CAUSAL KNOWLEDGE-BASED APPROACH TO FORMULATING SIX SIGMA MANAGEMENT STRATEGY: AN EMPIRICAL EVALUATION

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Causal Knowledge-Based Approach to Formulating Six Sigma Management Strategy: An Empirical Evaluation

Completed Research Paper

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Abstract

Six Sigma Management has played a very important role in improving corporate performance. Literature shows that a great deal of components is influencing the success of Six Sigma Management. Problems with analyzing those components related to the Six Sigma Management lie in the fact that there exist complicated forms of causal relationships among them, forcing the Six Sigma strategists to rely on simple and intuitive interpretation of a few number of components. Therefore, it was inevitable that a bunch of valuable information is lost during the Six Sigma Management analysis. To overcome such pitfalls, this study proposed a Cognitive Map (CM) extracted from Six Sigma experts, and exploring a set of robust and effective Six Sigma strategies with the aid of CM simulations. Empirical results obtained from field survey data collected from a number of Samsung companies in South Korea proved the validity of our proposed approach.

Keywords: Cognitive Map, Six Sigma, corporate competitiveness, business process management, TQM
**Introduction**

IS has been closely related with the business process management ever since its inception, in particular, IS has been closely integrated into the business process improvement through designing information systems to support the business units. As an important method of business process management, Six Sigma’s implementation process is supported by IS (Chang-Tseh et al. 2007; Tiwari et al. 2008). Six Sigma Management relies highly on the transparency and accuracy of information to simply the business process and help manager’s to make better decisions systematically in a complicated marketplace. In the Six Sigma literature, there exist various models representing causal relation of necessary elements for successful Six Sigma Management for companies adopting Six Sigma Management as a business innovation to establish various strategies. However, it is practically difficult to develop Six Sigma Management strategy based on various qualitative variables with this model. It is even difficulty because Six Sigma Management is carried on a project basis, where various internal and external elements need to be dealt with.

In this paper, a comprehensive model that can accommodate various elements by a Cognitive Map (CM) from experts’ knowledge is explored. In general, causal relation model can be presented in the format of cause and effect in CM. CM is able to represent values of casual sequence either in direction or size of change (Axelrod 1976; Eden et al. 1979; Kosko 1986). By CM, it is very helpful to eliminate uncertainty with complicated casual sequence to many elements relating specific problems (Kardaras and Karakostas 1999). It is possible for CM to represent a cause and effect relation where there are various internal and external influential elements in Six Sigma Management. The methodology proposed in this paper has the following special features. First, CM is formulated based on a casual sequence of structural equation model from literature research in previous paper. Second, CM is formulated by expert interview for qualitative elements in a structural equation model that are difficult to back up by literature. Third, CM contains various elements for developing Six Sigma Management strategy. Based on this, strategy is established for a business situation in Six Sigma Management.

**Literature Review**

**Basic Concepts in Cognitive Map**

The cognitive map, introduced by Tolman (1948) who wished to develop an alternative to the stimulus-response model of man (Eden 1992) and used later by Axelrod (1976), was originally utilized to represent knowledge in the political and social sciences, i.e., to analyze the cause and effect relationships that are perceived to exist among the elements of a given environment. Cognitive map is designed to examine whether the state of one element has an influence on the state of another. A cognitive map is composed of nodes, signed directed arcs, and causality values. Nodes represent causal concepts, signed directed arcs represent the causal relations between two concepts, and causality value is shown by ‘+’ and ‘−’. Causality value can also be “fuzzified” into a real value between –1 and 1 (Lee et al. 1992). However, Axelrod claimed that simple causality values of ‘+’ and ‘−’ are sufficient to represent human cognition because decision-makers do not typically use a more complicated set of relationships. In this study, we adopt the simple cognitive map.

Previous literature suggested that cognitive maps mainly describe the cognitive processes occurring in human’s minds while dealing with problems or thinking. For example, Lenz and Engledow (1986) stated that an individual’s perception and understanding of a problem can be captured in a cognitive structure consisting of interconnected sets of elements representing implicit views of one’s own interests, concerns, and tasks. Further, Huff (1990) clarified that cognitive maps are images of cognitive processes and attempted to utilize experts’ beliefs and cognition to explain ill-structured social relationships.

