Computational & Mathematical Organization Theory 3:2 (1997): 113–142

Adapting to the Changing Environment: A Theoretical Comparison of Decision Making Proficiency of Lean and Mass Organization Systems

ZHIANG LIN AND CHUN HUI
Department of Management of Organizations, School of Business and Management, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong
email: zh1h@corfu.heinz.cmu.edu; mnhui@uxmail.ust.hk

Abstract

In this paper we examine the adaptability of the Japanese style lean organization system and the traditional American style mass organization system under changing environments. From an organizational design perspective, key structural aspects of the two organizations are modeled in a problem solving context using computational methods. Organizational-level performance in terms of decision making accuracy and severity of errors is measured as an indicator of organizational adaptability under conditions where the task environment shifts between predictable to unpredictable or vise versa. Our study shows that both organizations have their respective advantages under different task environments and that they adapt to environmental shifts in different forms. Specifically, when the time pressure is high the lean organization system's performance is virtually identical to the mass organization system, even though the lean organization system's members are more proactive. When the time pressure is low, the mass organization system shows a much faster adaptability when the environment shifts to a predictable one but it is also more vulnerable when the environment shifts to an unpredictable one. In contrast, the lean organization system's response to the changing environment is characterized by its slower adaptability. When the environment shifts to an unpredictable one, the lean organization system shows a gradual improvement till reaching a high level. When the environment shifts to a predictable one, however, the lean organization system shows a gradual decrease of performance. Our study further shows that the lean organization system, with its strong team decision making emphasis, can be more successful in avoiding severe errors when compared with the mass organization system, even under a predictable task environment.

Keywords: organizational design, environmental change, computer simulation, adaptation, organizational learning

1. Introduction

Organizational adaptation has been an important topic in organizational learning, organizational change and development. In recent years, the importance of organizational adaptation has been further emphasized due to the increasing globalization processes and technological advances. In fact, it has been argued that organizational adaptation is the key to success for modern organizations (De Geus 1988), and that organizations must adapt or die (Wick 1995). Despite the general interest in organizational adaptation and some occasional assertions, the adaptability of two important organizations: the Japanese style lean organization system and the traditional American style mass organization system, has not been systematically studied, nor under conditions when the environment shifts. Though there have been claims that the lean organization system is superior than the mass organization system in all aspects (Womack et al. 1990), much evidence has been presented in fragmented case forms and focused mainly on technical aspects. Moreover, environmental conditions are often either ignored or assumed as unchangeable. In this paper, we wish to fill this gap and examine the adaptability of lean and mass organization systems with regard to their decision making proficiency in different changing environments. We first highlight the structural designs of the two organizations. Then we examine how these two systems perform as the environment shifts using a computational model. We believe such a systematic analysis will also enhance our understanding not only of the two important organization systems but also broader issues of how organizational design affects organization's adaptability.

2. Research Background

2.1. Organizational Adaptation

Organizations often operate in a changing environment. To survive, organizations have to understand and adapt to such changes (Milliken 1990; Weick 1987). Organizational adaptation can be regarded as the effort by the organization to fit the environment. Organizations, however, can take different forms in their adapting to the environment. Organizational adaptation can range from small changes reflected in individual members' actions to radical overall restructuring on the part of the organization. Most of the time, however, organizations tend to have structural inertia (Hannan and Freeman 1977), that is, they tend not to change dramatically, even when the environment changes (Milliken 1990). Often, organizations can take a more exploitative form in which they try to refine their current features to adjust to the environment (March 1991).

Organizational adaptation is often reflected through the change of organization's knowledge bases, which are also embedded in individual members' memories and can be updated through learning (Epple et al. 1991; Hutchins 1991; Simon 1991). Organizations use learning as a fundamental action in their response to environmental changes (Theresa et al. 1991; Weick 1984). To adapt successfully, an organization must learn well. Researchers have repeatedly linked organizational effective adaptation to organizational learning (Fiol and Lyles 1985; Sammon et al. 1984).

No matter how organizations change their designs and learn form their experiences in the face of environmental changes, whether they can truly be successful in their adaptation to the environmental change may be only judged by their performance (Huber 1991; Weick 1991). In the present study, we examine adaptation in terms of how accurate an organization's decisions are in responding to challenges posted by different changing environments. We do not assume that learning is a conscious activity (Huber 1991). However, we assume that organizations learn from its experience in that current decisions are affected by previous decisions (Levitt and March 1996).

While in this study we focus on learning as the fundamental action organizations take to adapt to the environmental change, our results can also provide implications to structural changes as we contrast two forms of organizations through a comparative static mode. In our future research, we will also address continuous structural changes as a means for organizational adaptation.

2.2. Organization System

Conceptualization of how an organization may respond to changing environments may stem from either a piecemeal or a systematic analysis. Piecemeal analysis focuses on how specific components or departments of an organization respond to changes. For example, the marketing department may respond to changing demands and tastes of customers in terms of specific measures or actions to address the issue. Systematic analysis, on the other hand, focuses on how the organization as a whole responds to changes. For example, the organization can be structured in such a way that prompt response to environmental changes can be obtained. In this study, we focus on organizational level performance by taking an open system approach (Thompson 1967).

An organizational system serves to coordinate various activities including production activities within an organization to achieve organizational goals (Daniel and Reitspergers 1992). While organizational control can take a number of forms, it is fundamentally manifested in how an organization is designed (Scott 1987). Organizations assign roles, design procedures, and provide feedback for their members, thus facilitating the coordination of efforts and enabling the accomplishment of collective outcomes (Coleman 1990). While organizations can design their structures, they also have to operate within the larger context of their environments (Scott 1987; Thompson 1967). Organizational environments provide organizations with opportunities and constraints. Thus, functionality of particular structural characteristics can and need to be examined in terms of their performance under organizational environments, with which the organization continuously interacts.

Organizations' responses to the environment, on the other hand, can be seen as a series of problem solving activities (Daft and Weick 1984; Scott 1987). Problem solving is about decision making. Problem solving emphasizes the flow of information, which has been regarded as the most critical aspect in connecting components of organizations (Scott 1987). Thus, the problem solving characteristics of an organization such as attitude towards problems should also affect the interplay between the environment and the structure of the organization.

To understand organizational adaptation, it is thus important to understand both the structural characteristics of the organization system and the problem solving characteristics of its members.

2.3. Lean and Mass Organization Systems

With the upsurge of the Japanese manufacturing companies in the eighties, much attention has been paid to the production techniques employed by these firms. Many studies have examined aspects of the Japanese production methods (Davy et al. 1991; Feigenbaum 1991; Reitsperger and Daniel 1990). Some researchers have proceeded to claim that the Japanese lean production technique will replace the American mass production technique "in all areas of industrial endeavor to become the standard global production system of the twenty-first century" (Womack et al. 1990: 278).

Despite the emphasis on the relative advantages of the Japanese and the American production techniques, relatively little research has been conducted to explore the corresponding management control systems of an organization that monitor these production systems.

There also exist concerns regarding the true superiority of the Japanese lean production technique under all situations (Porter 1990). Indeed, much evidence for the superiority of the Japanese lean production technique has been presented in fragmented forms with exclusive focus on the technical aspects within closed settings. As a result, systemic and coherent insights have been lacking regarding how, why, and when such production techniques may (or may not) be effective in a globally changing environment.

We believe, however, that the success or failure of the adoption of a production technique does not lie exclusively in the technical aspect itself. More importantly, without a good organizational control system, production technique alone will not succeed (Woodward 1958). The importance of organizational control in the success of technical productions has prompted researchers to look at lean and mass production as not just two techniques but two broadly integrated organizational systems (Scott 1987; Daniel and Reitsperger 1991). It is thus the objective of this study to systematically compare the relative performance of the Japanese lean and the American mass production techniques as embedded in two organizational systems. Instead of examining the effects of differential impact of classic structural characteristics on organizational adaptation, we focus on their organizational design and problem solving characteristics.

The lean organization system holds the key to the success of Japanese corporations, according to many management researchers (e.g., Womack et al. 1990). This system is originated from the Toyota production system, and covers more than just technical production methods and systems. In fact, some have argued that lean organization system is more appropriately a subject matter of management journals than operations journals because of its "systematic" perspective on understanding organizations (Imai 1986). The mass organization system, on the other hand, is associated with American organization systems, which is originated from Ford's production system. While there may be different versions of the two organizations, our objective is to build models or theories from an organizational design perspective to study how two prototypical systems behave in different environments, which can also have implications to other forms of organizations.

2.4. System Characteristics of Lean and Mass Organizations

Structural characteristics (Pugh et al. 1963; Daft 1982) have been related to outcomes such as problem solving proficiency of organizations (e.g., Houskisson and Galbraith 1985; Lin and Carley 1997) and organizational innovations (Daft 1982). Of the various structural characteristics examined, complexity, formalization, and centralization have been regarded as fundamental aspects of organizational structure (Daft 1982). These aspects are important because they capture the fundamental nature of how organizations coordinate and control the activities of members, which in turn can greatly impact the outcomes of organizations. With respect to the problem solving characteristic, we study whether the organizational members' attitude towards problems is proactive or reactive. Organizational operations are none other than problem solving activities (Scott 1987). Problem solving attitude can influence the way in which organizational members interact with each other, approach problems, and make decisions (Parsons 1956; Blumberg 1987; Abramson et al. 1993).

These three structural and one decision making characteristic underline the fundamental differences between lean and mass organization systems. In terms of structural characteristics, lean organizations favor team approach and are lower in complexity, formalization, and centralization than mass organizations (cf., Womack et al. 1990). In other words, lean organizations are similar to organic organizations in terms of structure (Burns and Stalker 1961; Courtright et al. 1989). However, not all organic organizations are like lean organizations because of different decision making orientations. Lean organizations are more proactive whereas mass organizations are more reactive in decision making. Lean organizations are structured in such a way that no waste is allowed, workers (of different horizontal and vertical positions) are supposed to be highly linked to each other, and that all workers are expected to anticipate and solve problems. Thus, in lean organizations complexity, formalization, and centralization are low to allow for more free flowing of information, and to encourage more employee involvement and participation. Decision making is supposed to be proactive such that the operating systems may be protected from interruptions and break downs as much as possible.

