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An optimization usability of information system project resources: using a QFD and Zero-One Goal Programming for reflection customer wants

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Abstract

This paper demonstrates the application of a Quality Function Deployment (QFD) and Zero-One Goal Programming model for selecting interdependent information system projects. Although there are lots of prior research for information system (IS) project selection, there are a few research for interdependent IS project selection. Effective project evaluation necessities incorporating the many conflicting objectives of decision maker(s) into decision models. Among the many proposed methodologies of multi-criteria decision making (MCDM), Goal Programming (GP) is the most popular and widely used.

The model departs from an earlier GP formulation of the problem that suggested QFD method for selection of priorities among the considered attributes or criteria. The application of the proposed methodology illustrated through an example.

Keywords: interdependence, IS project, QFD, GP

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1. Introduction

Information System (IS) Project evaluation and selection problems means identifying and appraising some considering alternative projects and allocating resources among those alternatives that, within the given constraints on resources, will maximize the net benefit to the organization [2,4,9]. IS projects resources allocation and the analysis of IS project investment projects are certainly among crucial decision problems for many organizations. This is because not only the limited resources and uncertainty but also to the fact that IS projects are much more complex than any other type of project. A lot of methodologies for IS project selection or research development projects have been developed and reported on during the last decades [3, 7,8,9,10,13]. To select the best set of IS project is difficult because there are lots of multiple factors such as project risk, corporate goals, limited availability of IS resources, etc., in the candidate IS projects [1,5,6,12,14,16]. Use of a practical IS project selection methodology is said to be essential for an effective IS planning [14, 20].

However, prior research is mainly focus on independent attributes, criteria or candidate project. In reality, there are many clearly interdependent cases in rear-world [18]. In other words, when we carried out some IS projects, there exists a great amount of sharing of hardware and software resources among various IS applicants [5, 6, 16]. For example, portions of programming code written for one application such as edit routines, sort routines, validation checks, and other generic codes are being reused as code for several other application projects providing substantial savings in developmental costs [5, 6, 20]. If the various interdependent factors among the IS projects are not be considered, the IS projects selection decision will result in a poor allocation of resources. To determine a project without considering this interdependent factors bring about lots of cost waste in organization. The success of an IS project depends on a concise and clear definition of objectives and the incorporation of these objectives in resources allocation.

Goal Programming is designed to deal with problems involving multiple conflicting objectives. When the drawback of GP, decision maker(s) must specify the goals and their priorities a priori, the result of problem formulation show a great different as the decision maker's judgments. Therefore, a systematic procedure is needed to determine the following factors in constructing the GP model through like a group discussion; 1) objectives, 2) desired level of attainment for each objective, 3) a degree of interdependence relationship, and 4) penalty weights for over-achievement or under-achievement of each goal. Another shortcoming of GP is the lack of a systematic approach to set priorities and trade-off among objectives and criteria [18]. In order to solve these problems, JW. Lee and SH. Kim [5, 6, 17] suggested the methodology of ANP and GP model. In this paper, we suggested the methodology of a new approach using a QFD tool [19] that is widely used to determine the customer needs.

The next section describes a literature review of QFD, GP and a type of interdependence. Section 3,4 suggested a proposed methodology with presents an illustrative example. The last section shows a summary and conclusion.

2. Review of a type of interdependence, QFD, and GP

2.1 Review of a type of interdependence

Many real world problems have an interdependent property among the criteria or candidate projects [1, 3, 14, 18]. Research and development within one enterprise are interrelated to various other functional areas of organization. These interdependencies can be classified into three types [14]: (1) technical interdependencies, (2) resources interdependencies, (3) benefit interdependencies. Technical interdependencies between may arise when the success or failure of one project significantly enhances or retards the progress of other projects. Second, resources interdependencies arise because of sharing hardware and software resources than if they were implemented separately. In other words, if a software code developed for one project is used in the second project. Benefit interdependencies occur when the total benefits to the organization derived from implementing two related projects increase due to their synergistic effect. Consideration for these interdependencies among criteria provides valuable cost savings and greater benefits to organizations. Santhanam and Kyparisis [14] proposed a mathematical methodology using nonlinear 0-1 programming for interdependent information system selection. Their model considered project interdependence and resource optimization. They considered project selection problems that have only one criteria not multiple criteria. In reality, it will be more appropriate to consider multiple criteria than to consider only one or two criteria in IS project selection problems which have interdependence property. JW. Lee and SH. Kim [5, 6] published the paper for solving this limitation. We will consider an interdependent IS selection problem having multiple criteria using a QFD for reflecting a customer needs.

