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A Simulation based Approach for Group Decision-Making Support

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ABSTRACT

The changing structure of organization and the increasing diversity of business have forced organizations to have abilities to coordinate dispersed business activities. They have required cooperation and coordination among the functional units in the organization which should involve group decision-making processes. Although many group decision-making support tools and methods have been introduced to enable the collaborative process of group decision-making, they often lack the features supporting the dynamic complexity issue frequently occurring at group decision-making processes. This results in cognitive unfit between the group decision-making tasks and their supporting tools, bringing about mixed results in their effects on group decision-making. 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.

Keywords: Group decision-making, System dynamics, Dynamic complexity

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1. INTRODUCTION

The increasing diversity of business, the collapse of corporate hierarchies, and the reliance on cross-functional tasks have forced organizations to have abilities to coordinate dispersed business activities. The agility of an organization's response to the market demand has been recognized as one of critical factors in meeting competition. These have required cooperation and coordination among functional units in the organization involving group decision-making processes. Group decision-making admittedly falls in the category of "wicked" problems, a class of problems that can be addressed through discussion and collaboration among the agents involved [24]. 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 [3] and a group is not just the aggregation of individuals [30]. 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 due to the following fundamental reason.

The previous studies have proposed that the rationality of human decision-making is bounded [11, 32, 44, 45]. Humans have a limited ability to process information [49] and perception of information is not comprehensive but selective [21]. Therefore, limited information processing capability forces functional units in an organization to do their best for their goals within their boundary without fully considering process interdependence, which leads to build up their own functional silos. As a result, group decision-making process is required to coordinate those activities. However, 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 [43, 49]. According to Senge [43], 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 group decision-making process without considering the issue.

Cognitive fit theory posits that superior problem-solving performance will result when the problem-solving task and the problem-solving tool involve the same cognitive style [47, 53, 54]. Therefore, in order to achieve better problem-solving performance, we have to select the same problem-solving tool in cognitive style as the problem-solving task in terms of cognitive fit. This study introduces a system dynamics methodology as a problem-solving tool to address the above issues on dynamic complexity in the group decision-making context.

2. RELATED RESEARCH AND ISSUES

2.1 Group Decision-Making

Each individual functional unit in an organization has its own set of goals, information, and interpretation of the problem. Functional units strive to achieve their goals based on information they have and interpretation with which they look into the problem. In any organization, multiple goals are developed and pursued, but the goals also have to be coordinated so that they reinforce each other rather than compete against one another [14]. The problem lies in the fact that one party may take actions conflicting with other parties because of the different goals. Different actions within the organization due to the goal conflict between multiple departments or functional units may lead to overall organizational ineffectiveness. Therefore, through group decision-making process, management coordinates each functional unit's activities in order to enhance overall organizational performance.

There is a growing recognition that information technology can help managers in their efforts to coordinate the decision-making processes [9]. 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, business process reengineering, and strategic alternatives selection [7, 34]. 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 [10, 19, 27]. Many research [20, 35, 52] have suggested clues for possible reasons of the inconsistencies in the results of existing studies. According to Chun and Park [10], these include contextual pressures, tasks, group characteristics, and GDSS configurations. 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 [13]. 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, 32, 44, 45]. Bounded rationality results from limitations on our knowledge, cognitive capabilities, and time [49]. Limited information processing capability forces an organization to divide the total task of making a decision into smaller units. By establishing subgoals the complexity of the total problem is vastly reduced while decomposition of decision problems into subgoals brings about coordination problems in terms of group decision-making. In deciding how to achieve a goal, each functional unit tends to ignore other aspects of the situation except for its own area. So, most organizations suffer somewhat from the "functional silo syndrome" that individual departments or functional units are strong and efficient, but the communication or connection between them is weak [37]. 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 [2, 17]. 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 [6]. For these reasons, group decision-making process usually raises a lot of intricate debates and negotiations among participants or functional units [24].

