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A Single Garbage Can Model and the Degree of Anarchy in Japanese Firms

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ABSTRACT

This paper is refreshing to see an empirical examination of the garbage can model, particularly in a sample drawn from Japanese firms. The garbage can model of organizational decision making was originally developed by Cohen, March, & Olsen (1972) to describe organized anarchy. This paper incorporates two methodologies in an attempt to both validate and extend the garbage can model: Simulation is first used to generate a research hypothesis, then several surveys are conducted to test that hypothesis and to empirically develop an ex-post model of decision ambiguity, flight and anarchy. The data support our hypothesis and we find out new conditions of ambiguity: (i) fluid participation, (ii) divorce of solution from discussion, and (iii) job performance rather than subjective assessments, which are clearly related to the simulation assumption of our single garbage can model. By using our new conditions of ambiguity, we develop a measure of degree of anarchy, and the regression analysis indicates a linear relationship between the flight ratio and the degree of anarchy.

KEY WORDS: garbage can model; simulation; ambiguity; degree of anarchy; flight ratio.

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INTRODUCTION

The garbage can model developed by Cohen, March, & Olsen (1972) is an extension of the organizational decision making theories rather than a contradiction to them (March & Olsen, 1986). Decision theory and classical theories of organizational decision making emphasize decision making as rational on the basis of expectations about future consequences of actions. The major criticisms on these theories are excessive time and information demands beyond the human bounded rationality (Simon, 1947; March & 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 & March, 1963). Though bounded rationality and conflict are major phenomena, they do not exhaust the problems of matching theories of decision making with many empirical observations, especially in the organizations characterized by three general properties of organized anarchy: problematic preferences, unclear technology, and fluid participation (Cohen et al., 1972).

The studies of universities suggest that the university is a familiar form of organized anarchy and that such organizations can be viewed as collections of problems looking for choice opportunities, solutions looking for problems, and participants looking for work. Decision processes are affected by timing of problems, solutions, participants and choice opportunities which are assumed to be independent, exogenous streams flowing through a system, and then solutions are linked to problems and participants are linked to choice opportunities primarily by their simultaneity.

Thus Cohen et al. (1972) develop the garbage can model in which a choice opportunity is viewed as a garbage can. Various kinds of garbage, that is, problems, solutions and energy, are dumped into a garbage can by participants as they are produced. The produced garbage is collected and a decision is made when a full garbage can is removed from the scene. In their model, decisions are classified into following three categories:

(a) Decision making by resolution. The choice resolves problems after some periods of working on them.

(b) Decision making by flight. When the choice resolves no problems after some periods of working on them, decision can be made if the problems leave the choice opportunity.

(c) Decision making by oversight. If there is effective energy available to make the new decision before problems become activated, decision will be made with minimal energy.

Decision making by resolution is the implicit normal style of decision making in classical theories. But their results of simulation reveal that decision making by resolution is not the most common style, except under conditions where flight is severely restricted or conditions of light load, and that decision making by flight and by oversight is a major feature of the process in general.

March & Olsen (1986) review research on the garbage can model. Though the garbage can model is originally developed to describe universities, it has been used as a general frame within which to describe almost any decision processes in many kinds of organizations ranging from schools to navies. For example, March & Olsen (1976) study decision making under ambiguity in American, Norwegian and Danish educational organizations. March & Weissinger-Baylon (1986) use garbage can ideas to illustrate naval peacetime and operational decision making.

With respect to Japanese organizations, Lynn (1982) compares how Japanese and American steel makers adopted a major new industrial technology, the basic oxygen furnace (BOF) which is now the world's most widely used steel making process and a major factor in the dramatic increase in international competitiveness of Japan's steel industry in the 1960s. He concludes that the processes observed at the later adopting firms of the BOF fit the classical decision model, but the processes observed at the early adopting firms fit the garbage can model. Recently, the empirical research of Takahashi (1992b) indicates that decision making by flight is a major feature of the decision processes in Japanese firms.

However, the garbage can model has failed to generate very much interest in the literature compared with alternative models in organizational theory such as contingency theory or population ecology. While the field has appreciated the metaphorical appeal of the garbage can model as an interesting way to discuss the anarchistic features of some organizations, it has not provided a particularly fertile ground for empirical research or theory development and has not found its way into the management textbooks as much more than a curiosity. This paper ambitiously tries to demonstrate both the utility and validity of the model for explaining real trends in organizational decision making.

The purpose of this paper is to examine the sensitivity of a simplified computer simulation of the garbage can model and subsequently to treat the linkages among three aspects of ambiguity and the types of decisions made in a sample of 2476 white-collar workers of 21 Japanese firms.

