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A System Dynamics Approach for Making Group Decision

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Abstract

The rapidly changing business environment has required cooperation and coordination among functional units in organizations which should involve group decision-making processes. Although many group decision-making support tools and methods have provided the collaborative capabilities for organizational members, they often lack features supporting the dynamic complexity issue frequently occurring at group decision-making processes. This study proposes system dynamics modeling as a group decision-making support tool to deal with the group decision-making tasks having properties of dynamic complexity in terms of cognitive fit theory.

1. INTRODUCTION

The increasing diversity of business, the erosion of corporate hierarchies, and the reliance on cross-functional tasks have forced organizations to have abilities to coordinate dispersed business activities. Group decision-making admittedly falls in the category of "wicked" problems, a class of problems that can be addressed through discussion and collaboration among agents involved. In group decision-making situations, an individual unit's optimal solution does not usually guarantee the Pareto optimal solution that is optimal in all participants [2] and a group is not just the aggregation of individuals [6]. Although many group decision-making support tools and methods such as GDSS (Group Decision Support Systems) have been introduced to deal with the group decision-making issues, there have been some mixed results in their effects on group decision-making.

Group decision-making process in an organizational context involves dynamic decision-making tasks having the characteristics of dynamic complexity. Dynamic complexity is concerned with the cause-effect relationships (in other words, the cross-functional interactions) over time across functional units [10, 14]. According to Senge [10], the real leverage in management situations lies in understanding dynamic complexity, not detail complexity dealing with static aspects. Although the dynamic complexity issue should be considered to be important to the organizational context, most organizations tend to try to address problem-solving tasks such as group decision-making process with dynamic complexity through approaches or methods not considered it. This study introduces system dynamics modeling as a problem-solving tool to address problem-solving tasks having properties of dynamic complexity in the group decision-making context.

2. RELATED LITERATURE REVIEW

2.1 Group Decision-Making Support

There is a growing recognition that information technology can help managers in their efforts to coordinate the group decision-making processes. As a consequence, GDSS have been used by groups in many organizations for a wide variety of activities necessarily involving group decision-making, ranging from product design to performance evaluation to business process reengineering to strategic alternatives. Although GDSS have provided the possibility of improvement in the group decision-making process, the effects of GDSS on group decision-making have been plagued by inconsistencies among study findings. Many research have suggested clues for possible reasons of the inconsistencies in the results of existing studies. Although many studies have pointed out mixed effects of GDSS and possible reasons for them, they often lack hidden features beneath group decision-making process itself.

Organizations process information to reduce uncertainty, which results from the lack of information [4]. However, functional units in an organization usually suffer from the lack of information in the group decision-making context because they have limited information on specific issues not belonging to them. This lack of information phenomenon has been supported by the fact that the rationality of human decision-making is bounded [11]. Group decision-making process to coordinate functional units' activities has the characteristics which are both dynamic and complex. It can be considered to be dynamic because it is argued that dynamic decision tasks have the following characteristics: (i) they require a series of decisions rather than a single decision; (ii) these decisions are interdependent; (iii) the environment changes as a consequence of both the decision-makers actions as well as other external factors [1]. It can be also considered to be complex because it is argued that complex decision tasks have the following complexity attributes: (i) multiple desired outcomes to attain; (ii) conflicting interdependence among outcomes; (iii) uncertain linkages among outcomes [3]. For these reasons, group decision-making process usually raises a lot of intricate debates and negotiations among participants or functional units.

The existence of multiple interpretations during group decision-making results in equivocality, which is associated with organizational confusion and ambiguity [4]. Dynamic complexity in the organizational context accounts for this multiple interpretation or equivocality. Most people tend to think of complexity in terms of the number of components in a system or the number of possibilities one must consider in making a decision, which is so called detail complexity or combinatorial complexity [10, 14]. However, most cases of multiple interpretations arise from dynamic complexity that often causes the unexpected behavior of complex systems resulting from the interactions of functional units over time. Dynamic complexity occurs at situations where cause and effect are subtle and where the effects over time of interventions are not obvious [10, 14]. Decision-makers faced with complex dynamic tasks under-represent the dynamic nature of the tasks and the interrelationships between components of the system and this misperception of feedback effect is attributed to a tendency of decision-makers to ignore all but the most obvious aspects of the feedback structure of a decision task [1].