The existence of multiple interpretations during group decision-making results in equivocality, which is associated with organizational confusion and ambiguity [13]. 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 [43, 51]. 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 [43, 49]. It is argued that dynamic complexity arises: (i) when the same action has different effects in the short run and the long run; (ii) when an action has one set of consequences locally and a very different set of consequences in another part of the system; (iii) and when cause and effect are distant in space and time [43, 51]. 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 [2, 4, 50].

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 [33] proposed a theory that humans were considered to be information processing systems. The theory assumes 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 [1, 54]. Cognitive fit theory suggests that problem-solving with cognitive fit leads to effective and efficient problem-solving performance [54]. The basic model of cognitive fit views problem-solving as the outcome of the relationship between the problem representation and the problem-solving task. Vessey [54] concluded that if both the problem representation and the problem-solving task involve the same cognitive style, then there is said to be cognitive fit between them.

Related research in human problem-solving has examined factors other than task and representation that could affect problem-solving performance [1, 55]. An extended model of cognitive fit theory included problem-solving tool as an additional determinant of problem-solving performance, which postulates that superior problem-solving performance will result when the problem-solving task and the problem-solving tool emphasizes the same type of information [1, 47]. This means that if there is "cognitive unfit" between the problem-solving task and the problem-solving tool, then the problem-solving performance would be worse than expected. 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 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 [51]. Systems thinking is a conceptual framework for seeing the whole and for seeing the interrelationships or the feedback loops among its elements [43]. In systems thinking, every influence can be both cause and effect. This means that the changes intended to improve performance in one part of an organization may inflict other part(s) with negative results. 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 by considering processes of change rather than snapshots or events [43]. 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 [18, 49, 51]. 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 [18, 49, 51]. 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 [5]. So, system dynamics approach facilitates the representation of two types of information – measurable variables such as inventory and hard-to-measure variables such as word-of-mouth effect. For the purpose of this study, it is necessary to note that system dynamics has the following features [26, 49, 51]:

- Feedback effects can be captured through system dynamics modeling and they create closed loops. All dynamics in an organization arise from the interaction of two types of feedback loops, positive (or self-reinforcing) and negative (or self-correcting) loops.
- System dynamics uses stocks and flows concept to model organizational situations. Stocks represent the accumulation in the system while flows link stocks and cause changes in stock levels.
- Time delays can be captured in system dynamics model. It is not uncommon that delays between taking a decision and its effects on the organization occur. Delays in feedback loops create instability and increase the tendency of systems to oscillate.

3. GROUP DECISION-MAKING PROCESS WITH SYSEM DYNAMICS

The literature relating to the decision-making process is extensive across various disciplines [36]. One of the most popular models of the decision-making process is Simon's [46] three-stage model: intelligence, design, and choice. Mintzberg et al. [31] 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 [31] model can loop back and forth among the three decision-making stages. Although a large number of subsequent studies have followed Simon's [46] linear approach on the decision-making process [28], 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 [30] continually searching for globally optimal solution, which necessarily involves interactions among participants and feedback. Therefore, this study proposes following three stages to describe the group decision-making process in the perspective of system dynamics, based on Mintzberg et al.'s [31] feedback view of decision-making model, as illustrated in Figure 1.

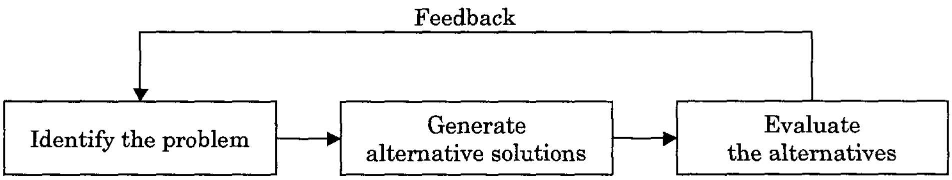


Figure 1. Group decision-making process with feedback

Group decision-making process starts from identifying problems among participants or functional units across the organization. The problems can be captured by identifying the cause-effect interrelationships in the organization. After identifying the potential problems, alternative solutions have to be provided. Alternative decision options also should be generated in a testable way so that they can be compared and evaluated among other options. Then, it proceeds to the evaluation stage, which is for testing the alternatives and selecting the optimal solution. The entire process embraces dynamic complexity to obtain significant leverage in a group decision-making process. To improve our ability to understand and manage dynamic complexity, we need the tools capable of capturing it. The tools must help participants evaluate the consequences of new decisions and new model structures generated during the group decision-making process. These tools include cognitive mapping and simulation modeling. Table 1 describes the group decision-making process in terms of system dynamics mechanism along with its supporting tools.