By decision making under ambiguity, March & Weissinger-Baylon (1986: 1) mean decision making in situations (i) where objectives, technology, or experience are unclear, (ii) where solutions and problems are joined together partly because of their simultaneous availability, and (iii) where the attention of decision makers is attenuated by the existence of multiple simultaneous demands on their time. These three conditions are sufficiently evocative to have the garbage can metaphor, but their conditions (i) and (iii) are not clearly related to the assumption of the garbage can model specified as computer simulation. Is their definition of ambiguity strictly correct and appropriate to predict the occurrence of the garbage can phenomena? This paper is refreshing to see an empirical examination of the garbage can model. We propose new three conditions of ambiguity: (i) fluid participation, (ii) divorce of solution from discussion, and (iii) job performance rather than subjective assessments. Then by using these new conditions, we develop and test a measure of degree of anarchy to predict the occurrence of decision making by flight through our empirical research.

A SINGLE GARBAGE CAN MODEL

The original garbage can model is translated into a computer simulation, which is still fruitful in analysis of organized anarchy although Padgett (1980) presents what he called a garbage can model for the case of a traditional Weberian bureaucracy in mathematically elaborate fashion of a stochastic process model. The original simulation model of Cohen et al. (1972) is specified in terms of the following four basic variables:

(a) Choice opportunities. Choice opportunity is an occasion when an organization is expected to produce a decision.

(b) Participants. Since participants come and go, each participant is characterized by a randomly generated sequence of potential energy available for problem solving at each choice opportunity.

(c) Problems. Each problem is characterized by an energy requirement to resolve a choice to which the problem is attached.

(d) Solutions. A solution coefficient, ranging between 0 and 1, is assumed to operate on the potential energies to determine the problem-solving output, called effective energy.

The original simulation model assumes some fixed number of choice opportunities, and then in order to reflect organizational segmentation in the simulation model, the decision structure (i.e., the mapping of choice opportunities onto participants) and the access structure (i.e., the mapping of problems onto choice opportunities) are represented by matrices. Therefore the FORTRAN program of the original garbage can model provided in the appendix of Cohen et al. (1972) is complicated by the array operations of these structures. However, March & Olsen (1986) point out that much of the discussion of the garbage can model has emphasized a special case of the original model in which both decision and access structures are completely open and that this unsegmented version has been useful and provocative.

Thus, to simplify the computer program, we assume a single choice opportunity, called a single garbage can. On this assumption, both decision and access structures degenerate and a single garbage can model becomes an unsegmented version of the garbage can model (Takahashi, 1993). In order to connect those four variables, the original simulation model needs three key behavioral assumptions: Energy additivity assumption, energy allocation assumption, and problem allocation assumption. But the assumptions of energy and problem allocation to plural choice opportunities are not necessary since a single garbage can model has only one choice opportunity. Thus a simulation model can be very simplified since there is no need of connecting variables according to the second and third assumptions. Now only the first assumption is needed as follows:

Energy additivity assumption: As soon as the total effective energy equals or exceeds the sum of all energy requirements of the problems attached to it, a decision is made.

Moreover, we can further simplify the simulation model by using a random number generator. The original garbage can model does not use a random number generator but reads random numbers as data, and then it is not appropriate to long-run simulation. In fact, the number of time periods of their simulation is only twenty, which is insufficient as computer simulation. Hence, we make the following assumption.

Randomness assumption: (1) At each time period, the entrances and exits of participants are respectively characterized by positive and negative potential energy, a uniform random number. (2) At each time period, the entrances and exits of problems are respectively characterized by positive and negative energy requirements, a uniform random number.

Thus we develop a very simple computer simulation program. A BASIC version of our single garbage can model is given in the appendix. In this program, decisions are classified into three categories: Decision making by resolution, by oversight, and by flight. According to decision styles of Cohen et al. (1972), if some problems leave and the remainder are solved, this case is defined as decision making by resolution.

To exercise the model, the following are fixed: (1) The solution coefficient *SC*=1 (program line number 170); (2) The maximal number of decisions *MAXK*=10000 (program line number 180).

An analysis of the simulations shows three major properties of garbage can decision processes. First, the mean decision time which is defined as the number of time periods per decision is sensitive to variations in load. A load coefficient *LC* which operates on the energy requirement of the problem at each entry time actually realizes energy load (program line number 250). Any load coefficient can be set (program line number 160) and *LC* ranges from 0.1 to 1.5 in the exercise of the program. Table 1 and Figure 1 show that an increase in load coefficient increases the mean decision time.

INSERT TABLE 1, FIGURE 1, AND FIGURE 2 ABOUT HERE

Second, the proportions of decision styles, resolution and flight, are sensitive to variations in load. As Table 1 and Figure 2 show, an increase in the load coefficient generally increases the use of flight and decreases the use of resolution as stated by Cohen et al. (1972).