Mass organizations, on the other hand, adopt a different management logic. The key of mass organizations is the high interchangeability of the components within rank in the system (Womack et al. 1990). Lower level workers, in particular, are not expected to be problem solvers. Instead, they are semi-skilled and are supposed to handle only small scope jobs. In this case, formalization is high to ensure interchangeability of the workers. Complexity is high as the organization gets bigger, because more specialized jobs and more vertical command levels have to be created. Since lower employees are not expected to be problem solvers, professional problem solvers (e.g., engineers) have to be hired. The creation of ranks between professionals and semi-skilled workers intensifies centralization. The decision making orientation of most mass organizations is reactive. Since the components of the system are interchangeable within rank, to ensure an operating system requires only post hoc repairs. Thus, it is not imperative for problem solvers to be proactive.

Table 1 has listed a summary of literature reviews of the contrasting characteristics between lean and mass organizations examined in the present study. Without doubt, lean and mass organization systems may have, to varying degrees, differ from the prototypes examined in the present study. Also, there may be other structural and problem solving characteristics that are omitted in the present study. It is not, however, our intent to be inclusive of all characteristics. Instead, model or theory building is best served when one begins with prototypes that represent stylized cases, and examine how these prototypes behave under various conditions. In the present study, we are interested in how the structural components and the problem solving orientations of two organization systems affect organization level decision making. We used the lean and the mass organizational system because results of the present study can be more readily interpreted in the context of real world organizational systems. Thus, our prototypes for the two organization systems are not, and need not be, identical to any given organizations in real life, even though our findings have implications for understanding real life organizational systems. We do argue, however, that the structural and problem solving characteristics of lean and mass organizations examined in the present study are representative of the stylized states of existence of these organizations.

Table 1. Lean and mass organization systems: An organizational design comparison from the literature.

	Lean organization system	Mass organization system
Complexity	Emphasizes leanness or no waste in structure (Cusumano 1988; Womack et al. 1990; Berggren 1992)	Allows complex and redundant structure (Womack et al. 1990)
	Fewer functional hierarchical levels (Wakabayashi and Graen 1991)	More hierarchical levels and more differentiated divisions (Cusumano 1988; Peters 1988; Womack et al. 1990)
Formalization	Emphasizes teamwork (Womack et al. 1990; Rehder 1992; Hogg 1993)	Emphasizes high division of individual labor (Weber 1947; Rehder 1992)
	Flexible job responsibilities (Rehder 1992)	Strict rules for individual job responsibilities (Drucker 1987; Walton and Susman 1989)
	Encourages multiple job skills and expertise (Womack et al. 1990; Rehder 1992; Hogg 1993)	Discourages multiple job skills (Drucker 1987; Walton and Susman 1989)
Centralization	Lateral communication is encouraged and decisions are made collectively on a team basis (Maguire and Pascale 1978; Womack et al. 1990)	Communication and decision making are based on strict vertical individual command chain (Womack et al. 1990; Zetka 1992)
	Encourages participation from lower-level employees and lateral-level co-workers (Haire et al. 1966; Maguire and Pascale 1978; Pascale 1978; Bass and Burger 1979; Hull and Azumi 1988; Womack et al. 1990)	Discourages participation from lower-level employees or lateral-level co-workers (Womack et al. 1990; Zetka 1992)
Decision making attitude	Workers actively search for problems (Takamiya 1969; Womack et al. 1990)	Workers passively wait for problems to happen (Takamiya 1969; Womack et al. 1990)
	Workers are trained to tackle problems (Lorriman and Kenjo 1994)	Workers are trained to pass rather than to tackle problems (Womack et al. 1990)

2.5. Environments

Organizations exist in changing environments, whether such changes are small or dramatic. Though organizations often fail to recognize such changes and prefer to be in their established environments, it is imperative that organizations adapt to environmental changes in order to achieve better performance or even survive (Milliken 1990). Organizational environment changes in many aspects. The most outstanding aspect is perhaps the change of its uncertainty as organizations progress with time. Such change can also vary in speed (Bourgeois and Eisenhardt 1988). With a fast shift in the nature, the environment puts additional time pressure on the part of the organization as a more timely response is often required for organizations to survive. In the present study, we focus on two aspects of environments: predictability (or certainty) of the environment and time stress.

2.5.1. Predictability. Task environments are forces outside the organization's control and affect organization's performance (Aldrich 1979). Predictability is perhaps the most examined issue in task environment, and is highly related to environmental certainty/uncertainty (Milliken 1987, 1990). It can refer to such things as variation of customer demands, market fluctuation, or change in technology, and can affect organization's survival (Koberg 1987; Lysonski et al. 1989). In a predictable environment, one type (or only a limited number of types) of task (e.g., customer demand) is dominant and the interrelationships among production components are less dependent, thus the environment is more stable, more routine in nature, and is more certain to the organization. In an unpredictable environment, multiple types of tasks (e.g., more variety of customer demand or more competition) can often occur, and there are strong interdependence among various components to handle the tasks, thus the task environment is more unstable, more non-routine in nature, and is more uncertain to the organization.

The requirement for organizational adaptability is much more modest in predictable than in unpredictable task environments. In predictable environments, organizational adaptability is optimal when the known environment demands are met by the system. More importantly, since no new changes or unexpected events are anticipated, no resources have to be committed to handle environmental fluctuation. Thus, the focus of organizational adaptation can be on minimizing disturbances from within the system. On the other hand, the requirement for organizational adaptation is much higher in unpredictable environments. To ensure adaptability, minimizing internal disturbances would not suffice. Instead, organizational systems must possess the capability to respond to uncertainties in environments.

Organizations will face even greater uncertainties when the environment changes its nature, for example from a predictable to an unpredictable one. Organizations' prior knowledge may become obsolete or may even hamper organizational responses. In this case, organizational adaptation requires more efficient processes to mobilize all resources to satisfy the demands of new environmental changes and to anticipate such changes.

2.5.2. Time Stress. While unpredictability exerts stress on organizations, organizations are also frequently encountered with the challenge of making not just correct decisions but timely ones. Time stress has been an important fact in human decision making (Orasanu and Salas 1992). In this study, time stress is resulted from the time requirement of the environment for organizations to make correct decisions and respond to the problems. An environment can exert a lot or only very little time stress on the organization. In low stress situations, organizations have ample time to respond to challenges in the environment. On the other hand, in high stress situations, organizations have little time to respond to challenges in the environment. Usually, organizations need to have more effective and efficient adaptability systems to handle high than low time stress environments. It is conceivable, however, that in extremely high time pressure environments, organizational systems would fail because they are overwhelmed.

Modern organizations, however, are particularly likely to be confronted with the challenge of responding in a timely manner to stay competitive. For example, in highly volatile industries where supplies have to be adjusted constantly to meet demands, the time it takes to respond to a problem situation is crucial (Hogg 1993). One such industry is the financial investment industry. Wall Street mutual fund managers or investment bankers have to monitor the market closely and be able to respond immediately to market situations. Environment is a broad concept, which may include political, economic, and labor environments, among others.

While we describe time stress and environmental change in separated forms, they are also highly associated with each. Time stress becomes especially critical when organizations are under environmental changes, as such changes often require highly timely response from the organization, thus adding additional pressure on the organization (Gupta and Wilemon 1990). Thus, even though we treat environmental shift as taking the same amount of time, we can still examine how organization adapt under relatively low or high speed transition of the environment (Bourgeois and Eisenhardt 1988).

In this paper, we examine how the lean and mass organizational systems perform in changing environments. We wish to explore how structural characteristics and organizational environments interact to produce intended organizational outcomes. In fact, the lean organization system has been specifically praised for its capability of adapting to the changing environment (Cusumano 1988; Womack et al. 1990). On the other hand, one of the major criticisms of the decline of the American automobile industry in the eighties is that the Americans were standing still while the Japanese were constantly learning to improve their own organization system to meet the global competition (e.g., Cusumano 1988). Thus, an examination of how different organizational systems behave in changing environments would greatly enhance our understanding of organizational adaptability.

3. Model

In the present study, we use a computer modeling approach to examine the decision making proficiency of the lean and the mass organizational systems in changing environments. Given the facts that many environmental settings are impossible to manipulate in the real world, various relationships among multiple factors are not expressible in mathematical forms, and the focus has been mainly on structural relationships, we believe our approach is not only feasible but also necessary. Rooted in organizational theory, we use computational techniques to model organizations as composed of members who can process information with their bounded rationality but are also constrained by organizational structures and affected by organizational environments (Baligh et al. 1996; Jin et al. 1995; Lin and Carley 1997). Through this approach, we can fully control the organizational environment and generate systematic and precise insights from the model. Researchers in organization science have produced some powerful results using computational techniques on organizational design issues (e.g., Carley and Prietula 1994; Jin et al. 1996; Lant and Mezias 1992).

In the following sections, we will briefly describe the structural relationships among the major parts of the model: task environments, organizational designs, and decision making outcomes. This model is revised based on the model developed by Lin and Carley (1995), where detailed description of the task can be found. The complete program is written in C language. The source code can be obtained from the authors upon request.

3.1. Modeling Task

In the computational model, a ternary choice classification task is built for which organizations have to make decisions regarding a series of quasi-repetitive problems, based on multiple indicators that can only be partly accessed by different organizational members in a distributed environment. Each of the nine indicators can take numbers as derived from the real world setting. In the model, a transformation function is built to further categorize the value of each indicator into three levels. Once the transformation is defined, the specifics of each incoming indicator become irrelevant, as they can all be turned into labels of 1, 2, or 3 and can thus be further processed in the decision making processes. This task can find resemblance in the real world. A few examples may include military radar detection, civilian air-traffic control, and manufacturing planning. For example, in the work by Lin and Carley (1995), the task is described in terms of radar detection through nine parameters of each aircraft which analysts can access through task decomposition schemes. In a manufacturing setting like we are currently studying, the task can be considered as consisting of a series of production proposals that require the organization to decide whether to reject, hold, or produce the production of certain products based on information from nine different indicators such as financial status of the company, human resources, technology, customer preference, etc.