Table 1. Group decision-making process using system dynamics

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

3.1 Identify the Problem

An organization can be perceived as a complex network consisting of interrelated causal elements. Various studies describe an organization as a cognitive entity [22, 23, 41-43]. 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 [29]. 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 [16]. Based on cognitive mapping, system dynamics offers a systematic tool, called a causal loop diagram, for uncovering counterintuitive dynamics that might be overlooked. Counterintuitive consequences are more likely when there are feedback loops which are not readily apparent. Much of the art of system dynamics modeling lies in discovering and representing the feedback processes [51]. A map of the feedback structure of decision-making situation is a starting point for analyzing what is causing a particular pattern of behavior [26]. A representation of the feedback structure requires the addition of positive (+) and negative (-) signs to each link in the causal loop diagram. A positive relationship refers to a condition in which a causal element A results in positive influence on B with an increase in the value of A producing a positive response in the value of B, while a negative relationship refers to a condition in which a causal element A results in negative influence on B with an increase in the value of A producing a decrease in the value of B [39].

As an illustration, suppose that a firm is suffering from sales fluctuations having periods of rapid sales growth alternating with periods of declining sales (this example is adapted from [26, 40]). It needs to understand which factors cause the situation, how to make decisions among the alternatives to overcome the situation, how to design a new business process structure to support the solution, and a host of other issues. It could be begun by identifying some of the feedback processes that could stimulate "orders" (a source of sales volume) through the group decision-making sessions consisting of various functional units related to the issue – e.g., marketing team, sales team, and production team, and they could be mapped with a causal loop diagram. Then, the causal loop diagram is expanded to embrace all the participants' knowledge and viewpoints on the issue as illustrated in Figure 2. In this example, feedback loops from three teams' perspectives are captured and integrated to deliver the whole system view on the issue areas. Two loops – order and production – are identified as the balancing or correcting loop (negative loop) with the loop polarity identifier B, while one loop – sales force – is identified as the reinforcing loop (positive loop) with the loop polarity identifier R. Elicited causal loop diagram enables decision-makers of functional units to understand the entire structure of the target business issue and helps them to estimate the behavior mechanism over time.

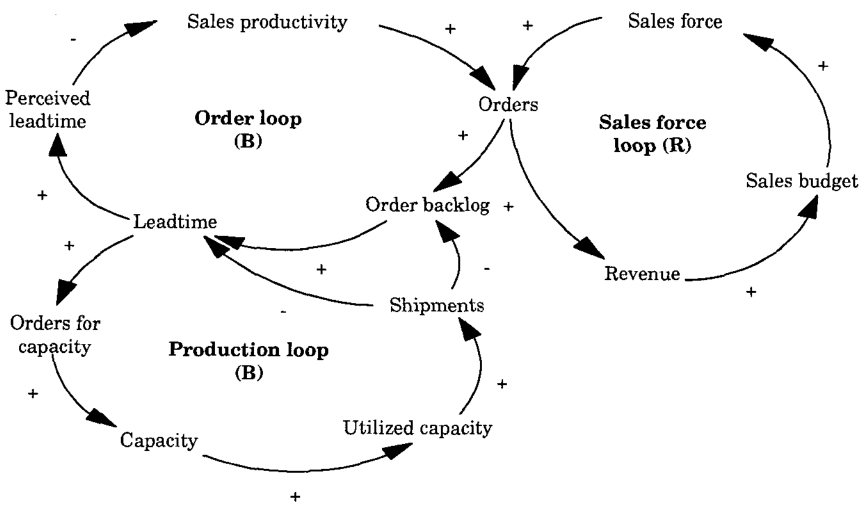
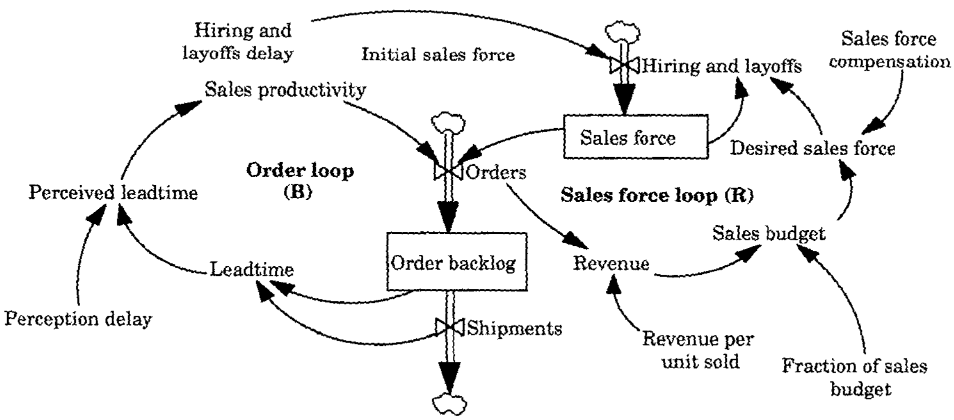