Third, but Table 1 and Figure 2 also show that the proportion of oversight is almost one third and stable with changes in load. In fact, the probability that the effective energy will become positive before problems become activated is independent of load, that is, the probability that a decision will be made by oversight is independent of load. A decision is made by oversight when energy required by problems, *ERP*, has been non-positive and energy from participants, *EP*, become positive. In our single garbage can model, a choice opportunity is considered to be activated when problems are attached to it or when participants provide some positive amount of potential energy to it, i.e., a choice opportunity is not activated if the energy required by problems, *ERP*, is non-positive and energy from participants, *EP*, is non-positive (program line number 280). Therefore the probability, P_0, that a decision will be made by oversight is calculated as follows.

$$
\begin{aligned}
P_0 &= \Pr\{EP > 0 \text{ and } ERP \leq 0 \mid EP > 0 \text{ or } ERP > 0\} \\
&= \Pr\{EP > 0 \text{ and } ERP \leq 0\} / \Pr\{EP > 0 \text{ or } ERP > 0\} \\
&= p(1 - q) / \{1 - (1 - p)(1 - q)\}
\end{aligned}
$$

where $p = \Pr\{EP > 0\}$, $q = \Pr\{ERP > 0\}$. Our simulation program fixes that $p = q = 1/2$. Then we obtain

$$P_0 = (1/4) / (3/4) = 1/3.$$

In fact, Table 1 indicates that the proportions of oversight are ranging between 0.3323 and 0.3437. It is notable that there exist such errors in the long-run simulations between the numbers of the time periods 16318 and 561532 in Table 1. These results probably stem from a garbage can assumption. But it does not always occur that an increase in load increases the use of oversight. Therefore we conclude that decision making by oversight is not sensitive to variations in load, and we focus our attention on decision making by flight. Thus, we obtain the following hypothesis.

Hypothesis: An increase in load increases the use of flight.

EMPIRICAL RESEARCH ON FLIGHT

Method

To test our hypothesis, we made surveys in 1991, 1992, and 1994. We selected 96 organizational units from the corporate divisions of 21 Japanese companies in total who were members of the Japan Productivity Center for Socio-Economic Development. We obtained 2476 white-collar workers' data from the questionnaires. The member companies of Japan Productivity Center are the biggest and representative firms of Japan. Most of them are listed on the First Section of Tokyo Securities Exchange and satisfy the high-level initial listing requirement.

In 1991, we selected six Japanese companies in the industries: railroad transportation (2), retail trade, electric service, telecommunication, banking. The respondent of each company was interviewed for approximately two hours to express corporate culture. This phase began in April, 1991 and was completed by August. The objectives of this phase were to develop the original questions and to specify groups of white-collar workers carrying heavy loads in the companies. We prepared an exhaustive list of frank statements of the phenomena of organized anarchy. Finally, we carefully revised all the items and prepared the selected list of 75 disjunctive yes-no questions. The original questionnaire was written in Japanese.

In 1991, we investigated all the white-collar workers in 30 organizational units of those six companies. The research was carried out from August 28 to September 2, 1991 through the delivery-collection and self-recording method. We obtained 907 respondents' data from the questionnaires (response rate was 89.2%). 87.2% were men, and an average age was 36.6 years. Through this survey, we selected eleven questions from among 75 questions by correlation analysis as is to be stated later.

In 1992, we investigated all the white-collar workers in 27 organizational units of seven Japanese companies in the industries: railroad transportation, hotels, construction, security, life insurance, consultant, computer. The research was carried out from September 2 to 7, 1992 through the delivery-collection and self-recording method. The questionnaires including selected eleven questions were completed by 740 white-collar workers (response rate was 89.6%). 76.4% were men, and an average age was 35.5 years.

In 1994, we investigated all the white-collar workers in 39 organizational units of eight Japanese companies in the industries: heavy industries, real estate development, railroad transportation, house building, construction consultant, computer, banking (2). The research was carried out from August 31 to September 5, 1994 through the delivery-collection and self-recording method. The questionnaires were completed by 829 white-collar workers (response rate was 93.7%). 72.0% were men, and an average age was 35.7 years.

In these surveys, we investigated the phenomena of decision making by flight in Japanese firms. Each respondent answered the following key question on flight:

Q0. When you can avoid completing your assigned tasks long enough, do they sometimes become unnecessary?: 1=yes, 0=no.

The ratio of "yes" to total respondents of question Q0 is called the *flight ratio*.

Results

Through the interviews in 1991, we succeeded to specify some groups of white-collar workers carrying heavy loads in the companies as follows.

Finding 1: The white-collar workers between the ages of 30 and 40 or the managers carry very heavy loads in the companies.

In fact, the pooled flight ratios of three surveys in Table 2 suggests a tendency of the managers to have a high flight ratio in comparison with the others. Moreover, the 30s exhibit a high flight ratio tendency, too. Thus, Finding 1 and Table 2 support our hypothesis. The flight ratio of managers between the ages of 30 and 39 (the shaded cells in Table 2) is 83.2% (= 114 / 137) in particular.