2.2 Cognitive Fit Theory

Group decision-making process can be a human problem-solving task involving interactions among various functional units when considering the above issue – dynamic complexity. Newell and Simon [8] proposed a theory that humans were considered to be information processing systems. The theory posits a set of cognitive processes that produce the problem-solving behavior of a human. Cognitive fit theory has explored the influence of the nature of the task and the way it is represented on problem-solving performance, based on Newell and Simon's previous work. Cognitive fit theory posits that problem-solving with cognitive fit leads to effective and efficient problem-solving performance [15]. The basic model of cognitive fit views problem-solving as the outcome of the relationship between the problem representation and the problem-solving task.

Related research in human problem-solving has examined factors other than task and representation that could affect problem-solving performance. An extended model of cognitive fit theory included problem-solving tool as an additional determinant of problem-solving performance, which posits that superior problem-solving performance will result when the problem-solving task and the problem-solving tool emphasizes the same type of information [13]. As a consequence, when we view group decision-making as a problem-solving task, we should focus on the selection of the appropriate problem-solving tool to reach a better performance result. This implies that we have to reconsider whether the existing group decision-making support tools and methods including GDSS are appropriate or not in terms of cognitive fit. If the group decision-making process as a problem-solving task involves the dynamic complexity issue, then the problem-solving tool should support it as well. Cognitive unfit might be one of the possible reasons for the inconsistencies among previous study findings for the effects of GDSS on group decision-making.

2.3 Systems Thinking and System Dynamics

In this context, we need an approach to handle the dynamic complexity issue during the group decision-making process. It is argued that the solution lies in systems thinking [14]. Systems thinking is a conceptual framework for seeing the whole and for seeing the interrelationships or the feedback loops among its elements [10]. In systems thinking, every influence can be both cause and effect. Therefore, It needs to shift away the focus from one particular part to many parts that have an impact upon one another. This shift to systems thinking is characterized by considering interrelationships rather than linear cause-effect chains, and considering processes of change rather than snapshots or events [10]. Systems thinking in a group decision-making setting facilitates understanding interrelationships among functional units derived from dynamic complexity.

System dynamics has been used in various domains for over thirty years and plays an important role in facilitating systems thinking [5, 14]. System dynamics is a methodology not only grounded in the theory of non-linear dynamics and feedback control developed in mathematics, physics, and engineering but also drawing on cognitive and social psychology, organization theory, economics, and other social sciences [5, 14]. Although system dynamics has often been seen as a hard-edged approach because of its quantitative aspects, nowadays its use as a soft tool for aiding problem structuring is increasingly recognized.

3. GROUP DECISION-MAKING PROCESS WITH SYSTEM DYNAMICS

The literature relating to the decision-making process is extensive across various disciplines. One of the most popular models of the decision-making process is Simon's [12] three-stage model: intelligence, design, and choice. Mintzberg et al. [7] also proposed three decision-making stages of identification, development, and selection. While Simon adopts a linear approach emphasizing sequential activities in making a decision, decision makers following Mintzberg et al.'s model can loop back and forth among the three decision-making stages. Although a large number of subsequent studies have followed Simon's linear approach on the decision-making process, it seems to be less appropriate in the group decision-making context because it involves interdependences and interactions among various participants or functional units. Group decision-making process is considered a mixed-motive negotiation task [6] continually searching for globally optimal solution, which necessarily involves interactions among participants and feedback. Therefore, this study proposes three stages, as shown in Table 1, to describe the group decision-making process in the perspective of system dynamics, based on Mintzberg et al.'s feedback view of decision-making model.