Figure 2. Identifying the problem with causal loop diagram

3.2 Generate Alternative Solutions

We can infer the dynamics of individual loop such as those shown in Figure 2. When multiple loops interact each other, however, it is almost impossible to determine by intuition what the dynamics will be [51]. 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 [51]. Although the simplicity of the causal loop diagram enhances communication capability and facilitates understanding of the issues among participants, it is not enough to build a simulation model. To develop the simulation model, it is useful to extend the causal loop diagram to include stocks and flows as illustrated in Figure 3 (adapted from [26, 40]). The stocks are represented as the rectangles, in this example, sales force and order backlog. The flows are represented as the pipes with valve, in this example, orders and shipments; in this case, orders (flow) move ordered quantity not yet delivered to order backlog (stock). These relationships between stocks and flows are formulated to run the simulation as shown in the Figure 3. 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: $\text{Stock}_{t} = \text{Stock}_{t\text{-}dt} + dt \times (\text{Inflow}_{t\text{-}dt} - \text{Outflow}_{t\text{-}dt})$.



Simulation Program Equations
Desired sales force = Sales budget / Sales force compensation
Hiring and layoffs = (Desired sales force - Sales force) / Hiring and layoffs delay
Leadtime = Order backlog / Shipments
Orders = Sales force × Sales productivity
Order backlogs = INTEG (+Orders – Shipments, 5 × Initial sales force)
Revenue = Orders × Revenue per unit sold
Sales budget = Revenue × Fraction of sales budget
Sales force = INTEG (Hiring and layoffs, Initial sales force)

Figure 3. Generating alternative solutions with stock and flow diagram (only for order and sales force loop)

From the simulation model based on the stock and flow diagram, in this example, we can identify the sales fluctuations resulting in the revenue changes as shown in the left side of Figure 4. Also, we can see from the causes tree of Figure 4 that orders are impacted by both sales force and sales productivity. By tracing the causes tree, it becomes evident that sales productivity is inversely associated with perceived leadtime and sales force is positively related to sales budget. As a consequence, it makes sense to examine two alternatives – increase sales budget ratio and decrease leadtime variation. To do so, some variables such as fraction of sales budget and leadtime threshold could be considered the decision variables to be simulated and tested during the group decision-making process.

