A Competency-based System for Supporting Corporate Information Systems Planning

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Abstract: The purpose of this paper is to address a framework to suggest a set of To-Be enablers for planning strategic information systems. One feature of the framework is the incorporation of measuring incomplete preferences in IT and process competency of experts. This paper presents a competency-based decision support system for supporting corporate strategic information systems planning (SISP), which is based on a prescriptive group decision making method showing how to aggregate experts' incomplete preference judgments. The system is suggested on the competency leverage concept for selecting technical or organizational enablers to attain organizational business objectives. We put the competencies between the objectives and enablers, measure the importance rates of competencies on the objectives, and derive target enablers for the company. This system is implemented in practice via a detailed three stage methodology. The three stages are defining current business, analyzing competency, and suggesting To Be Enablers. We apply the system to SISP task of a Korean manufacturing company.

Key-Words: Strategic information systems planning, Information systems selection, Decision support systems, Multiple attribute group decision making, Incomplete preference

1 Introduction

The purpose of SISP is to identify the most appropriate targets for automation and to schedule their installation, SISP has the potential to make huge contributions to business and other organization. Effective SISP can help organizations use information systems to reach business goals, a major objective of senior executives. As the organizations are becoming increasingly dependent upon IT in order to achieve their corporate objectives and meet their business needs, the necessity for implementing widely applicable IT best practices standards and methodologies, offering high quality services is evident. The issue of managing the IT becomes less and less a technical problem, and more and more the problem of the whole organization i.e. a 'business problem' and many companies nowadays formally nominate executive directors for such activities [19].

The purpose of this paper is to address a model to suggest a set of To-Be enablers for planning strategic information systems. One feature of the model is the incorporation of measuring incomplete preferences in IT and process competency of experts. We put the competency between the objectives and To-Be enablers, measure the importance rates of competencies on the objectives, and derive target enablers for the company. The importance of a competency is calculated using experts' incomplete preference judgments regarding relationships of importance rates between competencies on each objective. Relaxation of such precise preference judgments that have been used in many information systems planning methods is advantageous and a way to reduce gap between theoretical research and practical needs. Anandalingam and Olsson [1] state that the presence of incomplete information is a result of the fact that the experts have limited attention and information processing capabilities to exact value judgments, and/or many of the criteria are intangible or nonmonetary because they reflect social and environmental impacts. The model is applied to the real-world problem of selecting strategic information systems for a customer service affiliate of a Korean manufacturing company. The real-world example demonstrates the feasibility of our proposed model. Through the survey of selection criteria for planning strategic information systems in the field of manufacturing industry, we have identified some of the important requirements such as strategic competency and To-Be enablers.

2. Prior Research on SISP

A number of methods have been applied to IS selection including scoring, ranking, mathematical optimization, and multi-criteria decision analysis [21]. Many managers and IT experts share the opinion that IS/IT in a company should be in accordance with the company objectives and management strategies [11]. The business environment is changing quickly. A learning (intelligent) organization is an organization that is able to adapt to the environment by changing its business model. For such organization the key to success is a continuous process of its business model innovation. The organization and the IS must evolve dynamically (and partially automatically) with business according to changes in the business model and in the business environment [5, 6].

The AHP method, introduced by Saaty [17], directs how to determine the priority of a set of alternatives and the relative importance of attributes in a multiple criteria decision-making problem, and has been widely discussed in various aspects [8, 9]. The need for alignment between IT applications and strategy is well established in the literature. Pant et al. [12] suggested a framework for Web-based information systems planning. The premise of their panning framework is that Web-based systems should be driven by the push view of information technology, which will substantially enhance their effectiveness and efficiency. In a 'push view,' new information technology pushes the scope of a company's business as well as its strategy. The methodology is suitable for for-profit organizations that change their business strategy through new information technology.