One of the practical aims of cognitive mapping is to attain an appropriate and powerful link between the qualitative aspects of a problem definition and the role of quantitative analysis (Eden et al. 1986). Cognitive mapping is a tool enabling a group of experts and/or specialists to negotiate a definition of the problem visualized in the form of a model amenable to further elaboration and to the analysis of complexity (Eden 1988).
Cognitive Map Applications

Cognitive map has proven especially useful in political science (Axelrod 1976), administrative science (Eden et al. 1979), and management science, in which many decision variables and uncontrollable variables are causally interrelated (Eden and Ackermann 1989; Lee and Clark 1997), making it difficult for decision-makers to analyze hidden causal relationships contributing to more relevant and meaningful solutions (Eden and Ackermann 1989; Eden and Jones 1980; Eden et al. 1979; Klein and Cooper 1982; Lee and Kim 1997; Montazemi and Conrath 1986; Park and Kim 1995). For instance, in a study on decision makers’ beliefs about the causes and effects of structure, Ford and Hegarty (1984) found that cognitive mapping technique is very effective. Calori et al. (1994) proposed a methodology to measure cognitive complexity, and applied it in an exploratory test of the relationships between the scope of the company and the cognitive complexity of the CEO. The results empirically confirmed the complexity of the task of reconciling forces of integration and forces of local adaptation, in combination with product lines, geographic areas, and functional specialties.

Cognitive map has also been successfully applied in such areas as decision making in complex war games (Klein and Cooper 1982), organizational problems (Lee et al., 1992, Barr et al., 1992, Voyer, 1994), strategic planning (Ramaprasad and Poon 1985), information retrieval (Johnson and Briggs 1994), and distributed decision process modeling (Zhang et al. 1994). Barr et al. (1992) proposed the relationship between cognitive change and organizational renewal by investigating the link between changes in mental models and changes in organizational action, through analyzing the causal assertions made by leaders of two initially similar U.S. railroads over a 25-year period. Utilizes a qualitative methodology—RCM to investigate the phenomenon of software operations support expertise, Nelson et al. (2000) demonstrated that the use of the RCM method discovers constructs of software operations support expertise not suggested by the general theory. Later, Xirosinnis & Glykas (2004) developed a cognitive based-method called FCM, a supplement to the BPR methodology, supplementing the strategic planning and business analysis phases of typical BPR projects with supporting “intelligent” reasoning of the anticipated (“to-be”) business performance.

Further, Lee et al. (1992) described the requirements for a computer-based system to support organizational learning and briefly reviewed facilities in existing Group Decision Support Systems. In their study, cognitive mapping was suggested to represent action-response beliefs and a prototype distributed system called The Collective Cognitive Mapping System (COCOMAP), supporting both individual maps and a collective map, has been designed to support group cognitive processes and then organizational learning via cognitive mapping. Langfield-Smith and Wirth (1992) suggested a methodology to measure differences between cognitive maps by developing the quantitative measures to analyze the content difference between two or more causal cognitive maps. In the same line of research, Wang (1996) formed the cognitive mapping neural networks to measure differences between cognitive maps complementing the previous static measures of differences between cognitive maps. The contribution of this method lies in its dynamic features of cognitive maps and revelation of more information about the differences in human cognition of the perceived real world.

In addition, researchers proposed diverse applications using cognitive map. For instance, causation in static and dynamic processes was represented by an M-labeled digraph and was used to find solutions for unstructured problems (Burns and Winstead 1985; Burns et al. 1989), information requirement analysis was performed by cognitive map (Montazemi and Conrath 1986), Kim and Pearl (1987) suggested an inference engine for causal and diagnostic reasoning based on Pearl’s (1986) causal network formalism, and Eden and Ackermann (1989) proposed SODA (Strategic Options Development and Analysis) which was designed to encourage organizational members to actively define their own strategies. In the meantime, cognitive map has been used to represent graph-theoretic behavior to investigate electrical circuits (Styblinski and Meyer 1991), describe plant control (Gotot et al. 1989) and virtual worlds (Dickerson and Kosko 1994). Cognitive map has also been applied to distributed decision process modeling on networks (Zhang et al. 1994), stock investment analysis problems (Lee and Kim 1997), and business process redesign (Kwahk and Kim 1999).

Cognitive Map and Decision-making

Decision-making is an important aspect of management activity (Eierman et al. 1995). Some theorists, such as Simon (1977), suggested that decision-making is a principle function of organizations. However, decision making within an organization is not always an easy task, particularly when the underlying problem is complex or poorly structured. Decision-makers are limited in their cognitive abilities to process complex information (Taylor 1975);
they may succumb to a variety of biases (Kahneman et al. 1982), and they may have a difficult time agreeing on a single solution that satisfies differing interests (Zigurs et al. 1988).