2.2 Goal Programming

Charnes and Cooper first introduced goal Programming in 1952 [5, 6]. GP has been applied in many diverse real world problems including capital budgeting, labor planning, media planning, and defense management [3, 20]. The GP model for IS project selection can be stated as follows:

Minimize $$Z = P_k(w\,d^+ + w\,d^-) \quad (1)$$

Subject to $$CX - (I\,d^+ - I\,d^-) = G \quad (2)$$

$$RX \le B \quad (3)$$

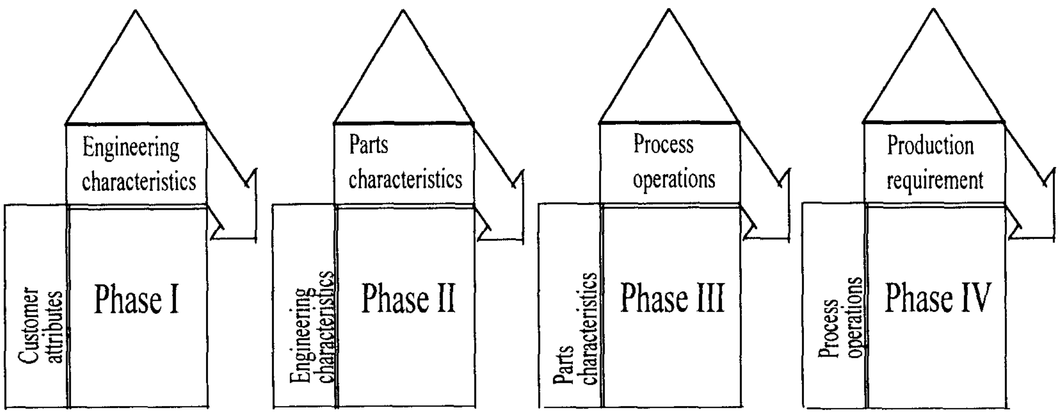
$$X = 0 \text{ or } 1 \ ; \quad d^+, d^- \ge 0$$

where Z is the sum of the deviation from goals stated in a column vector G. P_k is a preemptive priority (P_1 〉 P_2 〉 〉 〉 P_m) for m IS project goals , d^+ and d^- are m-column vector of positive and negative deviation variables, respectively. w is a mathematical weight on the IS projects. The w are attached to the deviational variable d for the n number of IS projects represented by the goal constraints. The lexicographic nature of GP treats the QFD and ANP weights as a sub-ranking of the IS projects within their specific P_k.. The larger the w, the more likely the corresponding IS project will be selected. In equation (2) above, C is a $m \times n$ matrix of constraints representing the contribution of each IS project, X is a

-column vector of decision variables representing the n number of possible IS projects to choose from, and I is an $m \times n$ matrix. G represents a column vector of goals of the selection process, such that the summation of the C's for the projects selected will equal the value of G. in equation (3) above, resource constraints are represented in the model. B represents a column vector of available resources that are obligatory values required in the summation of the R's for the IS projects selected.

2.3 Quality Function Deployment

QFD is a new product development process that stresses cross-functional integration. QFD provides a specific approach for ensuring quality throughout each stage of the product development and production process [19]. QFD was originally developed and used in Japan at the Kobe Shipyards of Mitsubishi Heavy Industries, Ltd, in 1972. QFD can be defined as an overall concept that provides a means of translating the needs of customers through the various stages of product planning, engineering and manufacturing into a final product. The overall objective of QFD is to reduce the length of the product development cycle while simultaneously improving product quality and delivering the product at a lower cost. QFD has three fundamental objectives. These are: (1) to identify the customer, (2) to identify what the customer wants, (3) how to fulfill customer's wants.



[Fig. 1] Linked houses convey the customer's voice through to manufacturing

QFD is accomplished through a series of charts which are a conceptual map, providing the means for inter-functional communications. The chart is usually called a House of Quality (HOQ). HOQ relates the variables associated with one design phase to the variables associated with the subsequent design phase. Four linked houses in [Fig. 1] implicitly convey the voice of the customer through to manufacturing.

. In this paper, HOQ among the product planning phases (Phase I in Fig. 1) is described in detail. HOQ charts of other phases can be analyzed in a similar way.