The value of this stylized task is that it allows distributed decision making in a wide range of different settings so long as each problem can be considered as composed of nine parameters that can be categorized into three levels (e.g., in a radar task, it may be low criticality, medium criticality, and high criticality, and in a manufacturing task, it may be low tendency to produce, medium tendency to produce, and high tendency to produce) and the decision of which requires distributed expertise. It is assumed that these nine parameters can be correctly assessed by organizational members and interpreted correctly. However, because of bounded rationality, each member of the organization naturally can only process a limited number of information while each one or two single indicators may not provide a complete picture of the situation. Thus, an organization's decision requires coordination among various people who work with different indicators.

This is of course a very rough and simplified description of decision making in a manufacturing setting, as manufacturing often involve decomposition of the task as well as recomposition of the task, while in our task, we mainly focus on an-already decomposed task for which organizations can assign members to work on in a distributed setting. Thus this task focuses more on the bottom-up task composition process even though communication within the organization is capable of moving in all directions as constrained by the structure.

In this model, each member at a given time can take one of the specified actions such as asking for information, reading information, making a decision, passing up a decision, or waiting (Table 2). Each action will take a certain amount of time and is constrained by the status of other actions. To take an action, a member must also check other members' actions and the remaining amount of time units for the problem. For example, the top-level manager can only take the action to ask for information or wait if he/she has not received any passed up decision from lower-level members. The organization communicates vertically in both ways. Higher level managers can ask for information from lower-level members, while lower-level members can pass up their recommendations. When a problem occurs, the top-level manager can ask for information, and so do the middle-level managers, if any. After each analyst finishes reading information from the environment and makes a certain judgment based on a pre-trained decision rule (which can be different for different types of organizations), the recommendation is passed on to a middle-level manager. After receiving the recommendations from the lower level, the middle-level

Table 2. Relationships among actions of each agent[†].

Name of action	Time units needed by action	Pre-required action	Status of action taken	Status of action plausible	Status of action in process	Time units to complete action
A1: Ask for information	1	—				
A2: Read information	$1 * \#$	A1				
A3: Make a decision	x	A2				
A4: Pass up a decision	1	A3				
A5: Wait	1	—				

Note:
†: "Status of Action Plausible" becomes 1 when "Time Units Needed by Action" is smaller than the total time units remaining for the problem, as assigned to the organization and the "Pre-required Action" is taken for the current action.

"Time Units to Complete Action" is assigned to be equal to "Time Needed for Action" at the beginning of the action, and decrements one unit after each time unit. Once "Time Units to Complete Action" is less than or equal to 0, "Status of Action Taken" becomes 1 and "Status of Action in Process" becomes 0.

Once an action is started and when "Time Units to Complete Action" is bigger than 0, "Status of Action in Process" will remain 1. This will block out all other actions being plausible.

When multiple actions are plausible, the action being taken at the earliest time will be given the priority.

#: Number of Pieces of Information Processed. Each time unit equals two seconds of real time as determined by Carley and Prietula's human experiment results.

x: Determined by the type of decision used by the agent. For an untrained or random decision, $x = 1$; for an operational decision, $x = 1 * \#$; and for an experiential decision, $x = 2 * \#$.

manager starts to make his/her own recommendation based on a pre-trained decision rule and then passes up the recommendation to the top level manager. The top-level manager, after receiving information from middle-level managers, then makes an organization decision. If the top level manager cannot finish making a decision when the time expires for the problem, he/she will then generate a random decision at the moment when the time expires.

3.2. Modeling Task Environment

Organizations operate under environments that can exhibit different characteristics. Organizations retrieve information from the environment and make judgment to respond to the change of the environment. The nature of the task environment and how organizations respond to the environment may impact organizations' outcomes. In the real world, the correctness of the decision can be judged by the reality, if there is one. In the example of production, which will be used to illustrate other points throughout the paper, the correctness of a decision to produce or reject in reality may be judged by the market reaction. This paper uses the advantage of computational modeling and builds the true state of each problem in an independent formula, thus we can know the correct decision for each problem situation. With this mechanism, we can have the baseline against which an organizational system's decision outcomes can be compared. In this paper, two types of environment can be pre-defined, with the following formula:

$$\Sigma = \text{T1} + \text{T2} + \text{T3} + \text{T4} + \text{T5} + \text{T6} + \text{T7} + \text{T8} + \text{T9}$$

In the formula, each Ti refers to one specific indicator that can take an integer value ranging from 1 to 3, with a number 3 representing a more positive indication towards the decision "C" (to produce), and a number 1 representing a more positive indication towards the decision "A" (to reject). By varying all possible values of nine indicators, the computer model can create a task environment that has a total of 19,683 different combinations of problems.

The distribution characteristic of the environment can be further predefined to make the environment either highly predictable or highly unpredictable by setting the cut-off values for Σ. For the highly predictable environment, the true decision "A" (to reject) is defined when Σ is no more than 13; "B" (to hold) is defined when Σ is between 14 and 17; and "C" (to produce) is defined when Σ is greater than or equal to 18. Under this categorization, the task environment contains 625 problems whose true decision should be to "reject", 7,647 whose true decisions should be to "hold", and 11,411 whose true decisions should be to "produce".

For the highly unpredictable task environment, the cut-off values for Σ are predefined differently. When Σ is less than or equal to 19, the true decision should be "A" (to reject) and when Σ is greater than or equal to 20, the true decision should be "C" (to produce). All other values will result in a true decision to be "B" (to hold). With some fine tuning in the computer program to generate as equal distribution as possible for, the environment will then be composed of 6,751 problems whose true decisions should be "A", 6,181 problems whose true decisions should be "B", and 6,751 problems whose true decision should be "C". This environment can pose greater uncertainty to organizations because problems of different natures can occur with equally likely probability thus creating higher risk of judgment errors.

The manipulations of the task environment are modeled independently and not known to organizations. The computer model also allows them to switch from one type to the other upon instruction of the experimenter, thus enabling us to examine how organizations may be able to adapt to such environmental shift.

3.3. Modeling Time Pressure

This paper also considers three levels of time pressure: low, medium, and high. Time pressure is modeled according to how much time organizations need to make decisions and how much time is actually allocated. In this study, each problem has a certain time requirement reflected in the number of time units assigned. A low time pressure puts little or no time constraint on the organization. The number of time units allowed for organizations to make decisions ranges from 41 to 60. The organizational decision-making process is supposed to be least affected by time.

A high time pressure requires an organization to respond quickly and so constrains the organization's decision-making process. In this case, the number of time units allowed for organizations to make decisions ranges from 1 to 20. The organizational decision-making process may get a much higher chance for being shortened.

A medium time pressure constrains organization's decision-making processes but allows at least one round of complete decision process by the organization. In this case, the number of time units allowed for organizations to make decisions ranges from 21 to 40.

3.4. Modeling Organizational Design

As described previously, the task faced by the organization is modeled as a distributed task that requires people with different expertise to work at different positions. It is the distributed nature of the task that requires members of the organization to communicate and coordinate with each other to reach an organizational decision. To make organizational decisions, each member works with the assigned role on a subset of information and passes judgment to his/her manager (if any). How members of the organization communicate and coordinate depend on the organization structure and problem solving attitude. For example, one organization may permit members to communicate both laterally and proactively, but the other may only allow vertical communication. How each member makes recommendations or decisions depends on the decision making procedure dictated by the type of organization he or she is in. In this study, we model two distinctive organizations. One is the lean organization system and the other is the mass organization system (figure 1).

For the lean organization system as illustrated in the left part of figure 1, two levels are built in the computer model, with the bottom level composed of three work teams and the top level composed of a management team. Each analyst (or operator) in the work team is in charge of two components from the task environment. Each analyst first processes the incoming information and selects a middle unbiased value as the individual judgment of the problem. He/she then communicates the judgment with other analysts in the same team. A team-level decision is made through a majority vote of all members and is reported to a designated manager. After receiving the team's recommendation, each manager discusses with other managers in the management team. The organization's decision is then made through a majority vote of all managers. During the decision making process, all members in the organization actively look for and process information, and communicate with other members whenever possible. Decision making processes in the lean organization system are further described in figure 2 for bottom-level analysts and top-level managers.

On the other hand, for the mass organization system as illustrated on the right side of figure 1, we build the computer model in such a way that there are three command levels. At the bottom level there are nine analysts (or operators) working in three small groups/divisions. At the middle level there are three middle-level managers who supervise respective divisions. Between the bottom level and the middle level there are also some overlapped communication linkages between analysts and managers. At the top level there is one CEO. Each analyst in the division only processes one component from the task environment. Each analyst first makes his/her individual judgment using an experientially-trained rule, which is based on aligning the current set of information with a judgment that he/she has been trained to apply for similar sets of information in the past. For example, if he/she sees an incoming piece of information as 1 (low criticality) and his/her previous training tells that given this situation the aircraft should be considered as neutral (2), he/she will then always report a 2. Each analyst then passes on the judgment to designated manager(s)