Today, a number of researchers are conducting a rigorous study on the process of SISP, and the processes includes largely identifying objectives, aligning IS with them and suggesting the direction of IS. Pepparda and Ward [13] defined organizational IS capability, developed a model linking resources with this IS capability, and illustrated how it effects business performance. It then moves on to introduce resource-based theory, suggesting that it is a theoretical construct that is suited to explaining the basis of sustainable competitive advantage through IT. The model includes formulating strategy, defining the IS contribution, defining the IT capability, exploitation, and delivering solutions. Salmelaa and Spilb [18] suggested the four-cycles method which attempted to combine the strengths of both the comprehensive and incremental planning to be able to recognize emerging trends and to make an e-business strategy. They considered IS planning as a continuous process that was periodically adjusted to the expectations of the participating managers. The cycles consist of agreeing on planning objectives and stakeholders, alignment of business objectives and information objectives, analyzing IS resources and IT infrastructure, and authorizing actions. Avison et al. [2] suggested that incorporating vision into an organization's business strategy was an important part of the strategic process. The process of developing and implementing a business vision comprises a series of stages; conception, intention, synthesis, integration and implementation. The examples of the techniques were matched with these requirements to produce an informal mapping of the technique onto the stage.

3. A System Framework

The premise of our framework is that information systems or enablers should be driven by the pull view as it is best suited to information-supportive businesses such as manufacturing organizations. It is, however, very difficult to directly connect business objectives and information systems because there are so many enablers for each objective and so many associations among them. So, we put the competencies (octagon) between objectives (triangle) and enablers (arrow) and measure the importance rates of competencies calculated from the SISP experts' preference information about importance relationships between competencies with respect to objectives. The main idea of the proposed framework is to align business objectives with technical or organizational enablers through organizational competencies, as shown in Fig. 1. The dotted line and solid line represent the As-Is level and To-Be level of each of objectives and competencies respectively.

3.1 Competency and enabler

There are two kinds of alignments. One is the alignment between business objectives and competencies. The business objectives are related with a set of the organization's competencies C_i, $i = 1,...,N$. The degree of association between competencies is different from objectives. It is very difficult to enter a degree of association with scaled numerical values, so the information is given by SISP experts in the incomplete form of preference relationships. This association concept of objectives and competencies is based on the new six 'S' framework for the relationship between the role of information systems and the competencies in IS management [14].

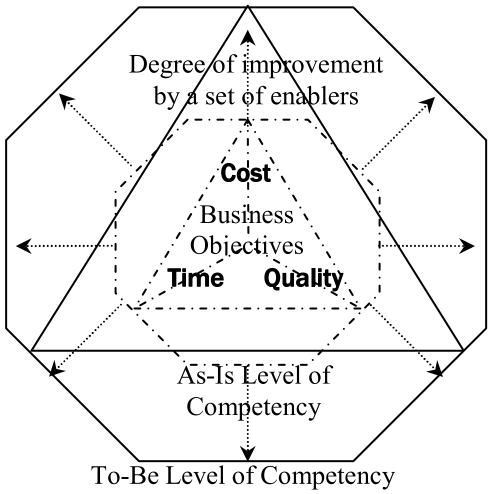

Fig. 1. System framework.

In our framework, the competencies are classified as either IT-related or process-related. IT-related competencies are further classified as IT management, IT architecture (i.e., software, hardware, and network), organizational application, and information management areas, such as application data, information, and knowledge. Process-related competencies are related with an interconnected chain of primary activities, such as those involved with producing, selling, and servicing products, as suggested by Porter and Millar [15]. These competencies can be specified by extended processes such as product data management (PDM), customer relationship management (CRM), supply chain management (SCM), and so on. The process competencies can be specified in various ways and are differentiated by types of products or industries. In our framework, K SISP experts specify the competencies suitable to specific industry situations.