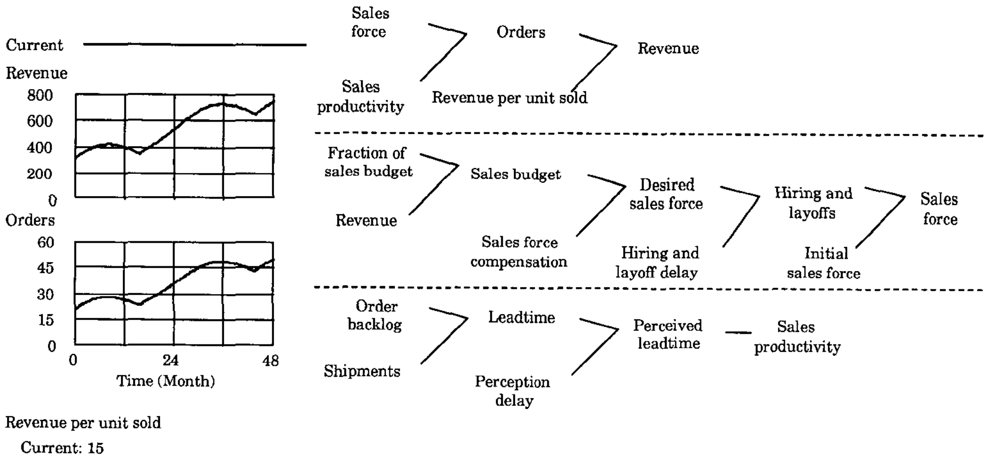


Figure 4. Revenue fluctuation and its causes tree

3.3 Evaluate 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.

Two different approaches are examined, in this example, to address the undesirable revenue and order patterns identified by group decision-making participants as shown in Figure 5. First, the increase of sales force is evaluated. Sales budget ratio is increased by 25% from 0.4 to 0.5. This policy change leads to a radical improvement in the trend of revenue when compared to the current policy.

Revenue grows rapidly faster than before and its substantial declines do not occur any longer. Although it looks good in terms of revenue and orders, however, the other thing seems to be not so positive. The leadtime becomes longer than before. It is expected that the longer leadtime lead to poor customer services and unstable capacity utilization. Besides, this policy might cause the conflict between sales team and production team due to the substantial increase of order backlog. Second, we switch from considering an alternative from sales team to considering a policy related to production team. To prevent the leadtime variation in advance, augmenting capacity before leadtime becomes worse is considered. This means, in this simulation model, setting leadtime threshold to a lower value. The leadtime threshold is reduced by 20% from 5.5 months to 4.4 months. Based on the result of simulation, this capacity agility policy seems to lead to a better performance when compared to the current policy and the sales force policy. In the perspective of revenue, it grows stably without any fluctuations although the sales volume (having the same or above level as the current policy) is inferior to the sales force policy. In the perspective of leadtime, this policy shows an improvement in its pattern of behavior as compared with the current policy not to mention the case of the sales force policy. As a consequence, it appears that increasing capacity agility might be appropriate among the alternatives.

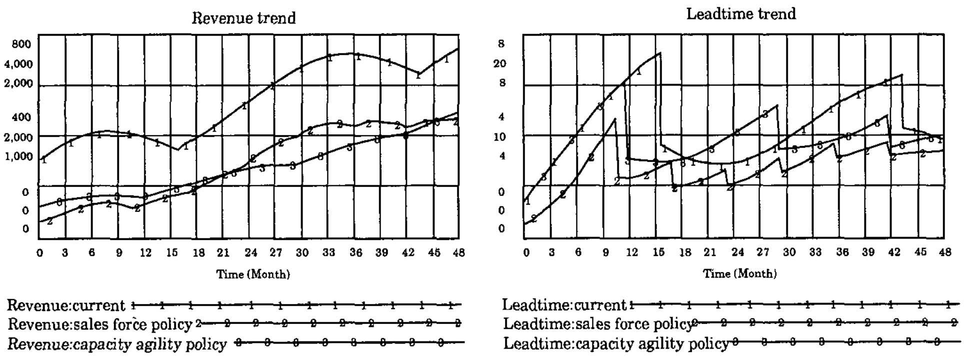


Figure 5. Evaluating the alternatives with system simulation

4. CASE STUDY

The study applied the proposed group decision-making support method to a local telecommunications company, BmT, Boston, 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. It targets newly developed and highly populated areas. In this application case, the present study aims to understand the group decision-making situation and its behavior mechanism by adopting system dynamics approach.