CM is widely used as a valuable tool in resolving complicated problems (Klein and Cooper 1982). For instances, Shapiro et al. (1988) proposed a discursive practices approach for the collective decision-making involving a change in conceptual language as well as an alteration in the modes of calculation for the decision-making process. Klein and Cooper (1982) illustrated the use of a cognitive mapping technique to examine the behavior and perceptions of individual decision-makers in a complex game, the result of which showed that the individual perceptions under the common decision-making environment differ in noticeable and sometimes surprising ways. The differences that have been observed fall into distinct classes varying with the size and complexity of the cognitive maps, their detailed interpretation, the players’ confidence and anticipation of the future, and the way in which maps are altered as time progresses.

Ülengin and Topçu (1997) discussed how to use an integrated cognitive map-knowledge based decision support model to help the transportation planners for them to select the most suitable alternatives for a water crossing infrastructure. Fuglseth and Grønhaug (2002) presented a consistent approach to elicit decision-makers’ concepts and causal beliefs for the construction and analysis of cause map with explicit theory-driven procedures to improve managers’ decision-making.

**Research Methodology**

We used a five step process to evoke the CM and to solve the strategic problem. The first step in this process is data elicitation. The second step is the actual construction of the CM. In the third step, the CM is subjected to a validation process. In the fourth step, the CM is analyzed and interpreted. The final step is problem solving.

**Figure 1. Procedure of Constructing CM and Inference**

**Step 1: Data Elicitation**
- select sample
- prepare guided interview with experts

**Step 2: Constructing CM**
- Identify causal statement
- Construct raw CM
- Identify coded concept
- Construct concept level CM
- Aggregate the maps across individuals

**Step 3: Validation of CM**
- Validate the concept linkage

**Step 4: Analyzing CM**
- Construct adjacency matrix
- Construct reachability matrix

**Step 5: Problem solving**
- inference
- Strategic decision making

**Step 1: Data Elicitation**

Prepare how to interview after sample selection of target strategy establishment. And, select an interviewer. An open interview technique is used in expert interview.
**Step 2: Constructing CM**

First, the causal statements are derived from the interviews with experts. Causal statements are statements that imply an explicit cause-effect relationship. Second, in order to establish raw CM, a causal statement is divided into cause and effect. Third, confirm a concept from raw causal statement. Fourth, establish CM of concept level. Lastly, aggregate a map with each and every expert.

**Step 3: Validation of CM**

This is a step to confirm the CM aggregated through Step 2. Member checks were used to validate the concepts and linkages in the aggregate CM (Lincoln and Guba 1985). In earlier step toward participated experts, propriety is confirmed with concept and linkage composing CM.

**Step 4: Analyzing CM**

Establish adjacency matrix and reachability matrix on an aggregated CM.

**Step 5: Problem solving**

Apply what-if analysis and apply in strategic decision problem with final CM.

**Experiments**

In this paper, data are extracted to establish models difficult to back-up. Before interview for data elicitation, uniformity in data extrusion process is maintained through explaining structural equation model to the experts. First, adopting degree to structural equation model is examined by survey. Survey is composed of 5 questions to verify propriety of Six Sigma structural equation model. The survey questionnaire was prepared by referring to several studies such as Bergeron et al. (1995), Susarla et al. (2003), and Garrity et al. (2005). Fifteen experts participated in the survey and the level of agreement among the fifteen experts was measured using Kendall’s coefficient of concordance. Kendall’s coefficient of concordance for the Six Sigma model was 0.7, indicating an acceptable level of agreement among the experts.

In this paper, a process of strategy adopting actual cases with previous methodology is examined. Current status for strategy development is as follows.

Insurance Company A said that more than 10% of agent is leaving every year. Renewal rate of the policy whose agent withdraws is 50% level that is 20% point lower than overall company average of 70% level. This caused about 30 billion won in loss. Insurance Company A is developing CM strategy in order improve renewal rate.

**Step 1: Data Elicitation**

Data elicitation is conducted through interviewing experts in this area. Respondents are 15 experienced individuals. This study used open interview techniques with probes. An interview guide was used to facilitate the process. Each interview lasted from 30 to 60 minutes. Respondents were asked about the specific situation. The interviewers were not constrained to suggested responses but encouraged to give their solution. Table 1 describes the respondents profile in this research.
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<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>37.40</td>
<td>2.20</td>
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<tr>
<td>Experience in sales (years)</td>
<td>8.53</td>
<td>1.73</td>
</tr>
<tr>
<td>Total work experience (years)</td>
<td>10.73</td>
<td>1.83</td>
</tr>
<tr>
<td>Six Sigma experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degree of belt certification (BB/GB)</td>
<td>60%</td>
<td>-</td>
</tr>
<tr>
<td>Ratio of training received (No belt)</td>
<td>40%</td>
<td>-</td>
</tr>
</tbody>
</table>

**Step 2: Constructing CM**

In the first step, the causal statements are derived from the interviews, following the guidelines suggested by Axelrod (1976) and Nelson et al. (2000). Causal statements are statements that imply an explicit cause and effect relationship. In general, some key words used to identify causal statements are “if-then”, “can lead to”, “because”, “so”, “as” etc.