The second kind of alignment is that between competencies and enablers. Every industry has many organizational and technical enablers for securing competencies. It is desirable for each company to select enablers that can improve the values of business objectives. However, it is very difficult to directly connect business objectives and enablers because there are so many enablers for each objective and so many associations among them. So, we put the competencies between objectives and enablers and evaluate the competencies based on objectives. Then the important competencies are extracted and used to find the set of enablers having the closest relations to them.

The enablers can be classified by relating competencies and are selected by industry experts. Venkatraman [20], and Handerson and Venkatraman [6] suggested a framework of IT-enabled business transformation, illustrated it with a wide array of examples, and derived implications and guidelines for management. The major categories of technical/organizational enablers and inhibitors were suggested. Min et al. [10] put more emphasis on IT opportunities to perform SISP. In this methodology, information systems were used not only for assisting business strategies, but also for the creation of new strategies. We define to-be enablers (TBEs) as IT-related enablers that improve business objectives through IT and process competencies. In summary, our framework is based on top-down planning in which the importance rate of business objectives is considered in terms of competency areas, and the priority of TBEs is determined by their degree of association with the competencies.

3.2 Mathematical background for calculating the importance rates of competencies

In order to evaluate the importance rates of competencies with respect to business objectives, we utilize incomplete information-based MAGDM methodology [7], which is applied to this problem because the analysis deals with situations in which decision alternatives, such as competencies, are evaluated on a finite number of attributes, such as business objectives. One of the best known and most widely used ways to evaluate alternatives, or competencies, $c = (c_1, \ldots, c_i, \ldots, c_N)$, is to utilize the weighted additive value decomposition

$$v(c_i) = \sum_{o=1}^{M} w_o v_{oi}(c_i) \quad (1)$$

of a value function v. Here, v_{oi} is the marginal value function of the i-th competency with respect to objective o such that $v_{oi} : c_i \rightarrow [0, 1]$ and w_o is the importance rate of the o-th objective that is given by the experts. If the decision parameters $v_{oi}(\cdot)$ are all exactly or numerically assessed by the expert group, finding the most important competencies is achieved by a simple calculation, as in formula (1). In some situations, however, it is no simple matter to accurately measure the exact values of competencies.

Rather, decision makers can give only certain linear relations that express incomplete information about the association relation between competencies on each objective. Examples of incomplete information are in the form of bounded descriptions: weak preference ($v_{oi} \geq v_{oj}$), strict preference ($v_{oi}-v_{oj} \geq \varepsilon$), preference with a multiple ($v_{oi} \geq \alpha_{ij} v_{oj}$), interval preference ($l_{oi} \leq v_{oi} \leq u_{oi}$) and preference difference ($v_{oi}-v_{oj} \leq v_{ol}-v_{om}$) [7]. A motivation of this research is to suggest a way to determine the importance rate of competencies based on the incomplete information of associations between competencies on each of the objectives.

The research on incomplete information in decision analysis has addressed tedious and time consuming information capturing in various ways, but it has not provided efficient mechanisms for propagating imprecise statements in group decision models. The increasing complexity of the socio-economic environment makes it less and less possible for single decision maker (DM) to consider all relevant aspects of a problem. Therefore, many organizations employ group members in decision making. Moving from single DM's setting to group members' setting introduces a great deal of complexity into the analysis. A group decision making process is usually understood to be the process of reducing different individual preferences among objects in a given set to a single collective preference, or group preference. Furthermore, when group members provide only incomplete information, a selection is not generally made in a single step.

3.3 Interactive procedure

The framework is implemented in practice via a detailed three-stage methodology. It focuses on the suggestion of IS direction based on the experts' evaluation of the competencies for target companies and excludes the suggestion of action plan. The three stages are: defining the strategic direction, analyzing the competencies, and suggesting To-Be enablers (TBEs). Fig. 2 shows three stages of the framework.