In total, the flight ratio is 63.4%. In all cells except for a few in Table 2, the flight ratios are greater than 50%. Thus, we obtain the following finding.

Finding 2: Decision making by flight is a regular feature of the usual decision processes of white-collar workers in Japanese firms.

INSERT TABLE 2 ABOUT HERE

In Search of Ambiguity

Now, let us examine the conditions of ambiguity. Through the correlation analysis of 75 questions using the data of 1991, we selected the highest correlated 10 questions with question Q0 as follows.

Q1. Are standards, rules and manuals used ineffectively?: 1 = yes, 0 = no. (V = 0.234)

Q2. If given the chance, would you like to change jobs?: 1 = yes, 0 = no. (V = 0.202)

Q3. Do you get orders from plural command structures?: 1 = yes, 0 = no. (V = 0.198)

Q4. Does your company have the atmosphere in which reaching the short-range norm tends to have priority over pursuing long-range goals?: 1 = yes, 0 = no. (V = 0.197)

Q5. Is your superiors' evaluation of your work appropriate and fair?: 1 = yes, 0 = no. (V = -0.195)

Q6. Does your company have the atmosphere in which discussions can be going on to gain mutual consent?: 1 = yes, 0 = no. (V = -0.188)

Q7. Are your true feelings more often voiced outside your company than during working hours?: 1 = yes, 0 = no. (V = 0.186)

Q8. Is there the tendency of your superiors to evaluate you in terms of personal likes and dislikes rather than by your actual performance and contributions?: 1 = yes, 0 = no. (V = 0.173)

Q9. Are the discussions further followed by working solutions with organizing special committees, "nemawashi", etc.?: 1 = yes, 0 = no. (V = -0.170)

Q10. Are your job targets clearly specified by your superiors?: 1 = yes, 0 = no. (V = -0.169)

Cramer's Vs are within parentheses. All the coefficients are statistically significant at level 0.001. For 2×2 cross tabulations, we obtain that Cramer's $V = \phi$ = Pearson's r = Kendall's τ_b (Upton, 1978; Takahashi, 1992a).

In 1992, using the questionnaire including eleven questions Q0 and Q1 to Q10, the research was carried out. In order to explain the flight ratio by ambiguity, it is the company rather than the person that serves as the unit of analysis. For each company, the ratio of "yes" to total respondents in question Qi is denoted by X_i, i=0,...,10. Thus, the flight ratio is denoted by X_0. Table 3 details descriptive statistics and correlation coefficients among these variables. Multicollinearity does not appear to pose a problem, as only seven out of possible 45 correlation coefficients are significant.

INSERT TABLE 3 ABOUT HERE

With respect to question Q7, in 1992, some company pointed out that frank discussions could be elicited outside company *and* during working hours. Therefore we conclude that question Q7 is inappropriate to such a company and that, by dropping variable X_7, we would attempt to explain the flight ratio by nine independent variables.

To examine March & Weissinger-Baylon's (1986) conditions of ambiguity, from among these nine questions, we select questions that can be related to their conditions. However, five questions do not have a direct relationship to their ambiguity. Only four questions Q1, Q3, Q4, and Q10 can be related to their conditions of ambiguity as follows:

(i) Objectives, technology, or experience are unclear: Q1 and Q10.

(ii) Solutions and problems are joined together partly because of their simultaneous availability: Q4.

(iii) The attention of decision makers is attenuated by the existence of multiple simultaneous demands on their time: Q3.

By using the data of thirteen companies (six companies in 1991 and seven companies in 1992), we regress X_0 on X_1, X_3, X_4, and X_{10}. The estimated coefficients are given in Table 4. But only the coefficient of X_1 is significant at level 0.05. The values of R^2 and F are very small; that is, the result is not significant at level 0.10 and then this model is unsatisfactory.

INSERT TABLE 4 ABOUT HERE

Therefore, their conditions of ambiguity are inappropriate to predict the occurrence of the garbage can phenomenon, and then the problem of selecting independent variables for a regression equations becomes an important one. A regression equation may be used to describe the relationship between the flight ratio and ambiguity. For this use there are two conflicting requirements: (i) to explain as much of the variation as possible, and (ii) to describe the relationship with as few variables as possible (Chatterjee & Price, 1977). In the present study, we try to choose the smallest number of independent variables that explains the most substantial part of variation in the flight ratio.

We attempt to fit all possible subset equations to a given body of data. With nine variables the total number of equations fitted is $2^9=512$ including an equation of all the variables and an equation of no variables. This method of all subset regressions clearly gives us the maximum amount of information. When using this method, the most promising are isolated using either Mallows' C_p or AIC (Akaike Information Criterion).