4.1 Identify the Problem

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 from revenue perspective in order to address the issue. Although some information or knowledge can be obtained from documents or databases, large portions of the full knowledge reside in mental models. Therefore, 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 6. Four reinforcement feedback loops exist – "Customer adoption", "Sales efforts", "Customer service", and "Claim settlement" – along with two balance feedback loops – "Competition" and "Obsolescence".

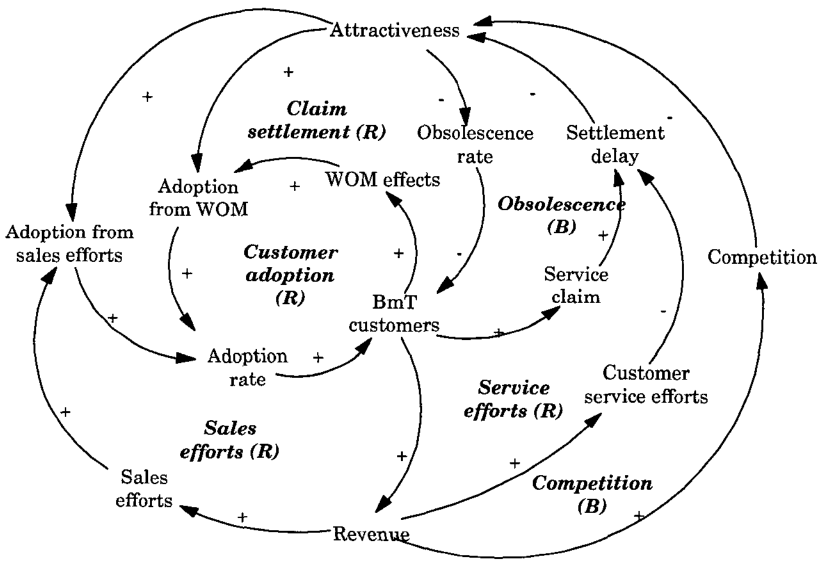


Figure 6. Revenue-related organizational knowledge in BmT

As a reinforcing loop, the "Customer adoption" loop shows how existing customers' word of mouth (WOM) has had an effect in capturing new customers. That is, current BmT customers contacted other possible customers, resulting in more customers adopting a BmT telephone service. The "Sales effort" loop represents the relationship between an increasing promotion budget and a capturing of new customers, obtained by increasing the customer base (market share). The "Service efforts" loop represents the relationship between an increased customer service budget and a decrease in settlement delay (a key factor in determining BmT attractiveness and customers' decisions to choose a BmT service). The "Claim settlement" loop is related to the relationship between the speedy settlement of customer claims and the extent to which this can improve the attractiveness of BmT.

As a balance loop, the "Competition" loop implies that BmT's increasing revenue affects competitors' awareness and that this eventually reinforces their sales operations or the emergence of new competitors in the market. This whole process results in diminishing the attractiveness of BmT. The "Obsolescence" loop demonstrates that the increase in the number of BmT customers proportionally increases the number of unsatisfied customers and delays settlements. This will decrease the attractiveness of BmT, causing customers to move to other competitors.

4.2 Generate Alternative Solutions

The organizational knowledge illustrated in Figure 6 was transformed into a formulated model as illustrated in the Appendix. 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".

4.3 Evaluate the Alternatives

In addition to model verification by BmT management and departments, the model was validated by comparing the historical data and simulation data on new customers for the previous eighteen months. The validity of extreme cases was also checked. Since then, the formulated model 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. Nevertheless, the number of customers has been increasing steadily, as has the revenue of BmT. Meanwhile the low price strategy resulted in increased attractiveness. In attracting new customers, the existing customers' WOM has turned out to be more successful than the promotion activities of sales team. In particular, the simulation results estimate the sales operation by MLM customers (5% of total customers) as capturing almost 50% of new customers. Considering their contributions, an ongoing key role for MLM customers can be anticipated through an MLM incentive scheme.