The first step is to identify strategic directions for the target company. The SISP expert group defines the business objectives, competencies, and enablers of the target company, with the help of the SISP library which contains business directions of the target company and of other companies in the same industry. An expert group is composed of department managers and external industry experts. We assume that the weight of the k-th expert is given by w^k, k = 1, ..., K. The group assigns the importance rate, w_o, to o-th objective, where $\sum_o w_o = 1$, $0 \leq w_o \leq 1$ and o=1,...,O.

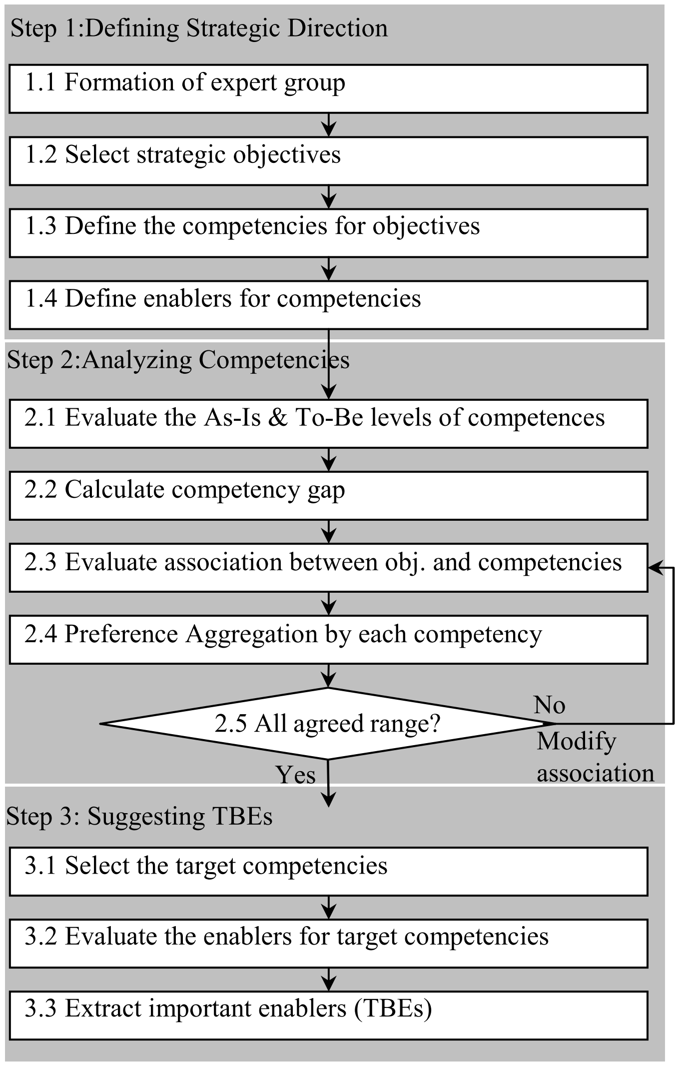

Fig. 2. Three stages of system.

The second step is to evaluate the current status of the company on the basis of the defined competencies and suggests competencies that could be improved. Experts individually evaluate the current (As-Is) levels and the desired (To-Be) levels of the competences. After getting the level scores of competencies from all experts, aggregated As-Is and To-Be levels of the competences are computed by the weighted sum of level scores of all experts, as shown in the following formula (2),

$$v_{AS}(c_i) = \sum_k w^k v^k_{AS}(c_i) \text{ and } v_{TB}(c_i) = \sum_k w^k v^k_{TB}(c_i) \quad (2).$$

We can get the gap of the i-th competency by computing the value of $v_{TB}(c_i)-v_{AS}(c_i)$. And, the degree of associations between competencies with respect to business objectives is evaluated by the shared opinions of the expert group regarding association relationships between competencies within each objective. We can then get the utility range of the i-th competency, $[v_{min}(c_i), v_{max}(c_i)]$, by solving formula (3).