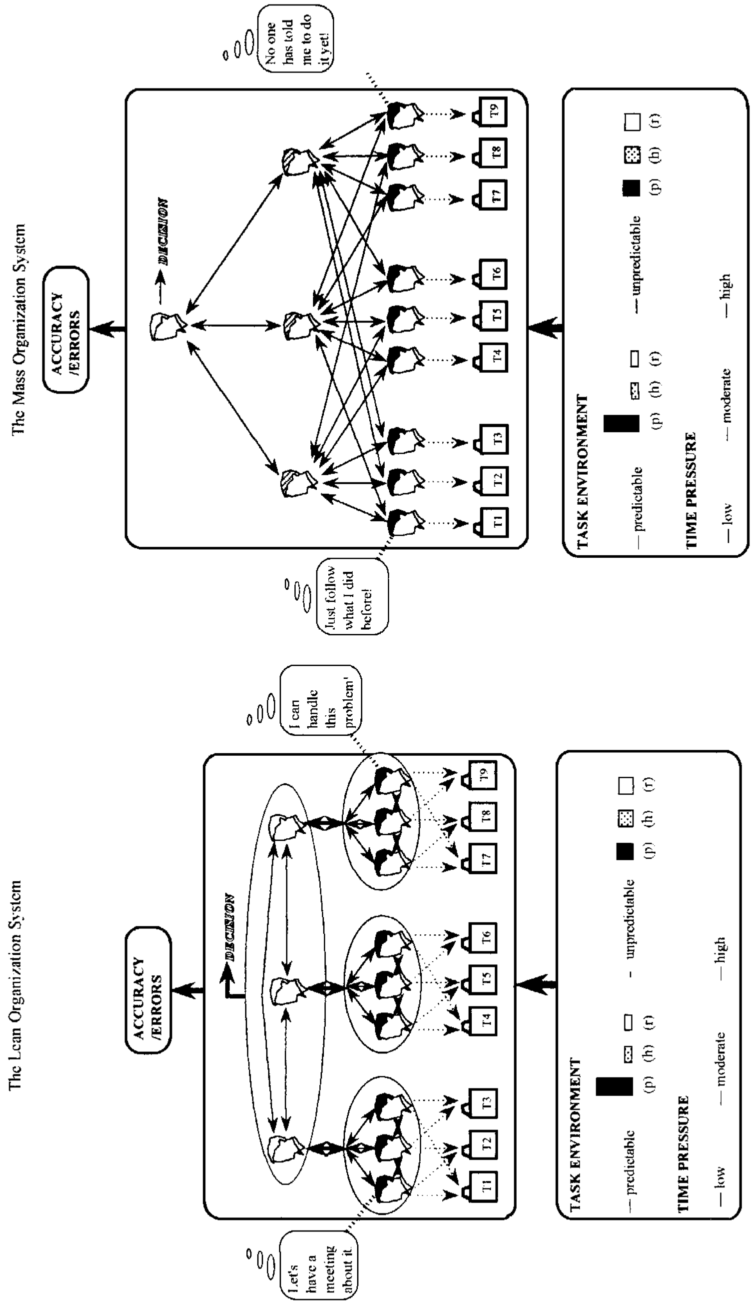

Figure 1. A stylized design of two organization systems.

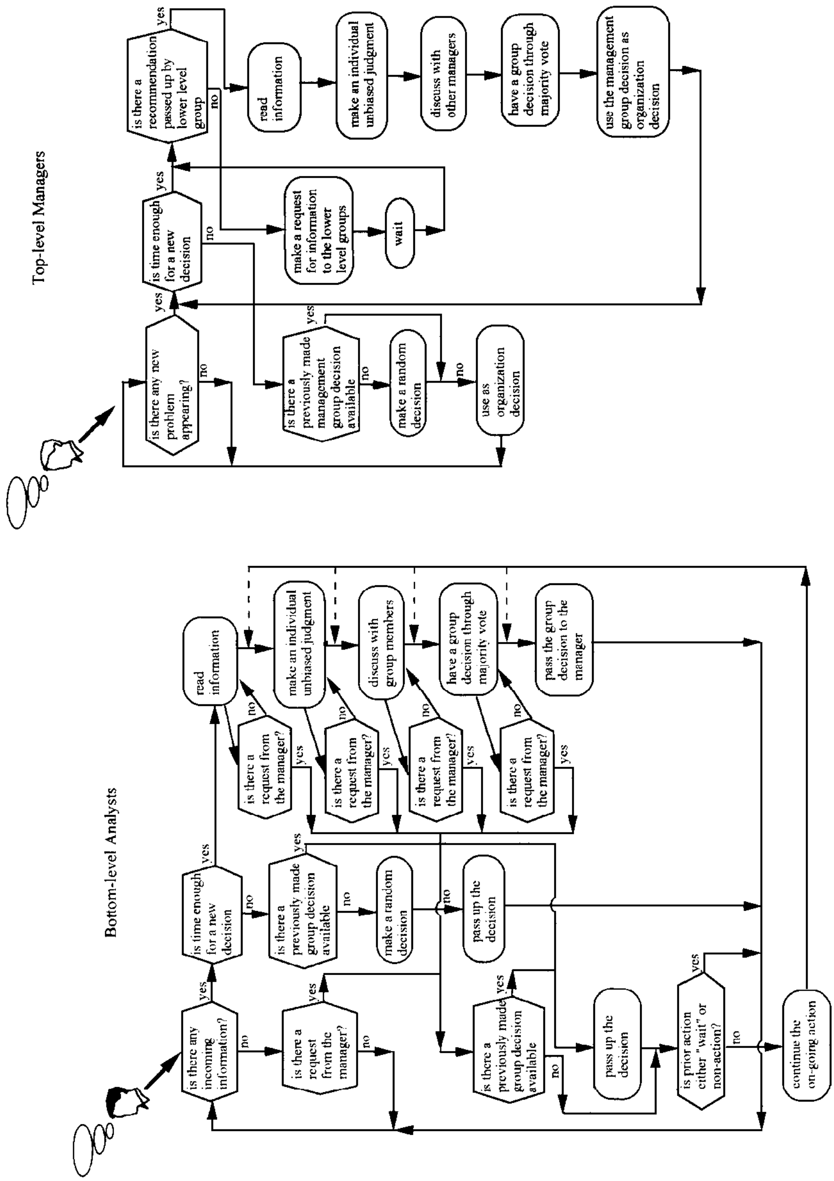

Figure 2. Decision making processes in the lean organization system.

directly, with no interaction within divisions. Each middle-level manager processes received information and makes an individual decision in a similar fashion before reporting his/her judgment to the top-level manager. The top-level manager alone makes the organization's final decision also using an experientially-trained rule. During the decision making process, each member in the organization always passively waits for the superiors to give orders to take any action. Decision making processes in the mass organization system are further described in figure 3 for bottom-level analysts, middle-level managers, and top-level managers.

Mass and lean organization systems are thus modeled according to their different structural and problem solving characteristics as described in the literature. The mass organizational system is more complex than the lean organizational system given its higher levels of vertical and horizontal differentiations in the structure than the lean organization system. The mass organization system is also more formalized than the lean system, in that each operator has access to only one task component. Also, each member in the organization only follows the method that he or she is most familiar with, which has been trained by the organization, and makes decisions purely based on how a similar problem was handled previously. Thus members are restricted by the past experience and have very limited alternatives and autonomy. In the mass organization system, centralization is high as decisions are concentrated as levels go up. At each level, members of the organization make decisions individually, with the top-level manager making the ultimate organizational decisions. Problem solving attitudes in mass organization system are reactive, in that members in the organization tend not to address problems or engage in problem solving processes until asked or forced by circumstances (such as time is running out).

In contrast, the lean organization system is modeled to be less complex and less formalized. Decision making is also not a specialized activity for top management. In case of the lean system, organizational decision is through majority vote of the three top-level managers, with all having equal weight. Thus, members share their opinions and have more alternatives and autonomy than that in the mass system. In this system, centralization is low as evidenced by majority rule. Problem solving attitudes in this system are proactive, in that members in the organization tend to address problems and engage in problem solving processes whenever they see them.

3.5. Modeling Organizational Outcome

In this study, we measure how organizations adapt to the changing environment through indicators of decision making proficiency, which is further categorized in three components: accuracy, percentage of minor errors, and percentage of severe errors. Decision making proficiency may be affected by changes in environments. In other words, organizations are confronted with different environments at different times. To compare lean and mass organization systems, we not only model organizations' problem solving accuracy but also model how organizations commit different types of errors.

3.5.1. Decision Making Accuracy. We first consider quality or accuracy of decision, which is an indicator of effectiveness. Accuracy of decision indicates how the organization

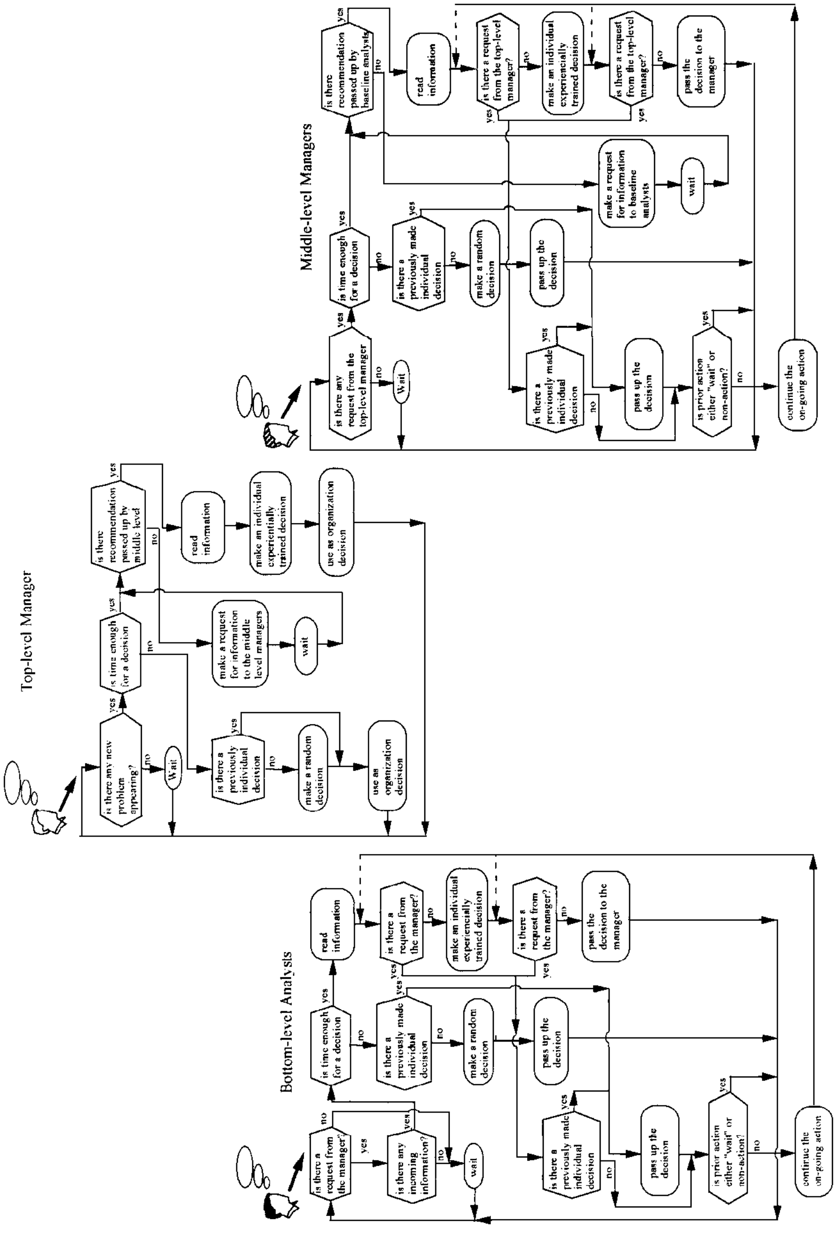

Figure 3. Decision making processes in the mass organization system.

can correctly classify problems into the right type as predefined by the task environment. It is measured as the percentage of correct decisions made by the organization given the number of problems presented to the organization.