The "voice of the customer" is represented on the left side of HOQ. The customer attribute (CA) is usually very qualitative and vague. CA's importance of the relative importance among the customer attribute is played an important role in identifying critical customer attributes and prioritizing design effort.

Engineering characteristics (EC) are the design requirements that affect one or more of the customer attributes. EC importance, the importance ratings for the engineering characteristics, can be calculated using the CA importance ratings and the weights assigned to the relationships between CA's and EC's.

The matrix in the main body of the HOQ identifies the relationships between the CA's and EC's by placing symbols at the intersections of the items that are related. It is also possible to depict the strength and nature (positive or negative) of the relationships by using different symbols. The design team typically assesses the strength and nature of the relationships in a subjective manner.

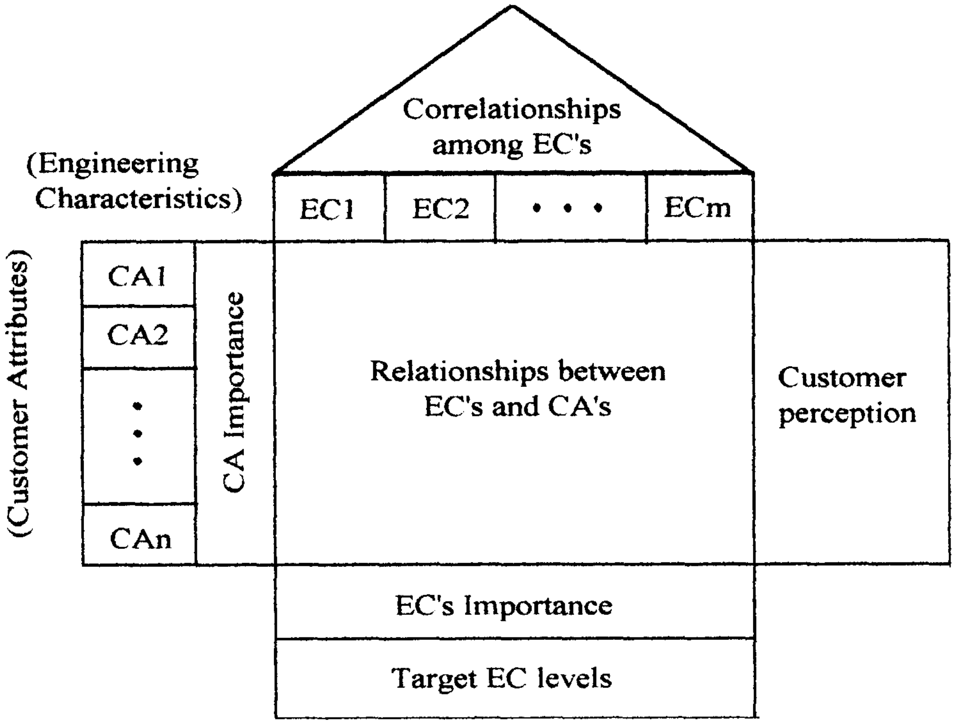
The "roof" part of HOQ, Correlations of EC's, establishes the correlation among the engineering characteristics, showing which engineering characteristics support or conflict with one another. The right side of HOQ, Customer perception, lists a competitive benchmarking on each customer attribute for the company and competitor's product. Target levels of engineering characteristics are determined using all the information in the HOQ. The HOQ framework is represented in figure 2.

3. Outline of the proposed methodology

The outlines of the proposed model in this paper as follows.

1) Define the variables for modeling of candidate projects. These variables are composed of considering criteria for project selection. These variables are composed

of customer wants that used to determine the best solution for the benefit of organization among the candidate projects. This variables reflect the customer attribute to the relation with the engineering characteristics in the phase I. This variables does not determine one or two decision maker(s), it is good to determine through a Delphi method or expert group committee.



[Fig. 2] The House of Quality

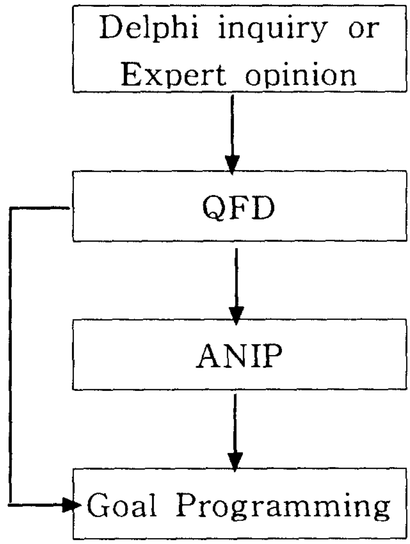
2) Use the QFD to determine the weight or relationship strength between considered criteria or decision variables. This step, we might use like a Delphi for collecting an opinion of experts. The experts are asked to specify the objectives that the organization should pursue when allocating resources among IS projects. If there is a case that must obtained relationship strength among the considered criteria or candidate projects, then go to step 3. Otherwise go to step 4.