$$v_{min}(c_i) = \text{minimize } \sum_o w_o v_{oi}(c_i) \text{ subject to } \Phi o \text{ and}$$
$$v_{max}(c_i) = \text{maximize } \sum_o w_o v_{oi}(c_i) \text{ subject to } \Phi o \quad (3)$$

The final step is to extract the most important enablers based on values of gap and the importance of competencies. The expert group defines thresholds of importance rates and gap as δ_1 and δ_2, respectively, and selects the target competencies having $P[v(c_i) > \delta_2] \geq 0.5$ or gap values equal to or larger than δ_1. To evaluate the importance rates of enablers on each of the target competencies, the group members assign importance rates by a 3-scale measurement to the corresponding enablers on each of the competencies. The importance rate, $v^k_i(E_j)$, means a score that the k-th group member assigns to the j-th enabler E_j in light of the i-th competency. The value of the j-th element, $v(E_j)$, is calculated by $\sum_k w^k v^k_i(E_j)$. We can represent the value of the j-th element by ranges $[v_{\min}(E_j), v_{\max}(E_j)]$ because the importance rates of the competencies are calculated by range values.

$$v_{\min}(E_j) = \sum_k \sum_i v_{min}(c_i) \cdot v^k_i(E_j)$$
$$\text{and } v_{\max}(E_j) = \sum_k \sum_i v_{max}(c_i) \cdot v^k_i(E_j) \quad (4)$$

The average values of the range are determined by computing $(v_{\min}(E_j) + v_{\max}(E_j))/2$. Finally, we select the most important J TBEs in the order of their average values.

4. Case Study

The procedures are coded by using the visual basic for application (VBA), which is built-in program language in the Excel spreadsheet. The Excel spreadsheet, coupled with the VBA, have unlimited capabilities in dealing with subjects on management science. The organization selected in this case study was a Korean manufacturing company. A SISP team that consisted of 5 department managers and 5 consultants performed SISP tasks. The team had manually performed a SISP task using a consulting framework which was very similar to that of the system, but differed in its methods of information collection and evaluation. We explain the system using a case study based on tasks conducted by the system supporting team.

Step 1. Defining the strategic direction of the Company

The team entered a set of strategic objectives, competencies, and TBEs into the spreadsheet. In this case, the affiliate was focusing on seven kinds of specific objectives within speed, cost, and quality categories. Each objective was specified by a set of detail objectives as shown in Table 1. For example, the speed objective was specified by the rate of order processing within a day and the response rate of an ordering call. The group assigned the importance rate to the objectives. The weight values signified that the cost category was an objective of great importance to the affiliate.

Table 1. Strategic Objectives

Category	Detail Objective Name	Weight
Speed	Rate of order processing within a day	0.2
	Response time	0.1
Cost	Pure production cost	0.2
	Additional sales profit	0.1
Quality	Customer satisfaction rate	0.2
	Competitive index of brand image	0.1
	Recall rate	0.1

In this situation, the affiliate's TBEs should be driven by the pull view, as it is most suitable to information-supportive businesses such as manufacturing organizations. The group specified IT competencies by IT management, IT architecture, application, and information management. Also, the group selected process competencies such as new business development, R&D, manufacturing, and logistics support. The experts defined the 16 enablers to significantly impact their IT and process competencies, as shown in Table 2. In the viewpoint of 'Application' IT competency, supplier collaboration system is important for supporting the affiliate's manufacturing and logistics processes, manufacturing monitoring system for manufacturing process, and so on. Each enabler has relationships with both IT and process competency. The strengths of relationships are various between them. The expert group evaluated the importance rates of the To Be enablers (TBE) with respect to each of the IT and process competencies.

Table 2-1. TBEs for IT competencies

IT competency	To Be enablers
IT Management	An e-business vision Periodic IT planning Effective training for employee Supportive organization
IT Architecture	Infrastructure for manufacturing Protected and secure systems Infrastructure for sharing information Customer & supplier communications
Application	Supplier collaboration system Manufacturing monitoring system Material management system Workflow Support system E-Biz enabling system
Information Management	Information to agreed standards Integrated Customer Database Decision support & key performance management

In the viewpoint of 'Manufacturing' process competency, manufacturing monitoring system is important for the affiliate because the efficiency of manufacturing is essential to the industry.

