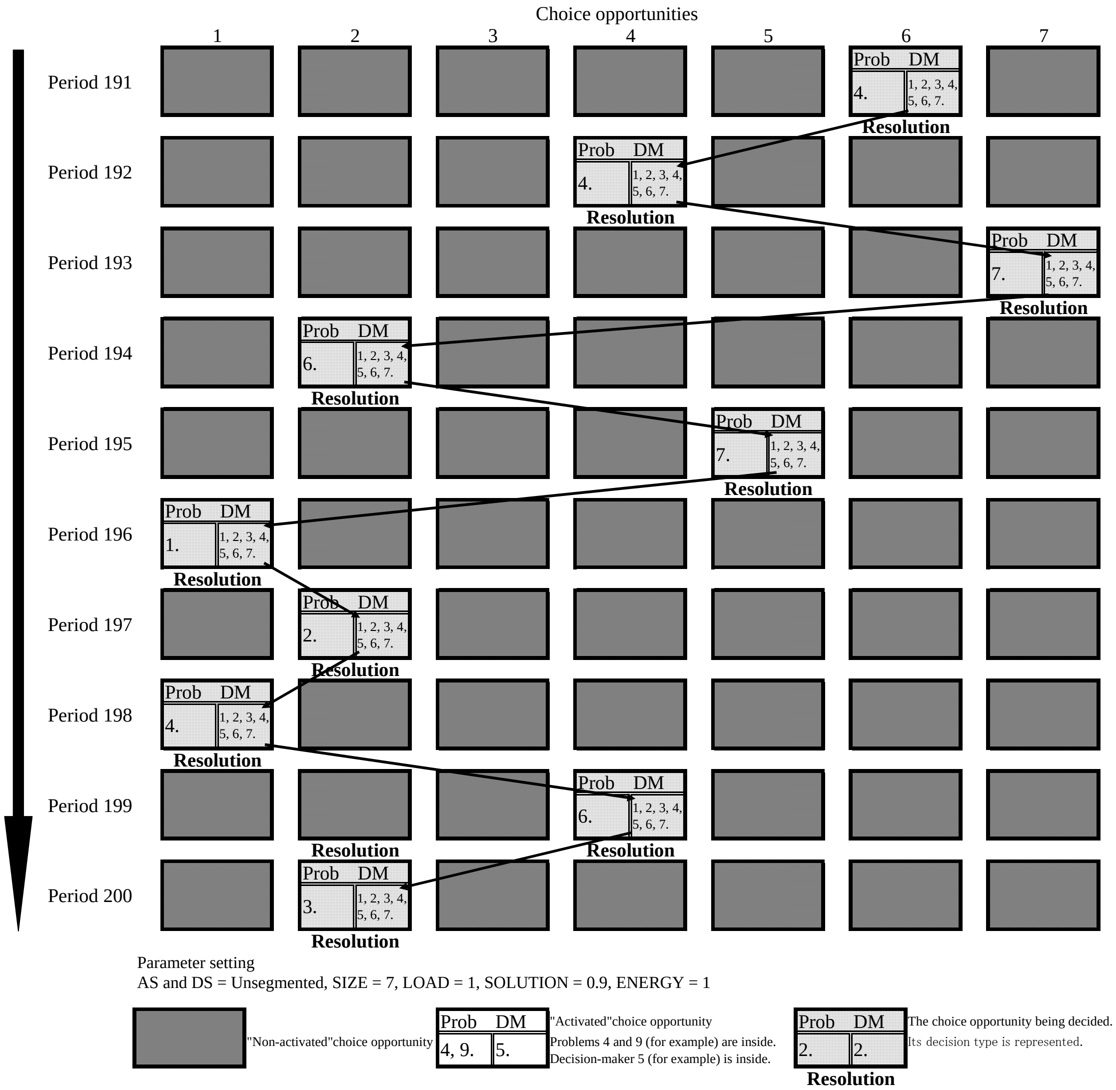
Figure 3 shows how “resolution” is dominant in unsegmented structures under the parameter setting of SIZE = 7, LOAD = 1, SOLUTION = 0.9, and ENERGY = 1.0. For simplification, the process described in this figure is limited to the last ten periods (period 191–200) of the simulation. As shown in Figure 3, choice “6” (C6) and problem “4” (P4) become activated at period 191. C6 is the sole activated choice, and it is accessible to all decision-makers and problems. Therefore, all decision-makers and activated problems (P4) enter C6. C6 is made by “resolution” because the effective energy EE is greater than the energy requirement ER (> 0). Then the simulation moves on to the subsequent period. C4 and P4 become activated. Similarly, as in the previous period, all decision-makers and activated problems (P4) enter C4. EE is greater than ER at C4, and the choice is made by “resolution.” In this way, all decision-makers gather at the new choices and resolve new problems at once. The combination of decision-makers at each choice does not change over time; that is, “combination change” is not observed.