3) Using product of matrix, find a steady state value. This step uses an algorithm of Saaty's Analytic Network Process (ANP). The value find in this step utilize the relative weight of QFD step. This value use the priorities of the candidate projects

that reflect the customer wants.

4) Using the weight obtained on step 2 or 3, formulate a GP model to evaluate considered alternatives.

5) Using the automated tools for GP, for example, LINDO, MathPro, and Microsoft EXCEL, find a solution for IS project selection.



[Fig. 3] An overview of the proposed model

A big different point is that there is more easy find relationship strength between customer attribute and engineering characteristic using a QFD than a prior research of JW. Lee and SH. Kim. Using a QFD is more visualized and specified to the decision makers than using a prior research of reference. In figure 3, an overview of the proposed model is represented. As the sight of the figure 3, first we find a criteria or decision variables using a Delphi inquiry [11] or expert team. Second we find relationship strength between customer attribute and engineering characteristic criteria or decision variables using a QFD. That is, QFD is a very good tool for finds customer requirements at the first step determine decision variables. This proposed methodology have a little modified view of using ANP and ZOGP published paper in reference [5, 6]. To use a QFD have a limited points that does not find relationship among considered criteria or candidate alternatives. If there exists this relationship, we have another step using other methodology like an ANP or JW. Lee and SH. Kim's method.

4. An illustrative application

SOHO Company (fictitious) is a medium-sized company. Its CEO (Chief Executive Officer) is currently reviewing the candidate projects in order to set long-term goals and formulate major strategies. The problem is that how to reflect the mangers' opinion for determine project selection. Lengthy debates and discussions have resulted in confusion and disagreements regarding SOHO's strategis goals and the projects to be undertaken to achieve these goals. In order to reflect manager's opinion, SOHO Company use a Delphi inquiry and QFD methodology. For selection project, there are a lot of considered criteria. In this paper, we use four criteria, cost saving, increased revenue, employment level, delivery time as a quantitative evaluation measure.

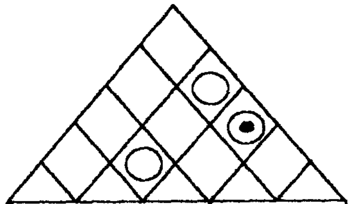
On the other side, this company has a limitation of using resources. For candidate project, the yearly cost, cost saving, increased revenue, employment level, delivery time and resource utilization are represented in table 1.

Table 1. Goal constraint project information

Decision variable	Estimated project					Goal	Weight
	1	2	3	4	5		
Cost Saving(000$)	120	90	150	70	80	$\geq$ 400	A
Increased Revenue(000$)	200	150	250	300	100	$\geq$ 750	B
Employment Level(# of people)	3	4	5	4	3	$\leq$ 15	C
Delivery time(month)	5	12	9	15	10	$\leq$ 40	D

In order to find relationship strength, we use the QFD. The results are represented in table 2. The weights in third column of table 1 are used the result of value in table 2.

Table2. QFD result of SOHO's managers



Relationship Symbols

◉ : very strong rel.
○ : strong rel.
△ : weak rel

◉ : 9 point
○ : 3 point
△ : 1 point

Customer Wants		Eng. Desg. Req'ts a1 Success Probability	a2 Project Impact	a3 New Technology	a4 Quality	a5 Risk	Demanded Weight	Relative Weight
Cost Saving	15			○	◉		180	0.113
Increased Revenue	15		○	◉			180	0.113
Employment Level	25	○	○		○	○	450	0.236
Delivery Time	45	◉		△	○	○	990	0.538
Technical Importance	Absolute	480	120	225	765	210		
Technical Importance	Relative	0.27	0.07	0.13	0.43	0.1		

The interdependent relationship of candidate project are very important factor and must have reflect to the determine selection of project. The formulation of interdependent factor is solved the concept of Nonlinear programming. The representation of interdependent factor is like formulate as $x_1 \geq x_3$, *or* $x_2 \geq x_4$. Since the product terms $x_1 x_3$ and $x_2 x_4$ may be simplified by noting that $x_3 = x_1 x_3$ and $x_4 = x_2 x_4$. We linearize the nonlinear terms using the concept of Glover and Woolsey's [5,6]. We introduce new variables $x_{1,3} \cong x_1 x_3$, $x_{2,4} \cong x_2 x_4$, $x_{2,5} \cong x_2 x_5$, $x_{4,5} \cong x_4 x_5$.