The examples of collected causal statements through interview with experts are as follows;

- If agent moves to competitors, then the renewal rate is low.
- If agent moves to competitors, then correctness of contact information of his/her policy holder is low.
- If a policy holder is a relative of the agent, then the policy holder’s possibility of shifting to competitors is high.
- If new agent moves to competitors, then the policy holder’s possibility of shifting to competitors is high.
- If relationship of agent and transferred agent is friendly, then correctness of contact information of his/her policy holder is high.
- If relationship of agent and transferred agent is friendly, then the renewal rate improves.
- The policy whose agent withdrew can lead bad correctness of contact information of the policy holder.
- If correctness of contact information is low, then the renewal rate decreases.
- Low correctness of contact information can lead low concerns of transferred agent.
- If a policy holder lasts contracts for long period, then the possibility of shifting to competitors is low.
- If agent can manage his/her policies well, then the renewal rate improves.
- If agent who has lots of contracts takes another one, then he/she cannot manage the contracts well as he/she wants.
- If management of the policy whose agent shifted to competitors becomes regular activity, then the branch manager/assistant shows high concerns.
- If branch manager/assistant shows high concerns, then the renewal rate improves.
- If management of the policy whose agent shifted to competitors has relationship with commission, then the concern of agent increases.
- If the concern of agent increases, then the renewal rate is high.

In the second step, the causal statements derived in the first step are broken into causes and effects to construct the raw CM.
Table 2. Results of Constructing raw CM

<table>
<thead>
<tr>
<th>Cause</th>
<th>Casual Connector</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>If management capability of branch manager whose branch lost policy holders by withdrawn agents is strong</td>
<td>If-then</td>
<td>Then branch assistant’s support for renewal improves</td>
</tr>
<tr>
<td>If management capability of branch manager whose branch lost policy holders by withdrawn agents is strong</td>
<td>If-then</td>
<td>Then the agent’s dissatisfaction is low</td>
</tr>
<tr>
<td>Branch manager’s use of IT systems</td>
<td>Can lead to</td>
<td>His/her management capability</td>
</tr>
<tr>
<td>Performing outbound call</td>
<td>Can lead to</td>
<td>Higher renewal a rate</td>
</tr>
<tr>
<td>If transferred agent’s contact to his/her policy holders increases</td>
<td>If-then</td>
<td>Then organizational support for outbound call improves</td>
</tr>
<tr>
<td>If correctness of contact information of the policy holder whose agent withdrew is better</td>
<td>If-then</td>
<td>Then the renewal rate improves</td>
</tr>
<tr>
<td>If agent focuses on promotion for the relatives</td>
<td>If-then</td>
<td>Then the correctness of policy holder’s information is low</td>
</tr>
<tr>
<td>If agent focuses on promotion for the relatives</td>
<td>If-then</td>
<td>Then the renewal rate is low</td>
</tr>
</tbody>
</table>

In the third step, conceptually relevant concepts from the raw causal statements are identified (Narayanan and Fahey 1990). It begins with grouping frequently mentioned words in the raw CM. These groupings were examined for theoretical or logical relevance and were placed into categories that would be understood and interpretable by researchers interested in related fields (Nelson et al. 2000).

Table 3. Results of Coded concept

<table>
<thead>
<tr>
<th>Raw Phase</th>
<th>Coded Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>The type of agent’s withdraw is “friendly”</td>
<td>Agent’s dissatisfaction</td>
</tr>
<tr>
<td>Correctness of contact information of the policy holder whose agent withdrew is better</td>
<td>Correctness of policy holder’s contact information</td>
</tr>
<tr>
<td>The branch assistant’s support for renewal is strong</td>
<td>Branch assistant’s support for renewal</td>
</tr>
<tr>
<td>The branch manager’s use of IT systems is better</td>
<td>Branch manager’s use of IT systems</td>
</tr>
<tr>
<td>Renewal rate of the policy holder whose agent withdrew improves</td>
<td>Renewal rate</td>
</tr>
<tr>
<td>Number of contacts to policy holders increases</td>
<td>Number of contacts to policy holders</td>
</tr>
<tr>
<td>Transferred agent’s contact to his/her policy holders stream lines</td>
<td>Transferred agent’s contact to policy holders</td>
</tr>
<tr>
<td>Renewal rate improves</td>
<td>Renewal rate</td>
</tr>
<tr>
<td>Agent focuses on promotion for the relatives</td>
<td>Agent’s sales quality (importance of a relative)</td>
</tr>
<tr>
<td>Management capability of branch manager whose branch lost policy holders by withdrawn agents is strong</td>
<td>Branch manager’s supervision</td>
</tr>
</tbody>
</table>