Figure 4 describes how “flight” prevails in the unsegmented structures under the parameter setting of SIZE = 7, LOAD = 9, SOLUTION = 0.1, and ENERGY = 1.0. As shown in Figure 4, Choice “3” (C3) becomes activated at period 191. No new problems appear because all problems have already been “activated (unsolved).” All problems and decision-makers enter C3, and they reach the next period without a decision because the problems are too heavy to be solved (energy requirement ER > effective energy EE). Then the simulation moves on to the next period. C4 becomes activated at the next period, 192. The deficit energy (ER – EE) of the old choice C3 is 62.30 ($7 \times$ LOAD $- 7 \times$ ENERGY $\times$ SOLUTION $= 7 \times 9 - 7 \times 1 \times 0.1$), which is more than that of the new choice C4, because the initial values of ER and EE are zero and LOAD is 1. Therefore, C4 is the closest to a decision. Besides, C4 is accessible to all decision-makers and problems. As a result, all decision-makers and problems move to C4. However, C4 is not made because ER is greater than EE. On the other hand, the old choice C2 is made because it has no problems (EE $\geq$ ER = 0). Its decision style is “flight.” ER at the previous period is greater than zero because there were the problems (P1, P2, P3, P4, P5, P6, and P7). In this way, all decision-makers and problems move in clusters from one choice to a new one, depending on the allocation assumptions. The old choices are always made by “flight,” because all problems have left the choices. Of course, the combination of decision-makers and problems does not change over time; that is, “combination change” is not observed. In sum, unsegmented structures do not lead to disorderly decision-making process, as pointed out by Bendor et al. (2001).

Table 2: The number of dominant decision styles in unsegmented structures

SIZE	LOAD	a: The number of the case in which any style is not dominant					b: The number of the case in which "resolution" is dominant					c: The number of the case in which "oversight" is dominant					d: The number of the case in which "flight" is dominant				
		SOLUTION					SOLUTION					SOLUTION					SOLUTION				
		0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9
3	1	0	0	0	0	0	0	3	50	50	50	4	4	0	0	0	46	39	0	0	0
	3	0	0	0	3	7	0	0	0	0	2	0	2	6	34	3	50	48	44	13	38
	5	0	0	0	3	1	0	0	0	0	0	0	0	1	6	23	50	50	49	41	26
	7	0	0	0	0	1	1	1	0	0	0	0	0	0	0	2	49	49	50	50	48
	9	0	0	0	0	0	2	0	0	0	0	3	0	0	0	2	46	50	50	50	48
5	1	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	3	0	0	0	0	0	0	0	0	50	50	0	1	3	0	0	50	49	47	0	0
	5	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	50	50	50	47	50
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	50	50	50	50
	9	0	0	1	0	0	0	0	0	0	0	1	0	0	2	0	49	50	50	48	50
7	1	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	3	0	0	0	0	0	0	0	50	50	50	0	1	0	0	0	50	49	0	0	0
	5	0	0	0	0	0	0	0	0	0	50	0	2	0	0	0	50	48	50	50	0
	7	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	50	49	50	50	50
	9	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	50	50	48	50	49
9	1	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	3	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	50	50	0	0	0
	5	0	0	0	0	0	0	0	0	50	50	0	0	0	0	0	50	50	50	0	0
	7	0	0	0	0	0	0	0	0	0	50	0	4	0	0	0	50	46	50	50	0
	9	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	50	48	50	50	50
11	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	50	50	50	50	2	0	0	0	0	48	0	0	0	0
	5	0	1	0	0	0	0	0	50	50	50	0	2	0	0	0	50	47	0	0	0
	7	0	1	1	0	0	0	0	0	50	50	0	2	0	0	0	50	47	49	0	0
	9	0	0	0	0	0	0	0	0	0	50	0	1	0	1	0	50	49	50	49	0
13	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	1	0	0	0	0	0	50	50	50	50	1	0	0	0	0	48	0	0	0	0
	5	1	0	0	0	0	0	0	50	50	50	0	1	0	0	0	49	49	0	0	0
	7	0	0	0	0	0	0	0	0	50	50	0	0	0	0	0	50	50	50	0	0
	9	0	0	0	0	0	0	0	0	50	50	0	1	0	0	0	50	49	50	0	0
15	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	5	0	0	0	0	0	0	0	50	50	50	0	2	0	0	0	50	48	0	0	0
	7	0	0	0	0	0	0	0	50	50	50	0	1	0	0	0	50	49	0	0	0
	9	0	0	0	0	0	0	0	0	50	50	0	0	0	0	0	50	50	50	0	0
17	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	5	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	7	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	50	50	0	0	0
	9	0	0	0	0	0	0	0	0	50	50	0	0	1	0	0	50	50	49	0	0
19	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	50	50	50	50	1	0	0	0	0	49	0	0	0	0
	5	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	7	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	50	50	0	0	0
	9	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	50	50	0	0	0
21	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	5	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	7	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	50	50	0	0	0
	9	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	50	50	0	0	0
23	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	50	50	50	50	0	0	0	0	0	50	0	0	0	0
	5	0	0	0	0	0	0	50	50	50	50	2	0	0	0	0	48	0	0	0	0
	7	0	0	0	0	0	0	0	50	50	50	0	0	0	0	0	50	50	0	0	0
	9	0	0	0	0	0	0	0	50	50	50	0	1	0	0	0	50	49	0	0	0