These variables mean the integer programming which have a zero-one variable. We suggested the formulation of SOHO's IS project selection problem in appendix A.

The information of interdependent IS project are showed in table 3.

In table 2, when we project select, the user's think delivery time and quality are very important factor. The next phase, project success probability and manpower are important factor. In table 2, the marked data are assumed found by the expert group opinion. The marked symbols means represented the relative weight between customer wants and engineering design requests by given relationship symbols. For example the value of demand weight between cost saving and engineering design requests, 180 is find by 15(relative weight of customer wants) * { 3 (the point of strong relationship) + 9 (the point of very strong relationship)}. Like the same way, the value of technical importance about the column of the matrix is found.

Table 3. The information of interdependent projects

Interdependent projects	Addition benefit (000$)	Shared cost saving (000$)	Shared employment level (people : manpower)
1, 3	30	▽ 40	▽ 1
2, 4	45	▽ 50	▽ 2
2, 5	25	▽ 35	▽ 1
4, 5	50	▽ 60	▽ 1/2

(▽means : cost down or decreased people)

In addition to the data of table 3, the contingent relation among the candidate project is as follows: (p_3, p_1),(p_4, p_3),(p_4, p_5), this data means p_1 contingent on p_3 in case of (p_3, p_1) . The weight (A,B,C,D) of table 1 is (0.113, 0.113, 0.236, 0.538) in table 2.

The final solution of this example in appendix A is determined to selection of project 1,3,4,5. The final results obtained by the LINDGO (PC Release 3.1) and the specific results are showed in appendix B. Because of selection of the project, cost saving obtained more than $520,000 and increased revenue obtained more than $950,000, etc.

5. Summary and conclusion

We have represented an application model on another approach view of considering interdependent factor using QFD and goal programming. There are a lots of variables considered in IS project selection. In selection of IS project, it is very important to reflect the users needs and consider the interdependent relationship among candidate criteria. In addition, the cost of difficulty in data gathering for modeling is no so critical than the risk in selecting the wrong project without considering the interdependence and customer wants. We introduced a new application of QFD considering customer wants in relation to the prior research. This paper moves one step closer to the reflecting the customer wants in selecting IS Project. The methodology of this paper will be helpful to whom the manager find the method of the determination problem of a type of weapons or the assignment of military power. The limitation of this paper is that we do not reflect the factor of engineering characteristic to the formulation of GP and does not application of real world problem. Our subsequent research will address these points.

Appendix A. the formulation of SOHO's company example

$$Minimize \quad Z = 0.113d_1^- + 0.113d_2^- + 0.236(d_3^+ + d_3^-) + 0.538d_4^+$$

$$subject\ to \quad 120x_1 + 90x_2 + 150x_3 + 70x_4 + 80x_5 + 40x_{1,3} + 50x_{2,4} + 35x_{2,5} + 60x_{4,5} - (d_1^+ - d_1^-) = 400$$

$$200x_1 + 150x_2 + 250x_3 + 300x_4 + 100x_5 + 30x_{1,3} + 45x_{2,4} + 25x_{2,5} + 50x_{4,5} - (d_2^+ - d_2^-) = 750$$

$$3x_1 + 4x_2 + 5x_3 + 4x_4 + 3x_5 - x_{1,3} - 2x_{2,4} - x_{2,5} - \frac{1}{2}x_{4,5} - (d_3^+ - d_3^-) = 15$$

$$5x_1 + 12x_2 + 9x_3 + 15x_4 + 10x_5 - (d_4^+ - d_4^-) = 40$$

$$90x_1 + 90x_2 + 150x_3 + 70x_4 + 30x_5 \geq 400$$

$$160x_1 + 150x_2 + 250x_3 + 300x_4 + 40x_5 \geq 750$$

$$2x_1 + 4x_2 + 5x_3 + 4x_4 + \frac{5}{2}x_5 - x_{1,3} - 2x_{2,4} - x_{2,5} - \frac{1}{2}x_{4,5} \leq 15$$

$$x_4 + x_5 - x_{4,5} \leq 1, \quad x_3 \geq x_1, \quad x_4 \geq x_3, \quad x_4 \geq x_5, \quad x_i = 0 \text{ or } 1, \text{ for } \forall i$$