3.5.2. Minor Errors. We then consider percentage of minor errors. Minor errors refer to those errors that is only one step away from the correct ones. For example, a decision of "produce" while actually should be "hold" is a type of minor error. The percentage of all such one-step-away errors is labeled as "percentage of minor errors".

3.5.3. Severe Errors. We finally measure percentage of severe errors. Severe errors happen when the decision is two steps away from the true ones. It happens when the decision is to "produce" in fact the actual correct one should be to "reject", or when the decision is to "reject" in fact the actual correct one should be to "produce". The percentage of all such two-step-away errors is labeled as "percentage of severe errors".

3.6. Summary

Our description of the model clearly shows that the major components of the model are interrelated. For example, time pressure may be related with the characteristics of the aircraft, such as speed and range, and thus the task environment. Organizational design is connected with the task environment through the resources access structure and organizations can learn from feedback from the task environment. While we are able to build such relationships using computer languages, it is apparent that such relationships are often too complicated or impossible to be expressed in mathematical equations.

3.7. Simulation Experiment

To compare the decision making proficiency of lean and mass organization systems in changing environments, we conduct two experiments. We first put both organizations under high time pressure and predictable task environment. Fifty groups of randomly selected problems are presented to both organizations with 100 problems in each group. After the 50 groups of problems, the task environment is switched to the unpredictable one. Another 50 groups of randomly selected problems are then presented to both organizations, with 100 problems in each group. After that 50 groups of problems, the time pressure is then switched to low and the task environment switched to predictable. After another 50 groups of problems (100 problems in each group), the task environment is finally switched to unpredictable again.

In a similar fashion, we conduct the other experiment but starting with the unpredictable task environment. The task environment again changes after every 50 groups of randomly selected problems and time pressure changes after 100 groups of problems.

During each experiment, both organizations follow their respective decision making processes as specified in the previous model section. After each round of decision, both organizations' are provided with the information of how accurate their decisions are. From the feedback, they can learn from their experiences. For each group of problems (100), accuracy of decision making, percentage of minor errors, and percentage of severe errors are all measured.

Thus, we have an experimental design of 2 levels of time pressures $\times 2$ types of task environments $\times 2$ types of organization systems.

4. Results

We compare how lean and mass organization systems perform under the changing task environment. Each group of problems will be treated as an observation point for our analyses. We measure performance with three criteria: accuracy of problem solving (decision making), percentage of minor errors, and percentage of severe errors. Let us first look at accuracy of decision making.

4.1. *Accuracy of Decisions*

4.1.1. Task Environment Starting from Predictable. The results show that when time pressure is high, both lean and mass organization systems' accuracy of decision making is identical (figure 4). When the task environment changes from predictable (mean = 31.1, std = 3.67, $n = 50$) to unpredictable (mean = 33.9, std = 5.07, $n = 50$), the percentage of correct decisions shows some slight increases.

When time pressure changes to low, lean and mass organization systems begin to show some very different patterns of accuracy of decision making. When the task environment is predictable, the mass organization system (mean = 56.3, std = 4.88, $n = 50$) outperforms the lean organization system (mean = 44.8, std = 4.69, $n = 50$) ($p < 0.01$). Such patterns change to the opposite, however, when the task environment becomes unpredictable. The mass organization system's performance of making accurate decisions drops dramatically (mean = 32.8, std = 4.15, $n = 50$) after the switch of task environment and never gets quite recovered. In contrast, the lean organization system increases performance significantly (mean = 56.0, std = 4.83, $n = 50$) when the task environment changes to unpredictable and soon begins to outperform the mass organization system ($p < 0.01$).

4.1.2. Task Environment Starting from Unpredictable. When time pressure is high, both lean and mass organization systems perform in the same way (also figure 4). Percentage of accurate decisions is generally around 33% (mean = 33.4, std = 4.59, $n = 50$). There is little change when the task environment changes from unpredictable to predictable (mean = 33.1, std = 4.43, $n = 50$).

When time pressure changes to low, we see some opposite patterns as compared with that shown in the top part of figure 4. When the task environment is unpredictable, the lean organization system (mean = 56.0, std = 4.83, $n = 50$) outperforms mass organization system (mean = 35.6, std = 5.37, $n = 50$)($p < 0.01$). But when the task environment changes to predictable, the mass organization system's performance of making accurate decisions increases slowly and then maintains at a higher level (mean = 53.9, std = 7.44, $n = 50$). In contrast, lean organization system's performance drops (mean = 44.8, std = 5.41, $n = 50$) with the change of the task environment, though such drop is not as big as previously shown

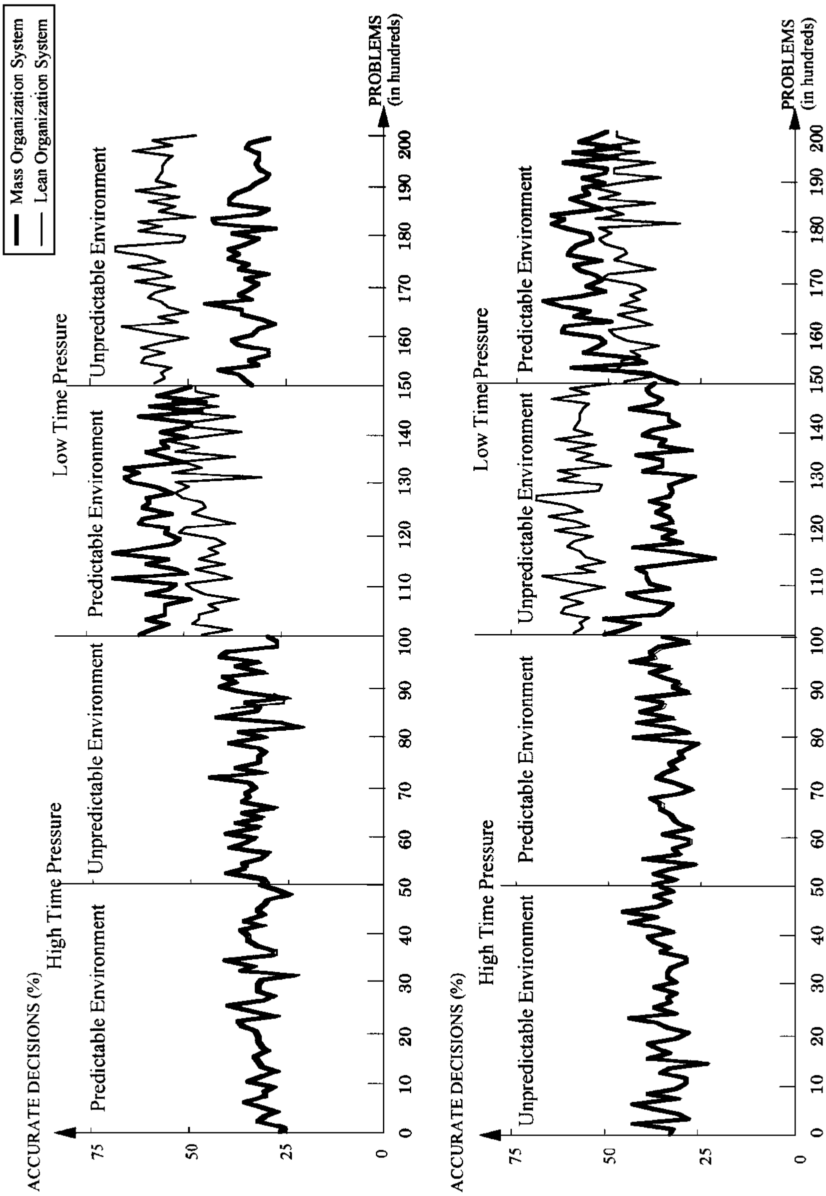

Figure 4. Accurate decisions made under changing environment.

by the mass organization system. The mass organization system also begins to outperform the lean organization system in the new predictable task environment ($p < 0.01$).

4.1.3. Summary. The above results suggest that when time pressure is very high, both organizations usually do not have enough time to prepare and make matured decisions. Thus, changing task environment has little impact on both lean and mass organization systems.

The results also show that lean and mass organization systems' advantage may change as the task environment changes. Mass organizations, because of their highly centralized and formalized structure, may be better to tackle a task environment that is stable and is dominated by few dimensions. In contrast, lean organizations can use their more active team approach and members' expertise to handle a more unpredictable and diverse task environment. Neither organization shows very high decision making proficiency to the changing task environment, though the lean organization system has some advantage over the mass organization system in having a lower rate of drop of performance when facing adversaries.

4.2. Percentage of Minor Errors

4.2.1. Task Environment Starting from Predictable. When time pressure is high, both lean and mass organization systems have very much the same pattern (mean = 48.4, std = 4.23, $n = 50$) (figure 5). Compared with accuracy of decisions, percentage of minor errors increases to a much higher level for both organizations ($p < 0.01$). Though there is some drop when the task environment changes to unpredictable (mean = 44.3, std = 6.14, $n = 50$), the overall pattern is relatively unaffected across the two task environments.

When time pressure changes to low, the lean organization system appears to have many more minor errors (mean = 54.4, std = 5.39, $n = 50$) than the mass organization system (mean = 40.65, std = 5.00, $n = 50$) under predictable task environment ($p < 0.01$). The difference remains when the task environment changes to unpredictable, even though both organizations' percentages of minor errors decrease, with a smaller drop by the lean organization system (mean = 42.6, std = 4.80, $n = 50$) as compared with the mass organization system (mean = 34.0, std = 4.47, $n = 50$).