Note: The cells painted in grey indicate more than 25 of 50 simulation runs fall into those decision style categories.



Arrows represent movements of decision makers. Problems are resolved at once before they fly to another choice opportunity.

Figure 3: A simulation process under unsegmented structures, light LOAD, and effective SOLUTION.

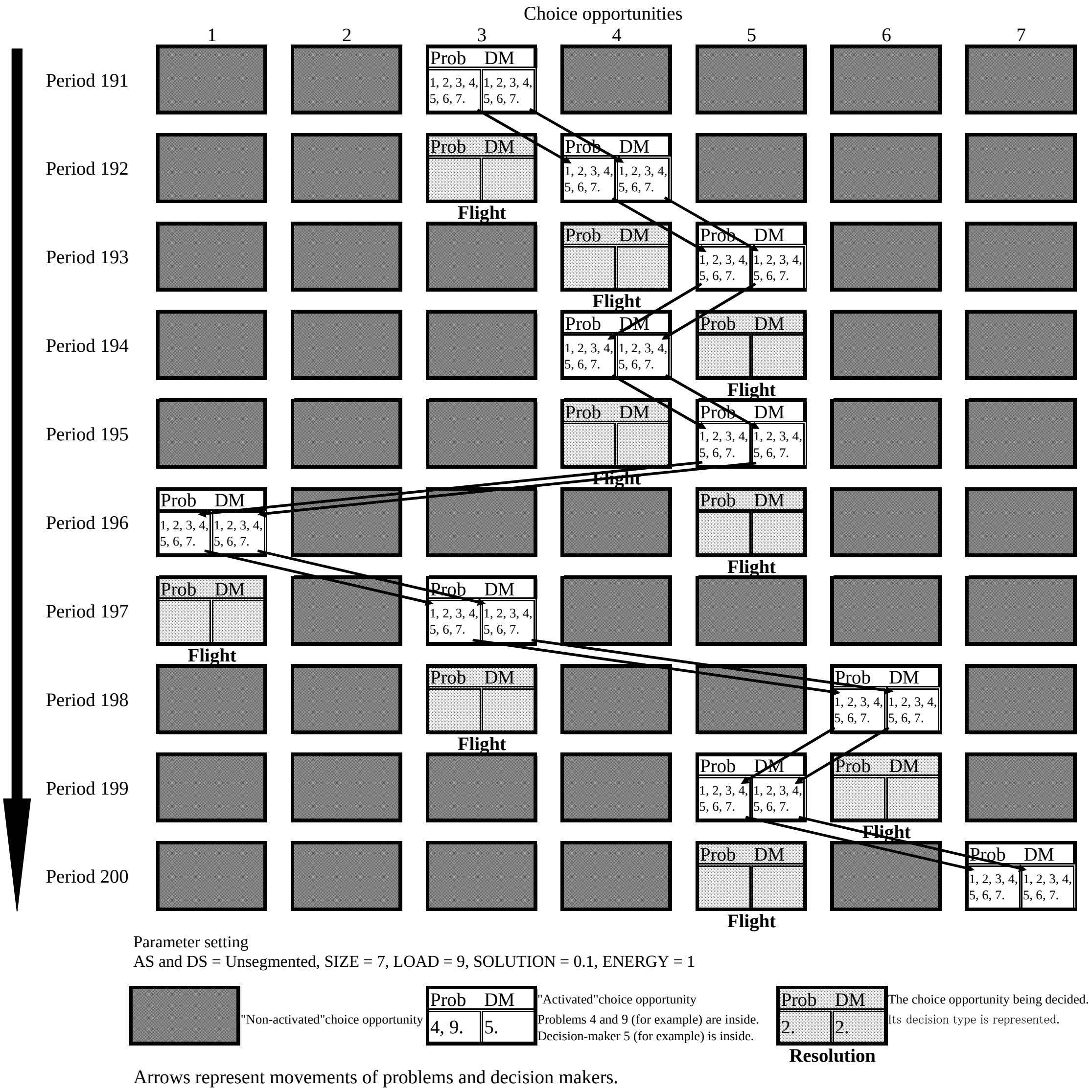


Figure 4: A simulation process under unsegmented structures, heavy LOAD, and ineffective SOLUTION.

4.2 Specialized structures

Tables 3a, 3b, 3c, and 3d show, under specialized structures, how many times each decision style gains a majority of the total number of decisions in each simulation run. “Decision style change,” which means that all three decision styles fail to obtain a majority, cannot be observed in specialized structures (Table 3a). “Resolution” is dominant in most cases (Table 3b), and “flight” never becomes dominant (Table 3d).

Figure 5 shows a decision-making process in specialized structures under the parameter setting of SIZE = 7, LOAD = 1, and SOLUTION = 0.1. Since each problem is associated with a single choice opportunity in a specialized access structure, problems cannot move to other choice opportunities. Therefore, decisions by “flight” never occur. Because each decision-maker also has access to only one choice opportunity, this concentrates their energy on the accessible choice every period for a long time, and then resolves the problem (see Choice “2” at period 199 and Choice “6” at period 200). However, if problems and their accessible choice opportunities are not activated simultaneously, decision-makers devote their energies to choice opportunities before problems enter, and make decisions by “oversight” (see Choice “3” at period 193 and Choice “2” at period 200). Of course, the combinations of choice opportunities, problems, and decision-makers do not change over time. In sum, disorderly decision-making process do not occur in specialized structures.

Table 3: The number of dominant decision styles in specialized structures

SIZE	LOAD	a: The number of the case in which any style is not dominant					b: The number of the case in which "resolution" is dominant					c: The number of the case in which "oversight" is dominant					d: The number of the case in which "flight" is dominant				
		SOLUTION					SOLUTION					SOLUTION					SOLUTION				
		0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9
3	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	49	50	50	50	50	2	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	48	50	50	50	50	5	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	46	50	49	50	50	6	0	1	0	0	0	0	0	0	0
	9	0	0	0	0	0	46	49	50	50	49	10	4	0	0	1	0	0	0	0	0