Appendix B. the final results of SOHO's example

Decesion variables	Deviation variables	Comments
$x_1 = x_3 = x_4 = x_5 = 1$	$d_1^+ = 0,\ d_1^- = 100$	1) Delivery time does not use one month
$x_2 = 0$	$d_2^+ = 0,\ d_2^- = 80$	2) Increased revenue obtain 100,000 by interdependent between project 1 and project 3.
	$d_3^+ = 0,\ d_3^- = 0$	3) cost saving obtain $80,000 by interdependent between project 4 and project 5.
	$d_4^+ = 0,\ d_4^- = 0$	

References

[1] R.L. Carraway and Schmidt, "An improved discrete dynamic programming algorithm for allocating resources among interdependent projects", Management Science, Vol.37(9), p.1195-1200, 1991.

[2] Buss, M.D.J., "How to rank computer projects", Harvard Business Review, Vol.40, p.118-125, 1983.

[3] B.V. Dean, M.J. Schniederjans, "A multiple objective selection methodology for strategic industry selection analysis, IEEE Transactions on Engineering Management, Vol.38(1), p.53-62, 1991.

[4] James J. Jiang and Gary Klein, "Project selection criteria by strategic orientation", Information & Management, Vol.36, p.63-75, 1999.

[5] Jin Woo Lee and Soung Hie Kim,, "An integrated approach for interdependent information system project selection", Journal of Project Management, Vol.18(6), December 2000(forthcoming).

[6] Jin Woo Lee and Soung Hie Kim., "Using analytic network process and goal programming for interdependent information system project selection", Computers & Operation Research, Forthcoming, 2000.

[7] D.L. Hall, A. Nauda, "An interactive approach for selecting R & D projects", IEEE Transactions on engineering Management, Vol.37(2), p.126-133, 1990.

[8] Lucas, H.C., and Moor, Jr., J.R., "A multiple-criterion scoring approach to information system project selection", *INFOR*, Vol.14, No.1, p.1-12 1976.

[9] McKeen, J.D., and Guimaraes, T., "Selecting MIS projects by steering committee", Communications of the ACM, Vol.28(12), p.1344-1352, 1985.

[10] G.M. McGrath, C.N.G. Dampy, E. More, "Planning for information systems integration: some key challenges", journal of information Science, Vol.20(3), p.149-160, 1994.

[11] N.C. Dalkey, "The Delphi method: An experimental study of group opinion," Rand Corp., Res. Pap. RM-5888-PR (June 1969).

[12] Reiter, S. and Rice, D.B., "Discrete optimizing solution procedures for linear and nonlinear integer programming problems", Management Science, Vol.12, No.11,

p.829-850, 1966.

[13] Ringuest, J.L.,and Graves, S.B., "The linear multi-objective R&D project selection problem", IEEE Transactions on Engineering Management, Vol.36, No.1, p54-57, 1989.

[14] Sanathanam, R., and Kyparisis, G.J., "A decision model for interdependent information system project selection", European journal of Operational Research, Vol.89, p.380-399, 1996.

[15] Sanathanam, R., and Kyparisis, G.J., " A multiple criteria decision model for information system project selection", Computers Ops Res, Vol.22 No.8, p.807-818, 1995.

[16] Schniederjans, M.J., and Sanathanam, R., "A multi-objective constrained resource information system project selection method", European journal of Operational Research, Vol.70, p.244-253, 1993.

[17] Soung Hie kim and Jin Woo Lee and., "An Analytic Delphi Network Process for Evaluating Telecommunication management Network Operations Systems (TMNOS)", Journal of the Military Operations Research Society of Korea, Vol.24, No.2, p.30-42, December, 1998.

[18] Thomas L. Saaty, The Analytic Network Process, RWS Publications, 1996.

[19] Gary S. Wasserman, "On how to prioritize design requirements during the QFD planning process", IIE transaction, Vol.25, No.3, p59-65, 1993.

[20] Weber, R., Werners, B., and Zimmerman, H.J., "Planning models for research and development", European journal of Operational Research, Vo.48, p.175-188, 1990.