In the fourth step, the concepts were re-put into concept level CM.
In the final step, the concept level CM was aggregated.
**Step 3: Validation of CM**

Member checks were used to validate the concepts and linkages in the aggregate CM (Lincoln and Guba 1985; Nelson et al. 2000). This is done by going back to the original expert respondents and asking their opinion about the concepts and linkages represented on the aggregate maps. The open-ended questions were asked. For example, “When you say promotion for personal connection, do you mean promotion for the relatives?”

The process and purpose of this comprehensive check is to test for factual and interpretive accuracy and to provide evidence of credibility and trustworthiness similar to internal validity in confirmatory studies (Lincoln and Guba, 1985).

**Step 4: Analyzing of CM**

Borrowing from past research in cognitive mapping (Bougon et al. 1977; Huff 1990; Narayanan and Fahey 1990), we focus on two matrices that capture direct and indirect causal linkages: the adjacency matrix and the reachability matrix.

The association or the nature of the causal linkage between two concepts is analyzed using an adjacency matrix. The adjacency matrix is an n×n matrix, where n is the total number of elements (concepts) in a cognitive map. The elements listed along the horizontal and vertical axes of an adjacency matrix will be the set of elements used in the cognitive map. Cells at the intersection of each row and column contain a number indicating the existence, direction and strength of the causal relationship between two elements (Smith and Wirth 1992).

The adjacency matrix shows only the direct cause-effect relationships between two elements or concepts. However this relationship does not capture the indirect linkages between concepts. Ford and Hegarty (1984) analyzed indirect causal effects by representing each cognitive map as a ‘reachability matrix’ (this is essentially the same as the ‘total effects’ matrix). A reachability matrix allows the effect of one element on all other elements within a map to be determined. It was argued that the reachability matrix provided a better basis for analysis than the adjacency matrix because of the inclusion of indirect relationships (Langfield-Smith and Wirth 1992). The reachability matrix allows a more complete picture of the causal relations specified in the adjacency matrix (Axelrod 1976; Ford and Hegarty 1984).

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</table>

**Figure 4. Adjacency matrix of the CM**
1. PC: possibility to contact with policy holders after agent’s withdrawal
2. ADS: agent’s dissatisfaction
3. STC: shifting of agent to competitor
4. NOC: number of contacts to policy holders
5. SUP: branch manager’s supervision
6. RES: branch manager’s resistance
7. PUB: publicity of results
8. CCI: correctness of policy holder’s contact information
9. RR: renewal rate of the policy whose agent withdraws
10. BAS: branch assistant’s supports for renewal
11. UIT: branch manager’s use of IT systems
12. CEO: CEO’s concerns
13. TR: training reinforcement
14. ASQ: agent’s sales quality (importance of a relative)
15. OUT: support of outbound call
16. CTP: transferred agent’s contact to policy holders
17. TAC: transferred agent’s concerns
18. MPH: management on policy holders after agent’s withdrawal
19. EI: evaluation intensity on renewal
20. RF: relation of contract management to fee
21. UOM: use of manual

**Step 5: Problem Solving**

With the final CM as depicted in Figure 3, it can be said that various causal sequence relations with qualitative variables are described in order to improve renewal rate of the policy.

To perform what-if analysis with the final CM, we use the reachability matrix. We now elaborate on the detailed situation terms for each node so that we can describe the experiments more practically. Table 4 shows node value of CM for improving renewal rate.