Table 2-2. TBEs for Process competencies

Process	To Be enablers
Winning new business	An e-business vision Periodic IT planning E-Biz enabling system Information to agreed standards Decision support & key performance management `
R&D	Protected and secure systems Infrastructure for sharing information Workflow Support system Integrated Customer Database
Manufacturing	Infrastructure for manufacturing Manufacturing monitoring system Effective training for employee
Logistics	Supplier collaboration system Protected and secure systems Integrated Customer Database Material management system Supportive organization

Step 2. Analyzing competencies

Now, each of the group members evaluated the current and desired levels of the eight competencies defined at the previous step. They could refer to the description information for the levels of competencies as shown in Table 3. We defined five levels of each of competencies. In the case of application competency, the minimum level is set to the local optimized system configuration and the maximum one to core competency-based system configuration. The expert group also set level 2 to partial interaction system, level 3 to internal supporting system, and level 4 to internal and external (full) supporting system. Then department managers evaluated their current level and set their desirable level by each competency. Finally, the system would suggest some alternatives to overcome the gap between the current and desirable levels.

Table 3. Level description of competencies

Compe-tency	Level 1	Level 2	Level 3	Level 4	Level 5
Manage-ment	No plan	Isolated from Objective	Strategic Planning	Verified Intermittent	Compatible with Objective
Architec-ture	Standalone	Local	Wide	External	Virtual
Applica-tion	Local Optimized	Partial Interaction	Internal Support	Full Support	Core Competency
Infor-mation	Paper based	Partial Electronic	Structured Electronic	Shared Electronic	Shared Knowledge
Win New Business	Unplanned and Reactive	Limited	Selective and Consistent	Competi-tive	Systematic Plan and Competitive
R&D	Passive	Timely	Affecting	Information based	Proactive & Virtual
Manufac-turing	Manual	Partial monitor	Status monitoring	Inventory monitoring	Systematic material management
Logistics	Manual	Partial monitor	Status monitoring	Warehouse management	Systematic monitoring

The system calculated the aggregated current and the desired levels of competencies as shown in Fig. 3.

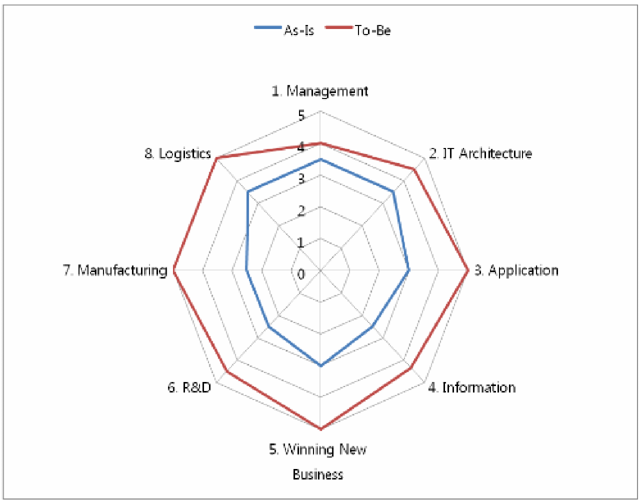

Fig. 3. As-Is & To-Be levels of competencies

Then, gap value between the current and desired levels on each of the eight competencies was calculated by the aggregated vales. The group provided a unanimous opinion regarding association relations between competencies on each of the objectives. For example, each of the four competencies, including IT management (C1), IT architecture (C2), and logistics competency (C8), is more important than new business development (C5), at least in terms of the cost objective; that is, C1, C2, C8 > C5. After obtaining all the relationship information between competencies, the system calculated the lower and upper bounds of importance rates of competencies by solving formula (3). The incomplete relationship information is denoted as constraints of formula (3). Finally, they determined the lower and upper bounds of the importance rates of the competencies as follows:
$[v_{min}(C_i), v_{max}(C_i)]$= [(0.25, 0.92), (0.43, 0.92), (0.37, 0.71), (0.57, 0.91), (0.22, 0.44), (0.53, 0.91), (0.22, 0.65), (0.42, 0.71)].