4.2.2. Task Environment Starting from Unpredictable. The pattern under high time pressure is very similar to the situation in the top half of figure 5. The change of the task environment had little impact on the percentage of minor errors for both organizations. The percentage of errors only slightly increases from unpredictable task environment (mean = 44.6, std = 4.29, $n = 50$) to predictable task environment (mean = 46.1, std = 4.54, $n = 50$).

When time pressure changes to low, the pattern is very much like the opposite of the situation shown in the top half of figure 5. In the unpredictable task environment, both organizations have a percentage of minor errors around 45% with the lean organization system (mean = 42.6, std = 4.80, $n = 50$) having a slightly lower average (mean = 44.7, std = 4.33, $n = 50$). When the task environment changes to predictable, the lean organization system's percentage of minor errors increases to a much higher level (mean = 54.4,

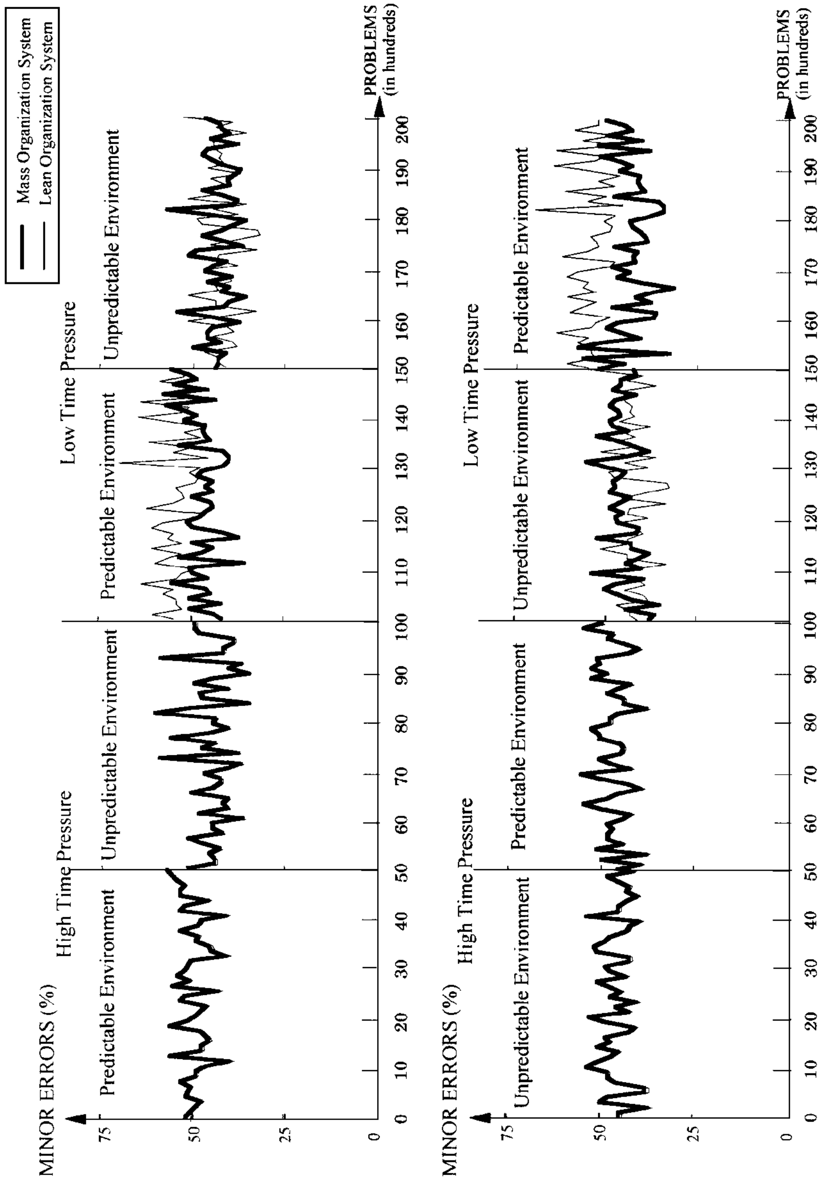

Figure 5. Minor errors made under changing environment.

std = 5.39, $n = 50$)($p < 0.01$). In contrast, the mass organization system's percentage of minor errors increases only slightly (mean = 42.4, std = 6.11, $n = 50$).

4.2.3. Summary. The above results suggest when under high time pressure, both lean and mass organization systems increase their chances of making minor errors. Such percentage of minor errors is again not affected by the changing task environment.

The above results also show that in terms of committing minor errors, both organization systems are again dependent upon the type of task environment. We also see some changes of the percentage of minor errors as the task environment changes, but not as dramatically for mass organization systems. This may suggest that mass organization system may be more stable under changing task environment in terms of committing minor errors.

4.3. Percentage of Severe Errors

4.3.1. Task Environment Starting from Predictable. Under high time pressure, percentage of severe errors for both lean and mass organization systems is again the same (mean = 20.5, std = 4.12, $n = 50$) (figure 6). It is however, much lower as compared with the percentage of minor errors ($p < 0.01$). Across the two changing task environments, the pattern remains the same with some small increase as the task environment changes from predictable (mean = 20.5, std = 4.12, $n = 50$) to unpredictable (mean = 21.8, std = 3.50, $n = 50$).

When the time pressure changes to low, we see some very interesting results. We see that under predicted task environment, both lean and mass organization systems are capable of avoiding severe errors, with the lean organization system (mean = 0.81, std = 0.99, $n = 50$) being a little better than the mass organization system (mean = 3.1, std = 1.64, $n = 50$). However, when the task environment changes to unpredictable, such virtue is only kept by the lean organization system (mean = 1.35, std = 1.18, $n = 50$). The mass organization system's chance of committing severe errors increases dramatically to around 30% (mean = 33.2, std = 4.40)($p < 0.01$).

4.3.2. Task Environment Starting from Unpredictable. Under high time pressure, the pattern of percentage of severe errors is very similar to that of the situation in the top half of figure 6, and is unaffected by the change of the task environment from unpredictable (mean = 22.0, std = 3.49, $n = 50$) to unpredictable (mean = 20.8, std = 4.69, $n = 50$).

When under low time pressure, as the task environment changes from unpredictable to predictable, the mass organization system's percentage of severe errors drops gradually from around 20% (mean = 19.8, std = 4.33, $n = 50$) to around only 4% (mean = 3.77, std = 3.77, $n = 50$) ($p < 0.01$). In the whole process, the lean organization system maintains a very low percentage of severe errors during both unpredictable (mean = 1.35, std = 1.18, $n = 50$) and predictable task environments (mean = 0.81, std = 0.99, $n = 50$).

4.3.3. Summary. These results suggest when under high time pressure, both lean and mass organization systems decreases their chances of making severe errors. Such percentage of severe errors is again not affected by the changing task environment. This phenomenon is

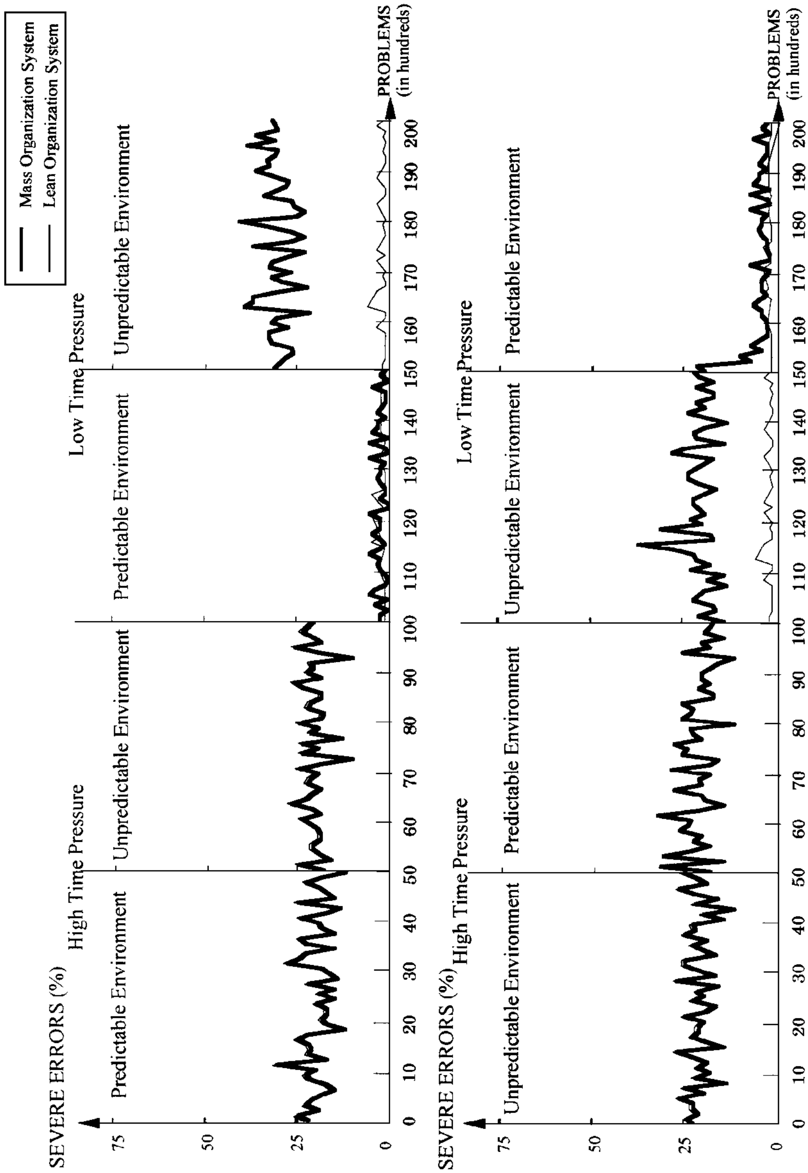

Figure 6. Severe errors made under changing environment.

interesting because it may be seen as a way for both lean and mass organization systems to respond to the environment in a safer way given the adverse situation of high time pressure.