<table>
<thead>
<tr>
<th>Concept</th>
<th>High</th>
<th>Average</th>
<th>Low</th>
<th>Outstanding</th>
<th>Above average</th>
<th>Below average</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>above 0.8</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.9</td>
<td>0.2~0.4</td>
<td>below 0.1</td>
</tr>
<tr>
<td>ADS</td>
<td>above 0.8</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
<td>below 0.2</td>
</tr>
<tr>
<td>RES</td>
<td>above 0.8</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
<td>below 0.2</td>
</tr>
<tr>
<td>PUB</td>
<td>above 0.7</td>
<td>0.5</td>
<td>below 0.3</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.3~0.5</td>
<td>below 0.2</td>
</tr>
<tr>
<td>CCI</td>
<td>above 0.7</td>
<td>0.5</td>
<td>below 0.3</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.3~0.5</td>
<td>below 0.2</td>
</tr>
<tr>
<td>UIT</td>
<td>above 0.8</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
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<tr>
<td>ASQ</td>
<td>above 0.7</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
<td>below 0.2</td>
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<tr>
<td>TAC</td>
<td>above 0.7</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
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<tr>
<td>EI</td>
<td>above 0.8</td>
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<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
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<tr>
<td>RF</td>
<td>above 0.7</td>
<td>0.5</td>
<td>below 0.2</td>
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<td>0.6~0.8</td>
<td>0.2~0.5</td>
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<tr>
<td>NOC</td>
<td>above 0.8</td>
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<td>0.6~0.8</td>
<td>0.2~0.5</td>
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<tr>
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<td>0.2~0.5</td>
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<td>BAS</td>
<td>above 0.8</td>
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<td>0.6~0.8</td>
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<tr>
<td>CEO</td>
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<td>below 0.2</td>
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<tr>
<td>TR</td>
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<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
<td>below 0.2</td>
</tr>
<tr>
<td>OUT</td>
<td>above 0.8</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
<td>below 0.2</td>
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<tr>
<td>CTP</td>
<td>above 0.8</td>
<td>0.5</td>
<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
<td>0.2~0.5</td>
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<tr>
<td>MPH</td>
<td>above 0.9</td>
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<td>below 0.2</td>
<td>below 0.3</td>
<td>0.6~0.8</td>
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<tr>
<td>UOM</td>
<td>above 0.9</td>
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<td>0.6~0.8</td>
<td>0.2~0.5</td>
<td>below 0.2</td>
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</tbody>
</table>

Although many scenarios can be derived from the data in Table 4, the following scenario is chosen for illustrative purpose.

**Scenario 1**

Scenario 1 assumes the disadvantageous situation. Original agent left with discontent so that agent’s dissatisfaction shows very high (ADS=0.9). Because agent’s dissatisfaction is high, correctness of policy holder’s contact information is also low (CCI=0.2). CEO’s concerns show average level in this situation (CEO=0.5) and training is also about average level to improve renewal rate (TR=0.5). Evaluation intensity on renewal is raised (EI=0.9), and relation of contract management to fee is raised (RF=0.9): adopted compulsive policies. This scenario’s node value is in the Table 5.
Table 5. Node value of scenario 1

<table>
<thead>
<tr>
<th>Criteria</th>
<th>High</th>
<th>Low</th>
<th>Average</th>
<th>Average</th>
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</tr>
</thead>
<tbody>
<tr>
<td>ADS</td>
<td>0.9</td>
<td>0.2</td>
<td>0.5</td>
<td>0.5</td>
<td>0.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Under these circumstances, the first concept vector \( C_1 = (0.0, 0.9, 0.0, 0.0, 0.0, 0.0, 0.0, 0.2, 0.0, 0.0, 0.0, 0.0, 0.5, 0.5, 0.0, 0.0, 0.0, 0.9, 0.9, 0.0) \) is created. We perform the cognitive map-based inference process as follows: the first concept vector, \( C_1 \), is adjusted based on the information in the scenario. Applying a 1/2 threshold for a convergence check (Kosko 1992), we computed the following reasoning processes to ensure that convergence can happen within a finite number of iterations. In Figure 6, the CM-based what-if result is labeled as “step” and the values inside the box can be either 0 or 1. The value will be 1 when the result is greater than the threshold. Otherwise, it will be 0. Step1 refers to the result after the first iteration, while step2 and step3 are generated after the second and the third iterations. The equilibrium state is reached when two consecutive step results are identical. In this scenario, the equilibrium state occurs after three iterations (as can be seen with step 3 equaling step 4).