By using this method, we find that the equations with small C_p ($C_p < 5$) contain two to six independent variables. For each number of independent variables, we select the greatest R^2 equation and the second greatest R^2 equation and then we obtain Table 5. Using C_p, we select equation (3). According to AIC, we select equation (3) or (5), where the difference of AIC between equations (3) and (5) is only 1.06 and is not supposed to be statistically significant (Sakamoto, Ishiguro, & Kitagawa, 1983). Equation (5) is obtained by adding X_5 to equation (3), but the coefficient of X_5 in equation (5) is not significant at level 0.10. Therefore equation (3) is considered as the best regression equation. As shown in Table 6, the value of R^2 of regression equation (3) is 0.7859 ($F = 11.013; p = 0.0023$), which is higher than that of Table 4, although equation (3) contains only three independent variables.

INSERT TABLE 5 AND TABLE 6 ABOUT HERE

Regression equation (3) suggested that the organization would have a high flight ratio when

(i) Fluid participation: The members would like to change jobs if given the chance (X_2);

(ii) Divorce of solution from discussion: The discussions may not be further followed by working solution (X_9);

(iii) Job performance rather than subjective assessments: There is the tendency to evaluate the subordinates by their actual performance and contributions rather than in terms of personal likes and dislikes (X_8).

These new conditions are quite different from March & Weissinger-Baylon's conditions of ambiguity. In comparison with their original conditions, our new conditions are clearly related to the assumption of the garbage can model specified as computer simulation. Conditions (i) and (ii) are essential to the simulation model of the garbage can. Although condition (iii) has never been pointed out by the preceding studies of the garbage can model, to attach great importance only to the job performance is a necessary condition that decision making by flight is a major feature of the decision process. In practice, job performance is associated with criteria that are measurable, and flight is less easily measured. The result of an obsession with job performance is the measuring of tangible contributions at the expense of intangible flight. If the superior makes subjective assessments of his subordinate's job quality, then problems are severely restricted in movement and decision making by flight is also severely restricted.

Degree of Anarchy

Now, let us develop a measure of the degree of organized anarchy by using our new conditions of ambiguity. From Table 6, all the absolute values of coefficients of regression equation (3) are ranging from 0.41 to 0.57, and they are at the almost equal level. Thus we can conclude that the degree of anarchy is calculated as the equally weighted sum of X_2, $(1 - X_8)$, and $(1 - X_9)$, where $(1 - X_8)$ and $(1 - X_9)$ denote the ratios of "no" to total respondents and we use them since X_8 and X_9 have negative coefficients in equation (3). Therefore the *degree of anarchy* (*DA*) is defined and calculated as follows:

$$DA = X_2 + (1 - X_8) + (1 - X_9).$$

DA is ranging between 0 and 3.

INSERT FIGURE 3 AND TABLE 7 ABOUT HERE

Using the data from 21 companies in 1991, 1992, and 1994, we calculate the degree of anarchy and then obtain the graph of the flight ratio versus the degree of anarchy (*DA*) in Figure 3. This figure indicates positive correlation ($r = 0.707$; $p = 0.0003$). A linear model is fitted to the data and we regress the flight ratio on *DA*. The estimated coefficients are given in Table 7, and the coefficient of *DA* is significant at $p = 0.0003$. The value of R^2 in Table 7 indicates a linear relationship between the flight ratio and *DA*. Thus we obtain the following finding.

Finding 3: If a company's degree of anarchy based on our new conditions of ambiguity is enhanced, its flight ratio increases, and vice-versa.

Furthermore, Figure 3 shows that public corporations and public utilities have low degrees of anarchy and low flight ratios. In other words, the organizations characterized by the low degree of anarchy actually maintain relations vassalage to the government.

On the other hand, from our empirical observations, we can conclude that Japanese universities would meet our new conditions of ambiguity and would be characterized by the high degree of anarchy. Cohen et al. (1972) originally developed the garbage can model to describe universities, which are characterized as organized anarchy. We made one revolution round the Japanese companies in this study, and we return to the organizations of its origin. The more completely the organization meets our new three conditions which display the characteristics of universities, the more frequently decision making by flight occurs in it.

DISCUSSION

Lutz (1982) argues that garbage can processes inhibit efficiency and responsiveness and greatly increase the likelihood of failure. But our surveys revealed that decision making by flight was a regular feature of the usual decision processes of white-collar workers in Japanese firms (Finding 2). Computer simulation showed that an increase in load increased the use of flight (Hypothesis) when the organization had a high degree of anarchy. Decision making by flight was a natural and frequent phenomenon under such conditions. If an organization's degree of anarchy was enhanced, its flight ratio naturally increased (Finding 3). Therefore we observed a linear relationship between the flight ratio and the degree of anarchy.

Several companies of the investigated 21 companies further reported on the function of flight that in the overloaded situations, the superiors allowed their subordinates to sidetrack the problems rated as low priority. This is the heart of training for general management. And this is exactly how decision making by flight is intended not to be restricted severely in Japanese firms.