5	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	48	50	50	50	50	2	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	48	50	50	50	50	2	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	46	49	50	50	50	11	1	1	0	0	0	0	0	0	0
	9	0	0	0	0	0	41	50	49	50	50	14	1	1	0	0	0	0	0	0	0
7	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	46	50	50	50	50	4	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	46	50	49	50	50	5	0	1	0	0	0	0	0	0	0
	7	0	0	0	0	0	42	49	50	50	50	13	2	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	42	49	50	50	50	15	1	1	0	0	0	0	0	0	0
9	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	50	50	50	50	50	3	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	47	50	50	50	50	4	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	39	49	49	50	50	11	3	1	0	0	0	0	0	0	0
	9	0	0	0	0	0	36	48	50	50	50	15	3	0	0	0	0	0	0	0	0
11	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	49	50	50	50	50	4	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	39	50	50	50	50	15	1	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	44	49	49	50	50	9	1	1	0	0	0	0	0	0	0
13	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	47	49	50	50	50	4	1	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	38	50	50	50	49	14	0	0	0	1	0	0	0	0	0
	9	0	0	0	0	0	37	49	50	49	50	14	1	0	1	0	0	0	0	0	0
15	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	49	50	50	50	50	1	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	48	50	50	50	50	2	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	36	49	50	50	50	16	1	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	43	49	50	50	50	8	1	0	0	0	0	0	0	0	0
17	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	49	50	50	50	50	1	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	43	49	50	50	50	8	1	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	41	48	50	50	50	9	3	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	41	50	50	49	50	11	1	2	1	0	0	0	0	0	0
19	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	43	50	50	50	50	9	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	37	48	50	50	50	13	2	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	41	50	50	50	50	11	1	0	0	0	0	0	0	0	0
21	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	50	50	50	50	50	1	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	47	50	50	50	50	5	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	38	50	50	50	50	13	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	48	50	50	50	50	7	1	0	0	0	0	0	0	0	0
23	1	0	0	0	0	0	50	50	50	50	50	0	0	0	0	0	0	0	0	0	0
	3	0	0	0	0	0	47	50	50	50	50	3	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	45	50	50	50	50	5	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	40	50	50	50	50	11	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	44	49	50	50	50	10	1	0	0	0	0	0	0	0	0

Note: The cells painted in grey indicate more than 25 of 50 simulation runs fall into those decision style categories.