Table 6. Node value of scenario 2

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Low</th>
<th>Average</th>
<th>High</th>
<th>Average</th>
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<th>Average</th>
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<tbody>
<tr>
<td>ADS</td>
<td>0.1</td>
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<td>0.8</td>
<td>0.5</td>
<td>0.7</td>
<td>0.5</td>
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</table>

In this circumstance, we perform the following what-if simulation as shown in Figure 7. Under these circumstances, the first concept vector \( C_1 = (0.1, 0.0, 0.5, 0.0, 0.8, 0.0, 0.5, 0.0, 0.0, 0.7, 0.0, 0.5, 0.0, 0.7, 1.73, 2.45, 1.09, 0.0, 0.0, 0.0) \) is created. After two iterations, the state of equilibrium is reached with (0.18 -0.42 -0.13 1.42 0.33 0.0 0.39 7.34 0.69 0.5 0 0 1.73 2.45 0 1.09 0 0 0).
### Figure 7. Inference process of scenario 2

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<tbody>
<tr>
<td>C1</td>
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<td>0.00</td>
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<tr>
<td>C2</td>
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<td>1.42</td>
<td>0.33</td>
<td>0.00</td>
<td>0.00</td>
<td>0.39</td>
<td>7.34</td>
<td>0.69</td>
<td>0.50</td>
<td>0.00</td>
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<td>1.73</td>
<td>0.00</td>
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**Discussions**

This study shows how CM can be used in developing Six Sigma Management strategy. Through the study, the suggested methodology has higher level of distinctive strengths than the existing ones.

**General Issue**

The core of suggested methodology in this study is CM. CM is developed through interviews with experts of the specific area and validation process. There are several special features.

First, comprehensiveness toward strategy development is achieved easily for providing an overall map (Huff 1990). There are various kinds of information for developing strategy in the integrated CM with individual expert knowledge, and especially cause-and-effect relation between variables can be easily verified.

Second, a hard variable to deal with can be considered. In the existing Six Sigma methodology, a hard variable to deal with is classified as “noise variable” and excluded from the management subject. And, although a cause related to human must be handled carefully in developing strategy, there are many cases to be excluded from consideration due to measurement issue. Because this methodology includes this noise variable, it is possible to find a practical plan compared to previous ones. In earlier cases, concepts including ‘agent’s dissatisfaction’, ‘agent’s sales quality’, and ‘branch manager’s supervision’ are hard variable to deal with in the existing Six Sigma methodology.

Third, depth of current information is deep. Compared to the previous methodology mainly dealt with direct variables, this methodology includes both direct and indirect variables. From earlier experiment, variables in existing methodology are composed of ones that are directly influential to renewal rate.

In addition, density is a measure for connectedness of CM (Calori et al. 1994). The density of a cognitive map is simply a measure of its degree of interconnection. It is computed by dividing the number of causal assertions by the maximum possible number of causal assertions (Hart 1977; Klein and Cooper 1982). Density of existing methodology with only direct relation is 0.14. However, if a problem is resolved with CM, density becomes higher than 0.14 as a result. This is because as a numerator becomes greater from a result of direct and indirect relation.

Lastly, this methodology is capable of various strategy developments, however previous methodology is difficult to use in a specific condition. Therefore, simulation such as what-if analysis and goal-seeking analysis is available.

**Relation to Six Sigma Methodology**

In the DMAIC methodology which is general roadmap in Six Sigma, relation or causal sequence between causing variables (x variable or key process input variable) is ignored, and a process selecting variables are carried on. It is hypothesized that relation between variables is independent. In the ‘Improve’ stage, relation between causing variables can be verified through experimental design method. However, it is difficult to use experimental design method in non-manufacturing and indirect office areas. And, if a proposed method with CM is applied, relation
among all variables (causing variables, x and y) can be verified. This methodology with DMAIC roadmap is as follows:

<table>
<thead>
<tr>
<th>General Approach</th>
<th>Proposed method (Approach with CM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>- Assign definition</td>
</tr>
<tr>
<td>Measure</td>
<td>- Contain causing variables, and select potential causing variable</td>
</tr>
<tr>
<td></td>
<td>- Use XY-matrix (or cause and effect matrix) as selecting tool for potential causing variable</td>
</tr>
<tr>
<td>Analysis</td>
<td>- Find x variable (causing variable) most influential to y variable through a simulation with an integrated map</td>
</tr>
<tr>
<td></td>
<td>- These variables are vital few x’s</td>
</tr>
<tr>
<td>Improve</td>
<td>- Suggest an improvement for the attainment of goal toward vital few x’s</td>
</tr>
<tr>
<td></td>
<td>- Use an experimental design method to find optimal alternative.</td>
</tr>
<tr>
<td>Control</td>
<td>- Develop maintenance and management plan for an improvement</td>
</tr>
</tbody>
</table>

### Evaluation

Various strengths are discussed on developing strategy with CM. To add more quantitative rigor to the results of evaluation, we performed a Wilcoxon test (Alavi 1982) based on a structured questionnaire survey completed by another group of twelve field experts. Aldag and Power (1986) suggested seven constructs of assessing decision makers’ attitudes towards decision making processes: (1) confidence in decision quality; (2) enhancement of problem-solving ability; (3) satisfaction with resource expenditure; (4) perceived acceptability of solution; (5) perceived process structure; (6) perceived process adequacy; and (7) positive affect toward process. Aldag and Power’s constructs were adopted to help us organize our questionnaire, which consisted of twenty-one items.