This means also time and labor saving (Takahashi, 1992b). If decision making by flight is severely restricted, it is natural that the organization cannot work smoothly and satisfactorily under the heavy load from a consideration of bounded rationality (Simon, 1947; March & Simon, 1958). Therefore, high flight ratio would not mean the much likelihood of failure in the organization under the favorable conditions of competent organizational members. In fact, it is directly responsible managers for efficiency who have a high flight ratio in comparison with the others in Japanese firms as indicated in Table 2.

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APPENDIX: A SINGLE GARBAGE CAN MODEL

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110 '**************************************************************************
120 '*  A Single Garbage Can Model  Version 2.2  Feb.1,1995                   *
130 '**************************************************************************
140 '*************** Initialization ******************************************
150 I=0: RESOLUTION=0: OVERSIGHT=0: FLIGHT=0
160 LC=1                    :'LC=Load Coefficient of ERP
170 SC=1                    :'SC=Solution Coefficient to deflate EE
180 MAXK=10000              :'MAXK=Number of decisions to be exercised
190 '*************** Garbage Can Process ************************************
200 J=0:TEE=0:ERC=0         :'to reset garbage can
210 I=I+1:J=J+1
220 EP=RND-0.5              :'EP=Energy from Participants    EP=I[-0.5,0.5)
230   TEE=TEE*SC+EP         :'TEE=Total Effective Energy
240   IF TEE<0 THEN TEE=0
250 ERP=LC*(RND-0.5)        :'ERP=Energy Required by Problems  ERP=LC*I[-0.5,0.5)
260   ERC=ERC+ERP           :'ERC=Energy Required by Choice
270   IF ERC<0 THEN ERC=0
280 IF J=1 AND TEE=0 AND ERC=0 THEN I=I-1:GOTO 200:'Case of no entry
290 IF TEE<ERC                   THEN        GOTO 210:'Case of no decision
300 '************** Summary Statistics ***************************************
310 IF J=1 AND TEE>0 AND ERC=0 THEN OVERSIGHT=OVERSIGHT+1   :GOTO 340
320 IF J>1 AND TEE>0 AND ERC=0 THEN FLIGHT=FLIGHT+1         :GOTO 340
330                                 RESOLUTION=RESOLUTION+1
340 K=RESOLUTION+OVERSIGHT+FLIGHT             :'K=number of decisions
350 IF K<MAXK THEN GOTO 200
360 PRINT K;I;RESOLUTION;OVERSIGHT;FLIGHT
370 STOP
380 RUN
```

Table 1