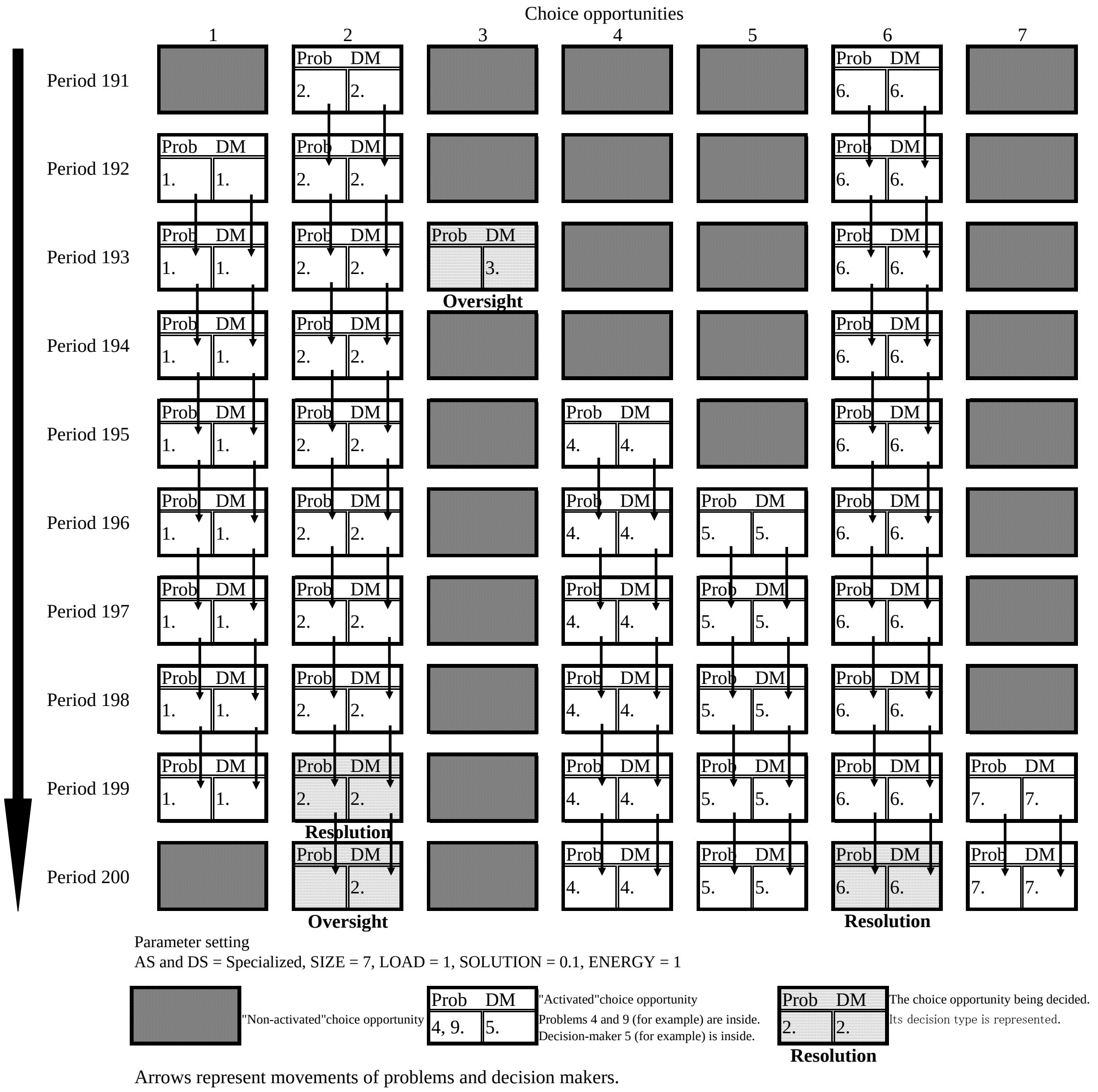


Figure 5: A simulation process under specialized structures.