We compared an experience about two methodologies: “proposed methodology (using CM)” and “existing DMAIC methodology (not using CM)”. For this purpose, the twelve field experts, who have been working as BB (Black Belt), were asked to answer by circling a number from one to seven, arranged horizontally beneath anchor point descriptions “Strongly Disagree (1),” “Neutral (4),” and “Strongly Agree (7)”. Because each respondent was asked to evaluate the questionnaire, after using proposed methodology, response results were analyzed statistically using the Wilcoxon matched-pairs test (Levin and Rubin 1998). The Wilcoxon test, a non-parametric approach, can be used to compare two variables within one group (Alavi 1982) and has been used broadly in the field of MIS research (Baroudi and Orlikowski 1989). Because the Wilcoxon test does not require a hypothesis about the form of distribution, it was suitable for our case, in which the sample numbered fewer than 30. For “using CM”, all decision performance measures showed higher means or improved values when compared to “not using CM”, indicating that using CM to solve the Six Sigma strategic problem positively influenced the decision-making process, decision outcomes, and decision performance. The result reveals that proposed methodology, based on the cognitive map could provide a better decision performance for problem solving than “not using CM”.

It is found that the relative items with systematic approach received high scores that include V17 (Analyzing the case was interesting), V2 (My case solution was a good one), V13 (My analysis of the case was systematic), V5 (I am pleased with the approach used to analyze the case), and V1 (The approach taken to solving the case was very structured). And, the relative constructs show higher scores that include ‘Enhancement of problem-solving ability’, ‘Perceived process structure’, and ‘Positive affect toward the decision process’.
Conclusion and Future Research Direction

This study focused on presenting a consolidated model of casual relations in Six Sigma that have effects on corporate competitiveness. In order to create this model, we presented an empirical analysis model based on existing literature research and explained the methodologies to create an actual casual relation model through Focus Group Interviews (FGI) with experts. This was to implement qualitative aspect of research that could not be backed up by literature. The methodologies were then applied to actual cases. We could confirm that these methodologies could be efficiently utilized in simulation models for setting up Six Sigma Management strategies. The following findings were identified as the result of this study.

First, based on the factors that we used to measure Six Sigma Management activities, we could find that Six Sigma Management exerted positive effect on corporate competitiveness through process innovation and quality improvement. More specifically, the Six Sigma Management had a positive impact on process innovation, which in turn surely affected quality improvement, eventually raising corporate competitiveness.

Second, we arranged in sequential order the factors for measuring Six Sigma Management. Six Sigma Management activities were classified in two categories, the preliminary preparation activity and substantial Six Sigma activities, and the effect of preliminary preparation activities to substantial Six Sigma Management activities was empirically analyzed. The results of the casual relationship of the model showed that they could be used as data for CM.

Third, we could, by utilizing CM, create an aggregated map which integrated the factors for Six Sigma Management measured in the model, and other factors derived from experts' knowledge. Through this map, the changes in factors of Six Sigma Management could be reflected on corporate strategies, and actual plans could be drawn out. One contribution of this study is that it made possible companies adopting Six Sigma Management to build concrete strategies. Moreover, the process of building CM was touched upon in detail through actual case studies, which enabled a better understanding of the methodologies of CM building.

Meanwhile, this study quoted the concept of TQM in making constructs for the survey to make up for the lack of existing research on Six Sigma Management activities. But we found that the empirical research results corresponded to the results of the existing literature. This meant that TQM can provide an important theoretical basis when making constructs related to Six Sigma. This was another contribution of this study.

Upon referring to the implications of this analysis, it is important to consider the following limitations. First, the survey covered only affiliates of Samsung Group, meaning that the research model cannot represent Korea's entire corporate sector. Second, a few objectively proven cases of effective Six Sigma Management performances have arisen in Korea. This made it difficult to represent universal views on Six Sigma Management. Third, greater objectivity should be given in setting the node value to promote strategy simulations for CM.

Further study issues include the following ones. First, in order to generalize the empirical results, the survey should include larger number of companies which would make research model more reasonable and general. Second, a new research model is needed to measure the performances of companies promoting Six Sigma Management. Third, it is also required to develop a methodology to secure objectivity of the strategic simulation model utilizing CM.

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