Table 1. Group decision-making process using system dynamics

Group decision-making process based on system dynamics		System dynamics tools
Identifying the problem	• To identify cause-effect interrelationships • To synthesize all the participants' views to generate the whole systems view	Cognitive mapping through Causal Loop Diagram
Generating alternative solutions	• To elicit alternative decision options • To model the alternatives in a testable way	Simulation modeling through Stock and Flow Diagram
Evaluating the alternatives	• To test for validating the alternatives • To select the Pareto optimal solution	System simulation

The study also applied the proposed group decision-making support method to a local telecommunications company, BmT, USA. BmT was established in 2000, and since then it has provided a local telephone service. The major concern for BmT is to increase revenue by capturing market share. BmT has adopted a multi-level marketing (MLM) strategy and has focused on finding a niche market based on demographic segmentation.

3.1 Identifying the Problem

An organization can be perceived as a complex network consisting of interrelated causal elements. Therefore, understanding of a problem can be captured in a cognitive map which consists of interconnected sets of elements representing implicit views of one's own interests, concerns, and tasks. Cognitive mapping provides some usefulness to the management and organization field and its purpose is to make the dynamics of interrelationships more visible, more explicit, and thus more comprehensible. Based on cognitive mapping, system dynamics offers a systematic tool, called a causal loop diagram (CLD), for uncovering counterintuitive dynamics that might be overlooked. Counterintuitive consequences are more likely when there are feedback loops which are not readily apparent. A map of the feedback structure of decision-making situation is a starting point for analyzing what is causing a pattern of behavior.

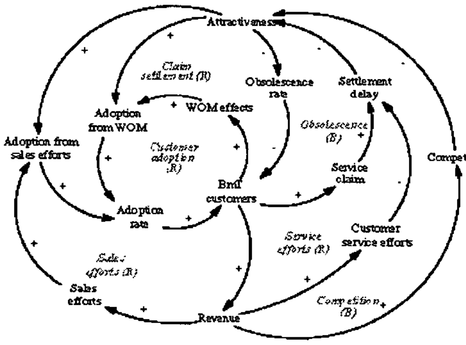

Figure 1. Organizational knowledge in BmT

The knowledge related to the issue, increasing revenue by capturing market share, is dispersed across BmT, and is kept by various teams. This knowledge must be identified and organized in order to address the issue. Group decision-making workshops and Interviews were conducted with top managers and departmental middle managers to identify the problem, and this was then integrated into the whole systems view. This organizational knowledge was simplified with CLD, as illustrated in Figure 1. Four reinforcement feedback loops exist—"Customer adoption", "Sales efforts", "Customer service", and "Claim settlement"—along with two balance feedback loops—"Competition" and "Obsolescence".

3.2 Generating Alternative Solutions

We can simply infer the dynamics of individual loop. When multiple loops interact each other, however, it is almost impossible to determine what the dynamics will be by intuition [14]. In that case, we must turn to computer simulation which can identify alternative decision options and test their validity. It is argued that simulations are virtual worlds in which managers can develop decision-making skill and conduct experiments [14]. To develop the simulation model, it is useful to extend the causal loop diagram to include stocks and flows. The stocks are represented as the rectangles, while the flows are represented as the pipes with valve. These relationships between stocks and flows are formulated to run the simulation. The amount of stock can be calculated by adding the initial stock volume to the difference between inflow and outflow during the given time step: $\text{Stock}_{t} = \text{Stock}_{t\text{-}dt} + dt \times (\text{Inflow}_{t\text{-}dt} - \text{Outflow}_{t\text{-}dt})$.