The above results also show that the lean organization system is more capable of avoiding severe errors under the changing task environment while the mass organization system is more rigid in terms of facing the changing task environment.

5. Discussion

5.1. Main Findings

This paper has systematically compared the Japanese style lean organization system and the traditional American style mass organization system with regard to their decision making adaptability to different environments. Specifically, we have examined two important aspects of organizational performance in decision making when the environment changes. Our study has shown that though the lean organization system is more proactive, its performance is virtually identical to the mass organization system when the time pressure is high and when decision making is mostly based on quick hunches. When the time pressure is low, the mass organization system shows a much faster adaptability when the environment shifts to a predictable one and its performance quickly outperforms the lean organization system. The mass organization, however, is much more vulnerable to the shift of the environment to the unpredictable one and its performance quickly drops to a level much lower than that of the lean organization system in the same environment. In contrast, the lean organization system's adaptability to the changing environment is characterized by its slower response (though its members are all proactive). When the environment shifts to an unpredictable one, the lean organization system shows a gradual improvement till a reaching a level above that of the mass organization system. When the environment shifts to a predictable one, the lean organization system also shows a gradual decrease of performance until reaching a level lower than that of the mass organization system. Our study further shows that the lean organization system, with a strong team decision emphasis, is more capable of avoiding severe errors when compared with the mass organization system, even when under predictable task environment, which the mass organization system is supposed to be specially trained for.

The above results suggest that the structural designs and problem solving attitudes of the two organizational systems, together with environmental factors, affect the organizations' adaptability in terms of decision making proficiency. The mass organization system is designed with strict hierarchical structure, rigid decision making procedure, and passive problem solving attitude. This system emphasizes high division of labor and prescriptive behavior, and is more like a specialist for a narrowly defined niche. This system is most effective when the problems it faces are simple and are previously trained for. When the mass organization system faces a predictable task environment, the problems that confront organizations are mostly of the same type and are well suited for specialized training and fine division of labor. Thus, the mass organization can optimize its unique designs and quickly learn to adapt to the environment and maintain a high performance. However, such designs are not suitable for an environment that is more diversified and uncertain. Especially, when the environment shifts from a predictable to an unpredictable one, the mass organization system tends to be hampered by its rigid procedure and mismatched individual past experience, and thus its adaptability deteriorates sharply in terms of organizational decision making performance.

On the other hand, the lean organization system emphasizes team based majority voting procedure, and more versatile skills of members. It is designed more as a generalist for a more widely-defined niche. Each member's individual experience is no longer important. Instead, the collective effort of the team or the entire organization is the primary drive for effective decision making. As a result, decisions through majority voting dominate individual judgment, which also reduces the chances of severe errors by individual members (unlike the mass organization system). This gives the organization the leverage to handle more diverse types of problems. In dispersed task environments, the problems that confront organizations are mostly of different types and are suited for generally trained procedures and multiple skilled labors. Thus, the lean organization can make full use of its design and have an effective adaptation to the environment and maintain a high performance. However, such designs are not as effective under an environment that is more clustered and certain. The lean organization system, with its strong team emphasis and balanced treatment of information, is also capable of avoiding "rushing-in" effect by a single high-level member of the organization. This can help the organization when it faces a more predictable environment. However, this feature can also be a two-edged sword because when the environment shifts to an unpredictable one that requires quick response, the lean organization system may lose some of the valuable time, though it is composed of proactive members.

It is also notable that the two organizations commit different kinds of errors in different conditions. Even though mass organizations are less likely to commit minor errors than lean organizations when the environment changes from unpredictable to predictable under low time pressure, they are more likely to commit severe errors under the same condition. Lean organizations, on the other hand, are more likely to commit minor errors, but less likely to commit severe errors, under the same condition. This finding has important implications for organizational designers. To the extent that an organization wants to avoid a particular kind of errors, one has to pay attention to the shifting nature of the environment and the operating conditions such as time pressure. This issue of the kind of error is particularly important when one considers the cost implications of errors. Errors usually imply costs. Thus, to the extent that costs of a particular kind of errors are high, organizational designers should carefully examine the kind of environments and operating environments an organization is likely to be in before investing resources in designing the final organizational form.

Though we have only focused on two existing organizational designs, one of our contributions, however, is that this study highlights the importance of the roles of complex designs in affecting decision making processes and outcomes. The findings did show that different forms of complex organizational design have an impact on organizations' decision making proficiency. Thus, one of the implications of the findings of the present study is that researchers should pay more attention to structural issues when studying higher level (e.g., teams or groups) decision making. Another contribution of the present study is that we highlight the importance of cross-level theorizing in decision making. While we focus on organizational level outcomes on this study, our model is actually built from very basic micro levels. We present a method through which judgments and decision making from lower level can be integrated via the different organizational structures we examined. We believe our study presents a unique approach to the study of decision making by addressing the importance of integration instead of aggregation in decision making processes, which is more realistic to organizational problems.

Beyond the emphasis of the importance of organizational adaptation, our study has also pointed out the directions for such learning and adaptation. From the performance of lean and mass organization systems under different situations, we can inform the organization what it may face and how it can prepare. For example, we can suggest to mass organizations that to succeed in a competitive and diversified global market, a decentralized hierarchy in structure and a proactive attitude towards problems may enhance their learning and adaptation capabilities. This has been demonstrated in the recent comebacks by the big-three auto-makers in the U.S.

Our results have in a different way confirmed the results by population ecology that organizations in different environments can exhibit different performance which may affect their adaptation. Our model has also supported the findings from other models developed from the same perspective on organizational design that organizational design and communication affect organizational outcomes, but the context can moderate these relationships (Baligh et al. 1996; Jin et al. 1996).

5.2. Advantages, Limitations, and Future Directions

The present research also demonstrates the utility of computer modeling techniques in studying management issues. With the ability to model the structural and decision making characteristics of lean and mass organization system using a meso approach, we demonstrate how the two organization systems adapt to different situations. This computer approach has several clear advantages. First, it allows us to control and manipulate organizational environments that may have only appeared in the past or will appear in the future. This kind of control is rarely afforded in field studies. Second, using computer simulation we can consider multiple causal factors simultaneously within a complex system, thus providing us with a fuller and systematic picture of the inter-play of various relationships. We believe that inconsistencies regarding lean and mass organization systems may be exactly due to the narrow focus on limited factors and from fragmented view points. Third, from this study, we also hope to answer the criticisms towards the contingency approach for its often vague, inconsistent, and tautological suggestions (Schoohoven 1981). We believe that with our approach we can greatly improve the contingency approach to be much more precise and systematic, and thus more applicable.

Computer simulation, with its short history of application in organization science, has achieved significant successes (Carley and Prietula 1994). We, however, should also caution ourselves when trying to generalize the results from our computer model to broader settings. While this model focuses on organizational designs of two production systems, we need to keep in mind that organization system may encompass more features which may or may not alter the results. Important issues like production cost and cultural characteristics that make those two systems sustainable in their different settings have been lightly touched but not fully incorporated. Because this model is based on a distributed classification task, we also need to understand that in the real world, there can be lean and mass organization systems that do not necessary follow such clear distinctions. For example, certain departments may posses much greater power in determining the organizational outcome, while in our model, we tend to treat all of them with equal weights. Sub-systems like reward systems in an organization have also been repeated shown to affect the outcome of an organization, which we have not addressed, though some general form of feedback is being considered.

Given these limitations, we should always try to understand what the real world organizations we are trying to model, and caution ourselves when attempting to generalize the simulation results to a population in the real world setting that exhibit features different from distributed decision making or involving three distinctive choices.

In our future study we should also be thinking of building more features of the two organization systems to make the model even closer to real organizations. For example, future research may be able to consider some motivational dimensions because it has been suggested in other studies that lean organization system is a commitment maximizing system and that it has the advantage of enhancing workers' motivation and effort. Also in today's world, there is probably no absolute lean or mass organization. In fact, a lot of organizations have integrated some aspects of both organizations. Some hybrid forms or new forms may appear. This would require a model with finer specifications and broader features.

Acknowledgments

This research is supported in part by the Competitive Earmarked Research Grant No. HKUST533/95H from the Research Grant Council of Hong Kong. An earlier version of the paper was presented at the International Conference on Comparative Management, National Sun Yat-sen University, Kaohsiung, Taiwan, May 26–28, 1996. We wish to thank two anonymous reviewers for their enlightening comments. Please send all correspondence to Dr. Chun Hui, Department of Management of Organizations, the Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong.

References

Abramson, N.R., H.W. Lane, H. Nagai and H. Takagi (1993), "A Comparison of Canadian and Japanese Cognitive Styles: Implications for Management Interaction," *Journal of International Business Studies*, 24(3), 575–587.

Aldrich, H.E. (1979), *Organizations and Environment*. Englewood Cliffs, NJ: Prentice Hall.

Baligh, H.H., R.M. Burton and B. Obel (1996), "Organizational Consultant: Creating a Useable Theory for Organizational Design," *Management Science*, 42(12), 1648–1662.

Bass, B.M. and P.C. Burger (1979), *Assessment of Managers: An International Comparison*. New York, NY: Free Press.

Berggren, C. (1992), *Alternatives to Lean Production*. Ithaca, NY: ILR Press.

Blumberg, R.L. (1987), Organizations in Contemporary Society, Englewood Cliffs, NJ: Prentice-Hall.

Bourgeous, L.J., III. and K.M. Eisenhardt (1988), "Strategic Decision Processes in the High Velocity Environments: Four Cases in the Microcomputer Industry," *Management Science*, 34(7), 816–835.

Burns, T. and G.M. Stalker (1961), *The Management of Innovation*. London: Tavistock.

Carley, K.M. and M.J. Prietula (1994), *Computational Organization Theory*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Coleman, J.S. (1990), *Foundations of Social Theory*. Boston, MA: Harvard University Press.

Courtright, J.A., G.T. Fairhurst and L.E. Rogers (1989), "Interaction Patterns in Organic and Mechanistic Systems," *Academy of Management of Journal*, 773–802.