4.3 Hierarchical structures

Tables 4a, 4b, 4c, and 4d show, under hierarchical structures, how many times each decision style gains a majority of the total number of decisions in each simulation run. As shown in Table 4a, it is hierarchical structures that lead to “decision style change.”

Figure 6 describes how “decision style change” occurs in hierarchical structures under the parameter setting of SIZE = 7, LOAD = 1, SOLUTION = 0.1, and ENERGY = 1.0. From period 191 to 192, decision-makers “2” (D2), “3” (D3), “4” (D4), “5” (D5), “6” (D6), and “7” (D7) at the higher levels move from Choice 1 (C1) to the new choice C2, which is the closest to a decision (ER minus EE is minimal). This is because the initial values of ER and EE of C2 are zero. D1 at the lower level, however, remains in C1. It cannot take part in C2 due to structural constraints. Therefore, the cluster of decision-makers is partly divided. Then, from period 192 to 193, the cluster of decision-makers at C2 is divided into two clusters: D6 and D7 at the higher levels fly to C6, and D1, D2, D3, D4, and D5 come together at C1. In the same way, the clusters of decision-makers have repeatedly been separated and integrated throughout the simulation process (see the arrows in Figure 6). The clusters of decision-makers are subject to constant realignment. Although problems are less active than decision-makers, the cluster of problem “1” (P1) and “2” (P2) is divided from period 191 to 192, and the cluster of P2 and P3 is divided from period 198 to 199. Problems at the lower levels, such as P1 from period 191 to 192 and P2 from period 198 to 199, cannot move due to structural constraints. In addition, the cluster of P2 and P3 flies back and forth between C1 and C2, which causes decisions by “flight.” In this way, decision-makers (and sometimes problems) at the higher levels tend to move from one choice to another, depending on the allocation assumptions. Those at the lower levels tend to be left with a limited set of choices. As a result, the combinations of participants change overtime; that is, “combination change” is observed. Because of “combination change” during these ten periods, decisions are made using a combination of the three styles.