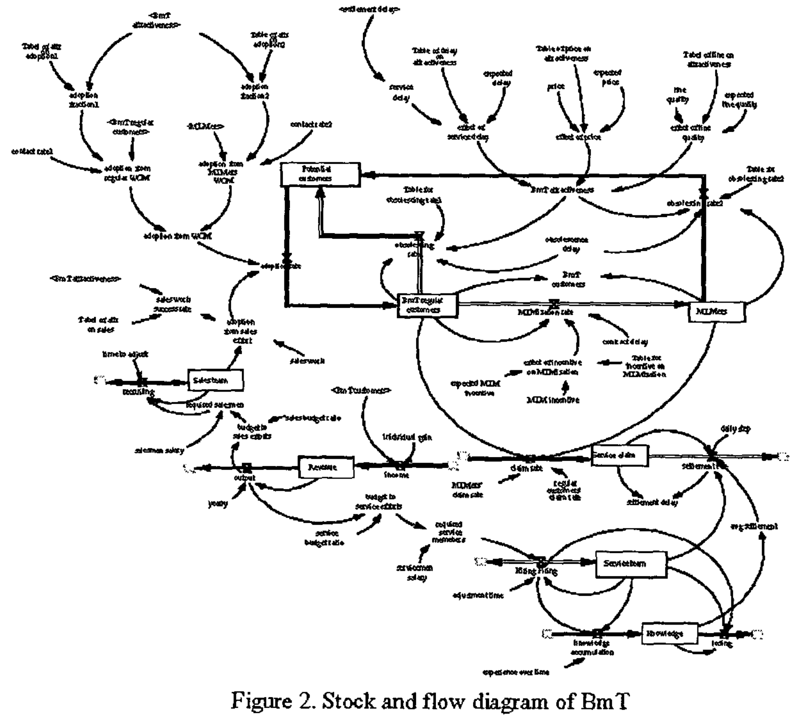

Figure 2. Stock and flow diagram of BmT

The organizational knowledge illustrated in Figure 1 was transformed into a formulated model as illustrated in Figure 2. Customers were classified into potential customers, BmT regular customers, and loyal customers (MLMers). BmT customers are represented by the sum of regular customers plus MLMers. Changing the potential customers to BmT regular customers can be achieved through either "adoption from sales effort" or through "adoption from word of mouth". Some of BmT's regular customers could become MLMers by contracts, and incentives for capturing new customers play an important role in this process. The total number of BmT customers determines the revenue, and this becomes a base for reallocating budget resources to the sales team and the customer service team. With the allocated budget, the sales team hires new sales members and undertakes sales activities on potential customers. The customer service team aims to install new lines and handle customer complaints. The settlement delay time affects the attractiveness of BmT. By accumulating experience, the complaint clearance ratio would eventually improve productivity.

The attractiveness of BmT consists of "service delay effect", "price effect", and "line quality effect". These values can be calculated by taking account of the discrepancies between actual values and expected values. Service delay time can be updated automatically by settlement delay time. The competition between local telephone service providers affects the expected price for customers, and the actual price refers to BmT's actual service price. Although "line quality" is a soft variable, it can be quantified using customers' perceptions. In a similar manner to the "expected price", "expected line quality" is affected by competition. The three table functions—"Table of delay on attractiveness", "Table of price on attractiveness", and "Table of line on attractiveness"—determine the impact of each factor on the attractiveness. The higher the attractiveness, the higher is the adoption rate and the lower is the obsolescence rate. In addition, attractiveness affects the "sales work success rate".

3.3 Evaluating the Alternatives

The decision options discussed from group decision-making session should be tested and validated before they are chosen as a policy to address the issues. The purpose can be achieved by running the simulation models for each alternative and by analyzing the results. The simulation model shows the critical role that interactions among different functional units of an organization can play in its success.

After the validity of extreme cases was checked, the formulated model of BmT case has run for four years. Based on the current strategy—lower price than existing service providers by ten percent and adoption of MLMers—in which no new competition is assumed (Scenario 1), customer complaints could be tackled within a short time because the number of customers was small at the beginning of simulation. However, the increased number of customers after six months accelerated the number of complaints, as a result of which the time taken for complaint clearance became longer. This resulted in lowering the attractiveness of BmT, and decreasing the speed of obtaining new BmT customers.

The introduction of a low price strategy by BmT could induce competitors to adopt the same low price strategy. In order to test customer behavior in such a situation, a new scenario was devised (Scenario 2) with a competitor having a price five percent lower than that of BmT. It was assumed that the competitor would introduce the new price strategy from 730 days—that is, after approximately two years. According to the simulation results, BmT's attractiveness was diminished by the effect of the competitor after day 730. In Scenario 2 situation, BmT can have various alternatives for a counter strategy.