Cusumano, M.A. (1988), “Manufacturing Innovation: Lessons from the Japanese Auto Industry,” *Sloan Management Review*, 30(1), 29–39.

Daft, R.L. (1982), “Bureaucratic Versus Non-bureaucratic Structure and the Process of Innovation and Change,” in S.B. Bacharach (Ed.), *Research in the Sociology of Organizations*, Greenwich, CT: JAI Press, Vol. 1, pp. 129–166.

Daft, R.L. and K.E. Weick (1984), “Toward a Model of Organizations as Interpretation Systems,” *Academy of Management Review*, 9, 284–295.

Daniel, S.J. and W.D. Reitsperger (1991), “Management Control Systems for J.I.T.: An Empirical Comparison of Japan and the U.S.,” *International Journal of Business Studies*, 22(4), 603–617.

Davy, J.A., R.E. White, N.J. Merritt and K. Gritzmacher (1992), “A Derivation of the Underlying Constructs of Just-In-Time Production Systems,” *Academy of Management Journal*, 35, 653–670.

De Geus, A.P. (1988), “Planning as Learning,” *Harvard Business Review*, 66(2), 70–74.

Drucker, P.F. (1987), “Workers’ Hands Bound by Tradition,” *Wall Street Journal*, 18.

Epple, D., L. Argote and R. Devadas (1991), “Organizational Learning Curves: A Method for Investigating Intra-Plant Transfer of Knowledge Acquired Through Learning by Doing,” *Organization Science*, 2(1), 59–87.

Feigenbaum, A.V. (1991), *Total Quality Control*. New York, NY: McGraw-Hill, Inc.

Fiol, C.M. and M.A. Lyles (1985), “Organizational Learning,” *Academy of Management Review*, 10, 803–813.

Gupta, A.K. and D.L. Wilemon (1990), “Accelerating the Development of Technology-Based New Products,” *California Management Review*, 24–44.

Haire, M., E.E. Ghiselli and L.W. Porter (1966), *Managerial Thinking: An International Study*. New York, NY: Wiley.

Hannan, M.T. and J. Freeman (1977), The Population Ecology of Organizations, *American Journal of Sociology*, 82, 929–964.

Hogg, T.M. (1993), “Lean Manufacturing,” *Human Systems Management*, 12(1), 35–40.

Hollenbeck, J.R., D.R. Ilgen, D.J. Sego, J. Hedlund, D.A. Major and J. Phillips (1995), “Multilevel Theory of Team Decision Making: Decision Performance in Teams Incorporating Distributed Expertise,” *Journal of Applied Psychology*, 80(2), 292–316.

Houskisson, R.E. and C.S. Galbraith (1985), “The Effect of Quantum Versus Incremental M-form Reorganization on Performance: A Time Series Exploration of Intervention Dynamics,” *Journal of Management*, 11, 55–70.

Huber, G.P. (1991), “Organizational Learning: The Contributing Processes and the Literatures,” *Organization Science*, 2(1), 88–115.

Hutchins, E. (1991), “Organizing Work by Adaptation,” *Organization Science*, 2(1), 15–39.

Imai, M. (1986), *Kaizen: The Key to Japans’ Competitive Success*. New York, NY: McGraw-Hill.

Jin, Y., R.E. Levitt, J.C. Kunz and T.R. Christiansen (1995), “The Virtual Design Team: A Computer Simulation Framework for Studying Organizational Aspects of Concurrent Design,” *Simulation*, 64(3), 160–174.

Jin, Y., R.E. Levitt, T.R. Christiansen and J.C. Kunz (1996), “The Virtual Design Team: A Computer Model of Project,” *Computational and mathematical Organization Theory*, 2(3), 171–196.

Koberg, C.S. (1987), “Resource Scarcity, Environmental Uncertainty and Adaptive Organizational Behavior,” *Academy of Management Journal*, 30(4), 798–807.

Krafcik, J.F. (1988), “Triumph of the Lean Production System,” *Sloan Management Review*, 30(1), 41–52.

Lant, T.K. and S.J. Mezias (1992), “An Organizational Learning Model of Convergence and Reorientation,” *Organization Science*, 3(1), 47–71.

Lant, T.K., F.J. Milliken and B. Batra (1992), “The Roles of Managerial Learning and Interpretation in Strategic Persistence and Reorientation: An Empirical Exploration,” *Strategic Management Journal*, 13, 585–608.

Levitt, B. and J. March (1996), “Organizational Learning,” in M.D. Cohen and L.S. Sproull (Eds.), *Organizational Learning*, CA: Sage Publications, pp. 516–540.

Lin, Z. and K.M. Carley (1995), “DYCORP: A Computational Framework for Examining Organizational Performance under Dynamic Conditions,” *The Journal of Mathematical Sociology*, 20(2–3), 193–217.

Lin, Z. and K.M. Carley (1997), “Organizational Response: The Cost Performance Tradeoff,” *Management Science*, 43(2), 217–234.

Lorriman, J. and T. Kenjo (1994), *Japan's Winning Margins*. Oxford: Oxford University Press.

Lounamaa, P.H. and J.G. March (1987), "Adaptive Coordination of a Learning Team," *Management Science*, 33(1), 107–123.

Lysonski, S., A. Singer and D. Wilemon (1989), "Coping with Environmental Uncertainty and Bounded Spanning in the Product Manager's Role," *The Journal of Consumer Marketing*, 6(2), 33–43.

Maguire, M.A. and R.T. Pascale (1978), "Communication, Decision-Making and Implementation among Managers in Japanese and American Managed Companies in the United States," *Sociology and Social Research*, 63, 1–23.

March, J.G. (1991), "Exploration and Exploitation in Organizational Learning," *Organization Science*, 2(1), 71–87.

Milliken, F.J. (1990), "Perceiving and Interpreting Environmental Change: An Examination of College Administrators' Interpretation of Changing Demographics," *Academy of Management Journal*, 33(1), 42–63.

Orasanu, J. and E. Salas (1992), "Team Decision Making in Complex Environments," in G. Klein, J. Orasanu and R. Calderwood (Eds.), *Decision Making in Action: Models and Methods.* Norwood, NJ: Ablex Publishing Corp.

Parsons, T. (1956), "Suggestions for a Sociological Approach to the Theory of Organizations," *Administrative Science Quarterly*, 1, 63–85.

Pascale, R.T. (1978), "Communication and Decision-Making across Cultures—Japanese and American Comparisons," *Administrative Science Quarterly*, 23, 91–110.

Porter, M. (1990), *The Competitive Advantage of Nations*. London: Macmillan.

Pugh, D.S., D.T. Hickson, C.R. Hinings, K.M. MacDonald, C. Turner and T. Lupton (1963), "A Conceptual Scheme for Organizational Analysis," *Administrative Science Quarterly*, 8, 289–315.

Rehder, R.R. (1992), "Building Cars as if People Mattered: The Japanese Lean System vs. Volvo's Uddevalla System," *Columbia Journal of World Business*, 27(2), 56–70.

Reitsperger, W.D. and S.J. Daniel (1990), "Japan vs. Silicon Valley: Quality-Cost Trade-Off Philosophies," *International Journal of Business Studies*, 21(2), 289–300.

Sammon, W.L., M.A. Kurland and R. Spitalnic (1984), *Business Competitor Intelligence: Methods for Collecting, Organizing, and Using Information*. New York: John Wiley.

Schoonhoven, C.B. (1981), "Problems with Contingency Theory: Testing Assumptions Hidden in the Language of Contingency Theory," *Administrative Science Quarterly*, 26, 349–377.

Scott, W.R. (1987), *Organizations: Rational, Natural, and Open Systems.* Englewood Cliffs, NJ: Prentice Hall.

Simon, H.A. (1991), "Bounded Rationality and Organizational Learning," *Organization Science*, 2(1), 125–139.

Takamiya, S. (1969), "Characteristics of Japanese Management and Its Recent Tendencies: Effectiveness of Japanese Management," *The Role of Management: Innovation, Integration, Internationalization: Proceedings of the 15th CIOS International Management Congress*, 394–405.

Thompson, J.D. (1967), *Organizations in Action.* New York, NY: McGraw-Hill.

Wakabayashi, M. and G. Graen (1991), "Cross-Cultural Human Resource Development: Japanese Manufacturing Firms in Central Japan and Central United States," in M. Trevor (Ed.), *International Business and the Management of Change*, Brookfield, VT: Avebury, pp. 147–169.

Walton, R. and G. Susman (1987), "People Policies for the New Machines," *Harvard Business Review*, 68, 98–106.

Weick, K.E. (1987), "Organizational Culture and High Reliability," *California Management Review*, 29(2), 112–127.

Wick, C.W. (1995), "From Ideas to Action: Creating a Learning Organization," *Human Resource Management*, 34(2), 299–311.

Womack, J.P., D.T. Jones and D. Roos (1990), *The Machine that Changed the World: Based on the Massachusetts Institute of Technology 5-Million Dollar 5-Year Study on the Future of the Automobile*. New York: Rawson Associates.

Woodward, J. (1958). *Management and Technology*. London: Her Majesty's Stationery Office.

Zetka, J.R., Jr. (1992), "Mass-Production Automation and Work-Group Solidarity in the Post-World War II Automobile Industry," *Work and Occupations*, 19(3), 255–271.

Zhiang Lin (first name pronounced as John) got his Ph.D. in Organizations and Policy Analysis from Carnegie Mellon University in 1994. He also holds a BS in Computer Science and a MS in Quantitative Geography both

from East China Normal University, and a M.Phil. in Public Policy Analysis and Management from Carnegie Mellon University. Since graduation, he has taught as an assistant professor at the Department of Management of Organizations, the Hong Kong University of Science and Technology. His research centers on computational organization theory with applications to organization design and change, information technology assessment, high risk organizations, and international management.

Chun Hui received both his M.A. in Social Psychology and his Ph.D. in Organizational Behavior/Human Resources Management from Indiana University at Bloomington, U.S.A. His research interests include leadership, conflicts management, selection, performance appraisal, and comparative management. He has published articles in mangement and social psychology journals, and chapters in academic books. He is an assistant professor at the Department of Management of Organizations, the Hong Kong University of Science and Technology.