Table 4: The number of dominant decision styles in hierarchical structures

SIZE	LOAD	a: The number of the case in which any style is not dominant					b: The number of the case in which "resolution" is dominant					c: The number of the case in which "oversight" is dominant					d: The number of the case in which "flight" is dominant				
		SOLUTION					SOLUTION					SOLUTION					SOLUTION				
		0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9	0.1	0.3	0.5	0.7	0.9
3	1	1	0	0	0	0	36	50	50	50	50	17	0	0	0	0	0	0	0	0	0
	3	0	1	2	5	2	41	40	37	37	47	15	10	12	8	1	0	0	0	0	0
	5	0	4	0	2	2	34	32	38	38	31	22	14	17	10	17	0	0	0	0	0
	7	0	0	0	0	4	34	32	44	35	26	19	19	10	16	20	0	0	0	0	0
	9	0	0	0	2	1	33	31	38	28	35	20	22	15	21	16	0	0	0	0	0
5	1	12	4	0	0	0	13	45	50	50	50	26	2	0	0	0	0	0	0	0	0
	3	3	17	14	15	3	24	12	29	29	45	24	21	7	6	2	0	0	0	0	0
	5	6	12	24	14	17	25	12	9	10	22	20	26	17	26	12	0	0	0	0	0
	7	3	5	20	18	16	32	14	11	11	11	18	33	19	21	23	0	0	0	0	0
	9	1	7	14	19	16	35	15	13	10	12	21	29	23	21	23	0	0	0	0	0
7	1	38	2	0	0	0	4	48	50	50	50	8	0	0	0	0	0	0	0	0	0
	3	31	35	23	4	2	7	2	22	44	48	11	13	5	2	0	1	0	0	0	0
	5	10	31	33	28	22	16	4	5	11	21	24	13	12	11	7	0	2	0	0	0
	7	11	28	32	37	34	18	7	3	7	2	23	15	15	6	14	0	0	0	0	0
	9	7	30	30	30	36	17	3	4	7	2	30	16	16	13	12	1	1	0	0	0
9	1	43	1	0	0	0	1	48	50	50	50	5	1	0	0	0	1	0	0	0	0
	3	29	42	13	3	1	0	4	37	46	49	13	3	0	1	0	8	1	0	0	0
	5	20	39	40	34	16	3	1	4	11	30	20	6	5	5	4	7	4	1	0	0
	7	22	32	40	44	35	8	2	0	1	10	12	9	7	3	5	8	7	3	2	0
	9	15	36	43	40	39	11	1	0	2	2	18	7	1	6	7	6	6	6	2	2
11	1	43	0	0	0	0	4	50	50	50	50	0	0	0	0	0	3	0	0	0	0
	3	28	39	22	4	0	0	3	28	45	50	1	1	0	1	0	21	7	0	0	0
	5	22	31	38	34	18	1	0	3	13	32	7	1	2	3	0	20	18	7	0	0
	7	15	22	33	41	40	2	0	0	1	7	7	3	3	2	3	26	25	14	6	0
	9	19	20	29	43	42	2	1	0	0	4	11	5	2	2	1	18	24	19	5	3
13	1	32	0	0	0	0	1	50	50	50	50	1	0	1	0	0	16	0	0	0	0
	3	5	39	14	1	0	0	2	36	49	50	1	0	0	0	0	44	9	0	0	0
	5	8	15	39	34	6	0	0	2	14	43	3	0	1	1	1	39	35	8	1	0
	7	11	15	24	35	34	0	0	0	4	12	1	4	1	2	3	38	31	25	9	1
	9	11	12	13	27	34	2	0	0	0	7	4	1	1	3	0	33	37	36	20	9
15	1	33	0	0	0	0	1	50	50	50	50	0	0	0	0	0	16	0	0	0	0
	3	4	36	5	0	0	0	2	45	50	50	0	1	0	0	0	46	11	0	0	0
	5	2	11	34	21	4	0	0	4	28	45	0	1	1	1	1	48	38	11	0	0
	7	6	4	19	32	32	0	0	0	5	17	2	0	0	1	1	42	46	31	12	0
	9	4	5	13	20	30	0	0	0	2	4	2	0	0	1	0	44	45	37	27	16
17	1	29	0	0	0	0	5	49	49	50	50	0	1	1	0	0	16	0	0	0	0
	3	3	27	5	0	0	0	4	45	50	50	0	0	0	0	0	47	19	0	0	0
	5	0	2	27	13	7	0	0	4	34	42	0	0	0	0	1	50	48	19	3	0
	7	2	4	9	28	19	0	0	0	4	26	0	0	0	1	0	48	46	41	17	5
	9	0	1	3	19	25	0	0	0	0	3	0	0	0	1	0	50	49	47	30	22
19	1	29	0	0	0	0	2	50	50	50	50	0	0	0	0	0	19	0	0	0	0
	3	1	24	5	1	0	0	4	45	49	49	0	0	0	0	1	49	22	0	0	0
	5	0	5	25	11	2	0	0	10	39	48	0	0	0	0	0	50	45	15	0	0
	7	0	0	6	29	20	0	0	1	2	24	0	0	0	0	1	50	50	43	19	5
	9	0	1	6	11	22	0	0	0	1	8	0	0	0	0	0	50	49	44	38	20
21	1	20	0	0	0	0	10	50	50	50	50	2	0	0	1	0	18	0	0	0	0
	3	1	20	3	0	0	0	7	46	50	50	0	0	1	0	0	49	23	0	0	0
	5	0	1	14	10	2	0	0	15	40	47	0	0	0	0	1	50	49	21	0	0
	7	0	0	4	19	20	0	0	0	6	28	0	0	0	0	0	50	50	46	25	2
	9	0	0	1	7	25	0	0	0	1	13	0	0	0	0	1	50	50	49	42	11
23	1	19	0	0	0	0	14	50	50	50	50	0	0	0	0	1	17	0	0	0	0
	3	0	17	1	0	0	0	10	48	49	50	0	0	1	1	0	50	23	0	0	0
	5	0	0	24	6	2	0	0	12	44	48	0	0	1	0	0	50	50	13	0	0
	7	0	0	0	22	5	0	0	0	12	44	0	0	0	0	0	50	50	50	16	1
	9	0	0	0	12	16	0	0	0	1	16	0	0	0	0	0	50	50	50	37	18

Note: The cells painted in grey indicate more than 25 of 50 simulation runs fall into those decision style categories.

Figure 6: A simulation process under hierarchical structures.

4.4 Boundary conditions for disorderly decision-making in hierarchical structures

LOAD and SOLUTION**:** Hierarchical structures do not always lead to disorderly decision-making behavior. “Decision style change” is common only when LOAD and SOLUTION are moderate (see diagonal cells in each SIZE in Table 4a). “Resolution” tends to prevail under light LOAD and effective SOLUTION (Table 4b), as does “flight” under heavy LOAD and ineffective SOLUTION (Table 4d).