In reinforcing the customer-adoption activities, "adoption from WOM" assumes a critical role. MLM incentive affects the MLMers' efforts which, in turn, affect "WOM effects" and "Adoption from WOM". For simulating the hypothetical scenario, the MLM incentives were increased up to twenty percent

(Scenario 3).

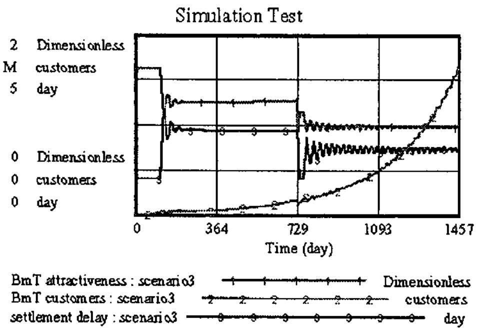

Figure 3. Testing on the BmT's reaction scenario 3

Figure 3 shows the simulation results of Scenario 3. This demonstrates that BmT can increase revenue by obtaining more customers continuously—based on management of BmT attractiveness and service delay. From this fact, retaining BmT customers and increasing the efforts of MLMers are seen to be prerequisites for increasing revenue—because the existing customer group is a source of WOM that affects new customer adoption. The attractiveness of BmT can be also enhanced by shortening service delay. In addition to discovering the best decision option, top management and other managers came to understand the elements involved, the interrelationships among them, and the behavior mechanism of the target business problem through group decision-making session.

4. DISCUSSION

This study can be discussed in terms of group process gains and losses in the group decision-making context. Process gains refer to the synergetic aspects of the group interactions that improve group performance relative to the individual member performance, while process losses refer to certain aspects of the group interactions that impair group performance relative to the efforts of individual members working alone [9]. Effectiveness or efficiency of group decision-making process can be achieved by increasing group process gains and reducing group process losses through system dynamics approach. For example, system dynamics modeling increases the amount of information and alternatives generated by the whole set of group (a process gain) and reduces equivocality or uncertainty among participants (a process loss). System dynamics approach leads to be more effective and objective in evaluation and error detection tasks (a process gain) and restrains fragmented member participation from the group process (a process loss).

This approach seems to be more appropriate to the group decision-making context with highly constrained tasks involving resource allocation. Highly constrained tasks can be classified as mixed motive negotiation tasks in which participants have mixed-motives to compete and cooperate [6]. In that case, it is important to understand the whole view of the system which should be shared among participants and how one part of decision can impact other parts over time. Although existing GDSS facilitate disseminating information to participants of group decision-making, it cannot force the group to think. Systems thinking would enable us to make decisions consistent with the global objective, resulting in collaborating individuals in a group. Various tools and techniques of system dynamics which is based on systems thinking can aid the group decision-makers to think.

5. CONCLUSION AND IMPLICATIONS

This research has several implications for an organization suffering from group decision-making issues resulting from the lack of systems thinking. First, the approach facilitates the identification of the interactions among functional units over time. This leads to a successful group decision-making by understanding dynamic complexity within the organizational activities. Second, organizational equivocality frequently occurring at the group decision-making process can be reduced through system dynamics approach. Equivocality is the ambiguity based on the existence of multiple and conflicting interpretations about an organizational situation. It was argued that equivocality could be reduced through the exchange of opinions, perceptions of relevant managers, construction of a joint cognitive map, and rapid feedback. Third, this approach provides more mentally appropriate tools in terms of cognitive fit. Sinha and Vessey [13] argued that matching the type of information provided by tool to that in the task would lead to effective and efficient problem-solving performance. A limitation in the proposed approach is that the approach begins with the assumption which organizational members or their groups participate in creating their own cognitive models appropriately reflecting the cause-effect interrelationships in an organization. But, it is not easy to produce a theoretically robust and valid causal model although participants verify the model.

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