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. This decreased attractiveness not only caused difficulty in capturing new customers, but also presented problems in retaining existing customers. The number of BmT customers has sequentially decreased. However, as the number of customers decreased, the number of complaints also decreased, which in turn shortened service delay.

In Scenario 2, BmT can have various alternatives for a counter strategy. These include increasing the sales budget, increasing the service budget, reinforcing the MLM incentive, cutting-down on service delay time, lowering service price, and improving the line quality. The basic direction of decision-making in this case should be towards improving the attractiveness of the organization and reinforcing the customer-adoption activities – which represent the core leverage in increasing revenue. 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). According to the simulation test, the number of BmT customers was seen to have increased continuously. However, the increase in the number of new customers also increased the number of complaints and eventually reduced the attractiveness through service delay. Although customers tend to be price-sensitive, they are also sensitive to service delay. Consequently, a new decision was required to reduce the average service delay. Allocating additional budget resources to service efforts, based on the number of claims, was considered appropriate.

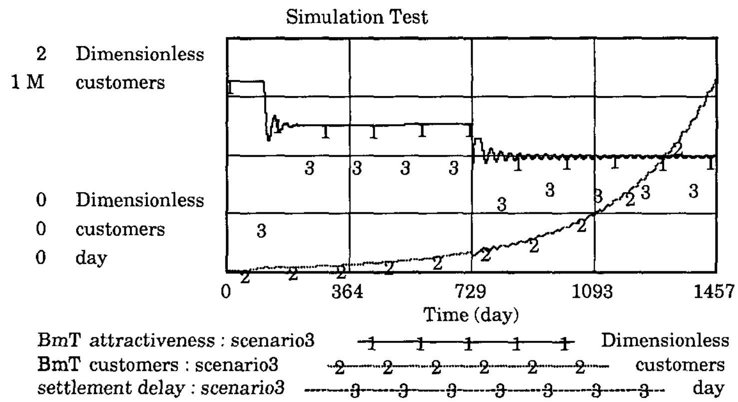


Figure 7. Testing on the BmT's reaction scenario 3

Figure 7 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. In addition, the attractiveness of BmT can be enhanced by shortening service delay. The decision option adopted in Scenario 3 can also be applied. 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 secession.

5. 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 [34]. 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).

It is possible to compare the proposed method which focuses on dynamic complexity with other methods which focus on detail complexity or combinatorial complexity. Because problem structuring identifies the factors and circumstances that make the situation problematic, the structure affects the outcome of problem solving [38]. As indicated in the application case, business problems are often too complex to allow recognition of the structure because of the many decision-making variables in mental models and the feedback loops among them. For this reason, most research on decision-making support in the Management Science area have focused on detail complexity, and have aimed to find an optimal solution by structuring the target problem with limited hard variables from the perspective of linear and static time. Without fully exploring the feedback loops in the model, it cannot be assumed that the solution will work well over time, although it might work well over a limited period of time [8, 18, 25, 51]. The proposed method has identified high-leverage decision options, and has shown how they can generate substantial synergy from joint implementation over time in the case of BmT, allowing for the dynamic complexity in the group decision-making phases.

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 [30, 38]. 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. Group decision-making support should aid individuals in a group to exchange information and make coordinated decisions [3]. Although existing GDSS facilitate disseminating information to participants of group decision-making, it cannot force the group to think [15]. 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.

6. CONCLUSION AND IMPLICATIONS

This study proposed an approach for supporting group decision-making process based on system dynamics. The suggested approach has achieved its aims by providing an understanding of: (i) identification of the problem by capturing the cause-effect interrelationships within an organization; (ii) generation of the alternative solutions by building the testable models reflecting decision options; (iii) evaluation of the alternatives by running the simulation models and analyzing the decision options along with the comparison results of the alternatives.

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. By the process of identifying the cause-effect interrelationships, organizational members come to understand each other better, and they become willing to transform their ideas into corporate synergy. 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 [56]. 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 [12]. Third, this approach provides more mentally appropriate tools in terms of cognitive fit. Sinha and Vessey [47] 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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APPENDIX

Stock and Flow Model of the BmT case