Several decision-makers can gather, even in hierarchical structures, as shown in Figure 6. Therefore, decision-makers with effective solutions can solve light problems as soon as they become activated. As a result, the common decision style is “resolution” under light LOAD and effective SOLUTION. On the other hand, decision-makers with ineffective solutions cannot solve heavy problems at once, and they reach the next period without making any decisions. In the next period, a new choice opportunity opens up, and decision-makers and problems that can participate in the new choice will move there together. Then the simulation moves on to the next period, and another new choice opportunity becomes activated. All remaining decision-makers and problems in the oldest choice opportunity may fly to the newest choice. As a result, the oldest choice is made by “flight,” because all problems there have left. Subject to structural restrictions, decision-makers and problems form several clusters and tend to move together to new choices, as shown in the case of unsegmented structures, heavy LOAD, and ineffective SOLUTION (cf. Figure 4).

SIZE**:** We can see many disorderly decision-making behaviors in medium-sized organizations (Table 4a). First, “flight” rarely happens in small organizations (Table 4d), because problems do not shift from one choice to another so much in small organizations. Under a small number of choice opportunities, all of them tend to become activated at an early stage, and new ones tend not to open up. Therefore, problems have no incentive to move away from their current choice opportunity, although they have the tendency to move to new choices, based on the allocation assumption.

In large organizations, the tendency noted in section 4.1 becomes increasingly prominent. Because of their large number, many decision-makers can gather at the new choice even in a hierarchical decision structure. As a result, problems tend to be solved at once in large SIZE; that is, “resolution” becomes dominant. However, when problems cannot be solved at once, unsolved problems tend to accumulate until all problems become activated. Subsequently, because of their large number, problems form several clusters and move together from choice to choice, even in a hierarchical structure, as shown in unsegmented structures (cf. Figure 4). As a result, choices are always made by "flight."

5. American university cases as hierarchical structures and disorderly decision-making

As noted so far, it is hierarchical structures that give rise to disorderly decision-making process. In the following, we will indicate that this paradoxical result is observable in real organizations.

It has been thought that the original authors of the garbage-can model examined decision-making in American universities, and translated its essence into the garbage-can model (e.g., Cohen and March, 1974; Cohen and March, 1976; March and Romelaer, 1976). After careful consideration of the cases reported by the original authors, however, we realized that they are about hierarchical structures. These authors report that people in administrative positions had to devote their energies to various choice opportunities, and that the professors who were not in significant positions could engage in a specific choice opportunity related to their own interests. March and Romelaer (1976) report that, since administrative actors (deans, chairpersons, provosts, etc.) were busy, their attention was divided among various concerns and a multitude of decision-making situations. Administrative actors also changed their positions more rapidly than the issues could be resolved. However, some people were devoting more energy to the choice opportunity than those occupying administrative positions. Cohen and March (1976) state that "some people consistently spend more time than others. Some problems are always there. There are important structural and normative constraints on the access and decision structures" (p. 175). Thus, we can categorize these cases as those in the hierarchical structure.

The original authors describe the decision-making process of universities as disorderly. First, they describe random movements of people (carriers of problems and energies). For example, March and Romelaer (1976) note that actors wandered in and out as the decision-making process developed, and that a different group was involved at each stage (overlapping to some degree with previous stages). Second, they describe "decision style change." Although they note that decisions were made by oversight and flight, because of "combination change," they also report that the issues addressed by that university (e.g., eliminating the program in speech) were eventually resolved. Thus, they regard the decision-making process as a mixture of three decision styles, rather than one of oversight and flight. Finally, they describe this decision-making process in terms of a bizarre soccer game: “Consider a round, sloped, multi-goal soccer field on which individuals play soccer. Different people (but not everyone) can join the game (or leave it) at different times. Some people can throw balls into the game or remove them. Individuals, while they are in the game, try to kick whatever ball comes near them in the direction of goals they like and away from goals they wish to avoid” (p. 276). This metaphor represents the disorderly decision-making process.

6. Conclusion

The widely accepted view on garbage-can decision-making has assumed that disorderly organizational structures give rise to disorderly decision-making process; that is, the combinations of choice opportunities, problems, decision-makers, and solutions change, and their decision styles also change over time (see “the widely accepted view” in Table 1). However, this has been based on a misinterpretation of the conditions and behavior of CMO’s simulation model. The real simulation processes in CMO’s model show that orderly (hierarchical) structures lead to disorderly decision-making process (see “This study” in Table 1). Besides, disorderly decision-making process are particularly common under medium-sized organization and moderate problems’ load (moderate solution effectiveness). The simulation result—disorderly decision-making process arising from hierarchical structures—is paradoxical but observable, because the American university cases examined by the original authors also show this paradoxical result. We should accept the results of this study, and develop further a theory that explains the orderly/disorderly paradox.

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