Proportions of Decision Styles by Load

(Solution Coefficient: $SC = 1.0$; The Number of Decisions: $K = 10{,}000$)

Load Coefficient (LC)	Mean Decision Time*	Decision Style Proportion (%) By Resolution	By Oversight	By Flight
0.1	1.6318	59.93	33.33	6.74
0.2	1.7266	59.70	33.28	7.02
0.3	1.8805	59.30	33.38	7.32
0.4	2.0915	58.65	33.70	7.65
0.5	2.3975	58.24	33.82	7.94
0.6	2.9683	57.56	34.23	8.21
0.7	3.5887	57.27	34.09	8.64
0.8	4.2061	57.22	33.42	9.36
0.9	5.4675	56.73	33.38	9.89
1.0	8.0929	56.09	33.43	10.48
1.1	11.4212	55.65	33.23	11.12
1.2	15.6606	55.04	33.39	11.57
1.3	19.6435	54.30	33.54	12.16
1.4	29.8381	53.78	33.43	12.79
1.5	56.1532	52.41	34.37	13.22

* Mean decision time = the number of total time periods / the number of decisions.

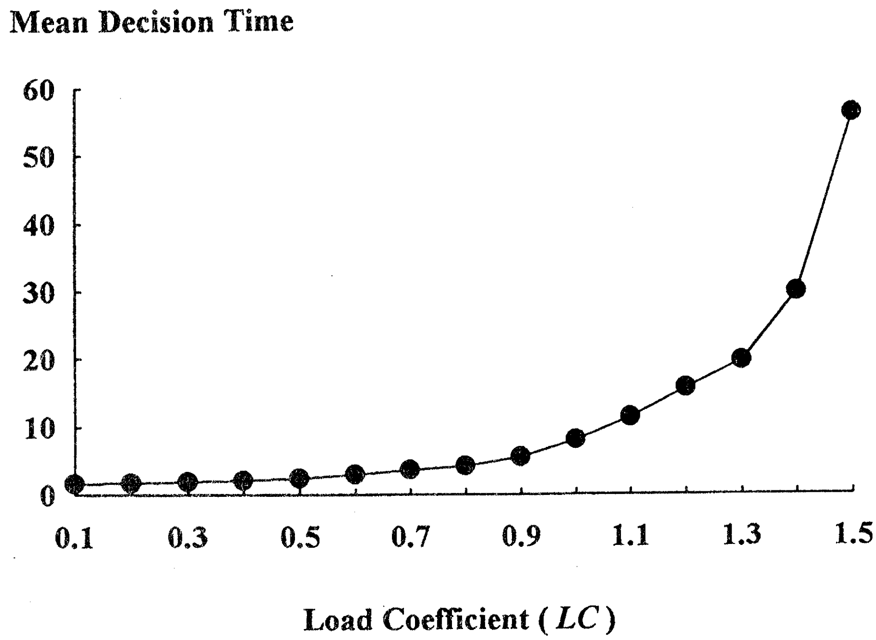

Figure 1

Mean Decision Time by Load

(Solution Coefficient: *SC* = 1.0; The Number of Decisions: *K* = 10,000)

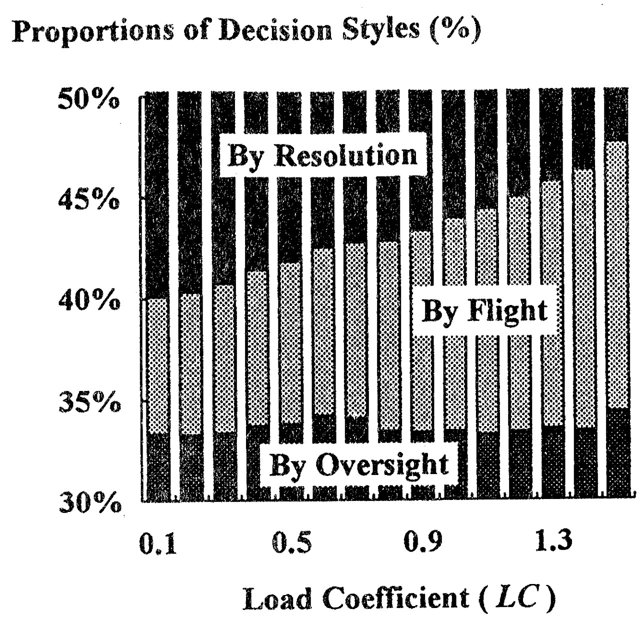

Figure 2

Proportions of Decision Styles by Load

(Solution Coefficient: $SC = 1.0$; The Number of Decisions: $K = 10{,}000$)

Table 2

Flight Ratios in Percentages for Position and Age Categories

Age	Position				
	General Manager	Manager	Chief	Ordinary	Total
20-24			100.0 (5)	47.6 (288)	48.5 (295)
25-29		100.0 (7)	80.0 (70)	43.3 (448)	68.0 (525)
30-34		87.0 (46)	74.4 (156)	64.2 (179)	71.1 (381)
35-39	75.0 (12)	81.3 (91)	67.9 (137)	70.3 (64)	72.7 (304)
40-44	76.3 (38)	66.2 (136)	58.8 (97)	60.6 (66)	64.1 (337)
45-49	71.4 (35)	55.3 (103)	55.1 (78)	51.3 (39)	56.9 (255)
50-54	55.3 (47)	61.1 (72)	46.6 (58)	56.3 (16)	54.9 (193)
55-	30.0 (20)	61.5 (13)	58.3 (12)	66.7 (15)	51.7 (60)
Total	62.5 (152)	68.4 (468)	65.9 (613)	60.1 (1115)	63.4 (2348)

The numbers of respondents are within parentheses.

The pooled flight ratio of the shaded cells is 83.2% (= 114 / 137).

Table 3

Descriptive Statistics and Correlation among Variables

	Mean	S.D.	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	0.579	0.120									
X_2	0.447	0.137	0.365								
X_3	0.582	0.091	0.487	-0.047							
X_4	0.770	0.098	0.623 *	0.290	0.672 *						
X_5	0.718	0.069	-0.018	-0.369	-0.340	-0.660 *					
X_6	0.423	0.102	0.135	0.024	-0.252	0.118	0.084				
X_7	0.518	0.087	-0.360	0.067	0.074	0.009	-0.481	-0.491			
X_8	0.433	0.087	-0.505	-0.037	-0.153	-0.125	-0.398	-0.084	0.611 *		
X_9	0.377	0.093	0.135	-0.332	0.099	0.118	0.130	0.585 *	-0.769 **	-0.262	
X_{10}	0.581	0.099	0.183	-0.346	0.008	-0.332	0.647 *	0.142	-0.460	-0.019	0.357