Step 3. Suggesting To-Be enablers

The group selected the target competencies in which values of gap and the importance rate were greater than their thresholds. The group could see the values at the GNI matrix, as shown in Fig. 4.

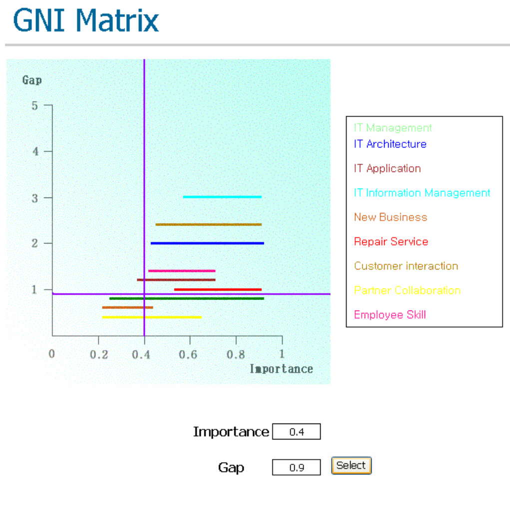

Fig. 4. GNI matrix for competencies.

The group predefined thresholds of gap and the importance rate as 0.9 and 0.4, respectively. In this case, the group selected six target competencies above thresholds; IT architecture, application, information management, R&D, manufacturing, and logistics. Next, group members evaluated the importance rates of TBEs with respect to each of the target competencies using a 3-scale measurement, such as H(igh), M(iddle), and L(ow). The TBEs to be evaluated are related with the target IT competencies. For example, one of the experts evaluated the importance rates of the first TBE of ‘infrastructure for manufacturing’ by H, L, L, H, M, and M with respect to each of the six target competencies. In the perspective of IT architecture and R&D competencies, the expert’s evaluation of that infrastructure for manufacturing was extremely important.

Then the analysis controller calculated the lower and upper bounds of the importance rates of TBEs by the weighted sum of the lower and upper bounds of the importance rates of competencies and the importance rates of TBEs. For example, the lower and upper bounds of the first TBE, infrastructure for manufacturing, are calculated by: $[v_{\min}(E_1), v_{\max}(E_1)]$ = [5.56, 10.35] where, $v_{\min}(E_1) = 0.43{\cdot}3 + 0.37{\cdot}1 + 0.57{\cdot}1 + 0.53{\cdot}3 + 0.45{\cdot}2 + 0.42{\cdot}2 = 5.56$ and $v_{\max}(E_1) = 0.92{\cdot}3 + 0.71{\cdot}1 + 0.91{\cdot}1 + 0.91{\cdot}3 + 0.91{\cdot}2 + 0.71{\cdot}2 = 10.35$. The average value of the TBE is 7.96. The system normalized the average values in proportion to the total score, 18, of competencies and then got 44.19 as the final value score of the competency. Finally, the group got the value scores of all TBEs in the same way and enumerates TBEs in the order of their scores.

We compared this result with that from the manual SISP task, which had been based on a manual consulting framework. The group selected eight TBEs in the order of their scores. Suggestions regarding TBE's 'material management system' and 'workflow support' were added and 'information to agreed standard' and 'decision support & key performance management' were excluded from the TBE list of the manual SISP result, although the rest were the same in both manual and supporting tasks.