* $p<0.05$; ** $p<0.01$.

Table 4

Regression Analysis of Flight Ratios

Variable	Coefficient	Standard Error	t	Significance
X_{10} Specified job targets	-0.6948	0.3151	-2.205	$p = 0.0585$
X_1 Ineffective manuals use	0.7898	0.2980	2.651	$p = 0.0292$
X_4 Short-range norm	-0.4122	0.4728	-0.872	$p = 0.4087$
X_3 Plural command structure	-0.0905	0.3710	-0.244	$p = 0.8135$
Constant	0.9715	0.3176	3.059	$p = 0.0156$

$R^2 = 0.5760$ Adjusted $R^2 = 0.3640$ $F(4,8) = 2.717$ $p = 0.1068$

Table 5

Criteria for Evaluating Regression Equations

Independent Variables	R^2	AIC	C_p
(1) X_2, X_8	0.6715	85.41	1.395
(2) X_2, X_1	0.6001	87.97	3.221
(3) X_2, X_8, X_9	0.7859	81.85	0.471
(4) X_2, X_8, X_6	0.7146	85.58	2.293
(5) X_2, X_8, X_9, X_5	0.8307	80.79	1.325
(6) X_2, X_8, X_9, X_4	0.8166	81.84	1.687
(7) $X_2, X_8, X_9, X_5, X_{10}$	0.8536	80.91	2.742
(8) X_2, X_8, X_9, X_5, X_1	0.8444	81.70	2.977
(9) $X_2, X_8, X_9, X_5, X_3, X_{10}$	0.8703	81.33	4.313
(10) $X_2, X_8, X_9, X_5, X_6, X_{10}$	0.8628	82.06	4.506

Table 6

Regression Analysis of Flight Ratios: Regression Equation (3)

Variable	Coefficient	Standard Error	t	Significance
X_2 Fluid participation	0.4378	0.1237	3.540	$p = 0.0063$
X_8 Subjective assessments	-0.5709	0.1911	-2.987	$p = 0.0153$
X_9 Discussion followed by solution	-0.4149	0.1892	-2.193	$p = 0.0560$
Constant	0.8636	0.1508	5.725	$p = 0.0003$

$R^2 = 0.7859$ Adjusted $R^2 = 0.7146$ $F(3,9) = 11.013$ $p = 0.0023$

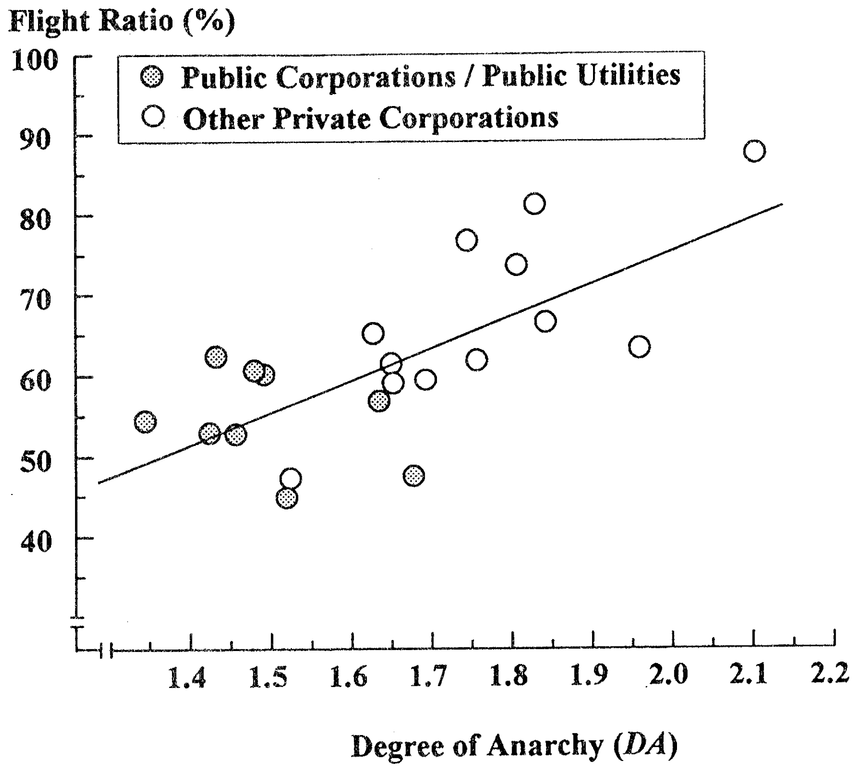

Figure 3

Graph of the Flight Ratio Versus the Degree of Anarchy ($r = 0.707$; $p = 0.0003$)

Table 7

Regression Analysis of Flight Ratios

Variable	Coefficient	Standard Error	t	Significance
Degree of Anarchy (*DA*)	0.4001	0.0918	4.356	$p = 0.0003$
Constant	-0.0433	0.1526	-0.284	$p = 0.7795$

$R^2 = 0.4996$ Adjusted $R^2 = 0.4733$ $F(1,19) = 18.972$ $p = 0.0003$

BIOGRAPHICAL NOTES

Nobuo Takahashi received a Ph.D. from the University of Tsukuba and is Associate Professor of Management Science at the Faculty of Economics, the University of Tokyo. His interests are in organization design, decision process models, and organization development. He has published papers in *Human Relations, Behavioral Science, European Journal of Operational Research, Omega,* and other journals. He is the author of the book *Design of Adaptive Organizations* from Springer and five books in Japanese.