Table 4. Final result

Rank	Competency	TBE	Score
1	Information Management	Integrated customer DB	47.8
2	Application	Manufacturing monitoring system	45.6
3	Application	Material management system	45.6
4	IT Architecture	Infrastructure for manufacturing	44.2
5	IT Architecture	Infrastructure for sharing information	44.2
6	IT Architecture	Customer & supplier communications	40.2
7	Application	Supplier collaboration system	38.9
8	Application	Workflow Support system	38.8

System Effectiveness Results and Discussion

It is important for us to evaluate indicators of such system attributes as efficiency, and satisfaction rate. We performed an experimental survey regarding satisfaction rates about processes and outputs supported by the system in comparison to ones of the manual SISP task. A t-test model was used to analyze users' responses to the post-study questionnaire, and results are shown in Table 5. Usually group supporting systems were evaluated by effectiveness measures such as system efficiency, participants' contributiuon, process effectiveness, and satisfaction rates of outcomes and processes [3, 4]. The system in this research could be evaluated by the same measures because the SISP expert members performed the SISP with the support of the system. The values in Table 5 represent the result of the mean difference test (t-test), with a significant level of 0.1, using a statistic package, SPSS for Windows.

Table 5. Effectiveness comparison results between system support and manual tasks

Effectiveness measure	System	Manual	t-value
System efficiency	4.45	3.55	2.69*
Participants' contribution	4.35	3.70	3.15*
Process quality	4.05	3.70	2.06
Outcome satisfaction rate	4.10	3.85	2.06
Process effectiveness	3.90	3.50	0.97

*: $p<0.1$, t-value: $t(df = 20, \alpha = 0.5) = 2.086$

The results showed that in two areas of system efficiency and participants' contribution items, there were significant differences between system supporting and manual SISP tasks. It was because the system allowed SISP team members to evaluate competencies and TBEs at the input screen of the system. This pattern of differences and the overall interaction seemed to indicate that the effectiveness of SISP processes in collecting the opinions of the experts was highly dependent on the system support. For the outcome satisfaction rate, the system supporting task scored higher than the manual task but the mean difference was not significant. For process quality and effectiveness items, the system supporting task was higher than the manual one but, again, the mean difference was not significant. Those who answered the questionnaire said that the SISP task referring to the industry library of objectives, competencies, and TBEs was very helpful. To take advantage of this, we need to build the library by inputting many industry cases for future reference.

5. Conclusion

The purpose of this paper is to address a model to suggest a set of To-Be enablers for planning strategic information systems. One feature of the model is the incorporation of measuring incomplete preferences in IT and process competency of experts. We put the competency between the objectives and To-Be enablers, measure the importance rates of competencies on the objectives, and derive target enablers for the company. The importance of a competency is calculated using experts' incomplete preference judgments regarding relationships of importance rates between competencies on each objective. Relaxation of such precise preference judgments that have been used in many information systems planning methods is advantageous and a way to reduce gap between theoretical research and practical needs. The model is applied to the real-world problem of selecting strategic information systems for a Korean manufacturing company. The real-world example demonstrates the feasibility of our proposed model. Through the survey of selection criteria for planning strategic information systems in the field of customer service industry, we have identified some of the important requirements such as strategic competency and To-Be enablers.

An effective and efficient SISP requires three things. First, it is necessary for a competitive company to drive the related enablers according to the importance rates of its business objectives. Second, planning should be performed in step with changes to the industrial environment surrounding the company in order to extract suitable competencies to the relating industry. Third, the kind of information the company gets and how it aggregates the industry experts' opinion must be considered. To reflect these considerations, we suggest a competency-based framework for SISP to determine the TBEs based on the importance rates of competencies. This framework is based on the concept of having an industry library available to derive competencies and enablers that reflect the company's situation. It will be necessary for the company to revise the library according to current business and IT trends. To effectively collect the opinions of the experts, we used incomplete information about association relations between competencies on each of the objectives, and used a 3-scale measurement for the importance rates of TBEs on competencies.

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