

AHP를 이용한 신규사업과제의 평가모형 개발 및 통신장비회사의 사례연구

조성백* · 한인구**

The Development of Evaluation Model for
New Business Projects Using AHP and Case Study of
Telecommunication Equipment Company

Sungbaek Cho* · Ingoo Han**

■ Abstract ■

The launch of a new business is crucial to the future growth and profitability of a company. A new business project typically requires a large amount of resources while it has a high possibility of failure. The evaluation of new business opportunities is therefore quite a critical decision-making to companies. This evaluation includes screening of a large number of criteria at a time which often makes decision-making very complicated. Management should evaluate the business alternatives in a sound and consistent manner that is hard to achieve because the new business evaluation is a typical semi/unstructured decision-making problem. The difficulty in such an evaluation will increase if it is required for management to consider both quantitative and qualitative criteria simultaneously. Under these circumstances, this study has proposed a decision-making framework that utilizes analytical hierarchy process (AHP). This study has identified a set of criteria essential to the new business evaluation and suggested a systematic framework for it. Both qualitative and quantitative evaluations are incorporated into the single framework in this study.

Keyword : new business evaluation, AHP

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* 런던대학교 박사과정

** 한국과학기술원 테크노경영대학원 교수

1. Introduction

The survival of a company depends on the constant growth and defense against competition. The weakened market position, dated technology or increased level of competition could be reasons for the continuous diversification of business areas and products. Typically, a new business is initiated with low market share in high potential growth markets, incurring high opportunity costs to the company [26]. Nevertheless, the new business is quite a risky adventure in that it has a high failure rate. According to Kleinschmidt and Cooper [19], the successful launch of new product was less than 60%.

There are three fundamental and essential decisions that should be continuously made within a company for its survival [6] : (1) what service or product to produced, what market to be served, and basically how the company is to go about doing these, (2) whom to hire and retain : which persons, which skills, which abilities, which personalities, how many, and so forth, and (3) how the available resources of the company, particularly money, should be allocated.

More specifically to new business, Roberts and Berry [26] recommended that the following questions in decision-making should be considered critical : (1) which product-markets should a company enter (2) how should a company enter these product-markets to maximize gain? If a company has decided to diversify its business to an entirely new area, its main concern would be with the latter question. In this case, it may consider various entry options such as the company's own development of required know-how, licensing, and the merger with other existing company. Organizing and personnel issue would

also be very complex in this case. In contrast, if it plans to extend its business portfolio that is based on existing business, it may not consider the entry options such as merge and acquisition. Rather it would consider its business capability, compared with existing business force

In general, the term, new business is very widely used to refer to both new product and the entrance to new market. New business, new product, and corporate venture are often used as synonyms because there is no clear distinction among them. The corporate venture is defined as any project which (1) involves an activity new to organization, (2) is initiated or conducted internally, (3) involves significantly higher risk of failure than the organization's basic business, (4) is characterized by greater uncertainty than the existing business, (5) will be managed separately for some time during its life, and (6) is undertaken for the purpose of increasing sales, profit, productivity, or quality [4]. On the other hand, the new product is defined as follows [21] : (1) the product which is new both to the market and to the company, (2) the new brand, which is new to the company, but not very new to the market, and (3) the new model, style or package.

In this paper, we defined new business as any business service and product that is new to a company's existing business portfolio. However, our interests in this paper were limited to the diversification of product to new market in the same industry where the company has already entered. Within this scope of new business, new business alternatives should be compatible with the company's existing technology, manufacturing, image, and promotion know-how. The television manufacturers entrance to VCR market can be a good example of this kind of new

business.

The main concern in this study is to develop a decision-making framework for the evaluation of new business opportunities. The new business evaluation is very complex and difficult semi/unstructured decision-making process. Therefore, the systematic analytical framework for new business evaluation may be helpful to the corporate managers. To concentrate on developing evaluation framework, we assumed that new business alternative have been screened. That is to say, each alternative to be evaluated should satisfy fundamental requirements such as fitness to the company's mission and goal, legal regulations, public interests, budget constraints, technical feasibility, and so on.

2. Research Background

2.1 General Framework for Evaluation

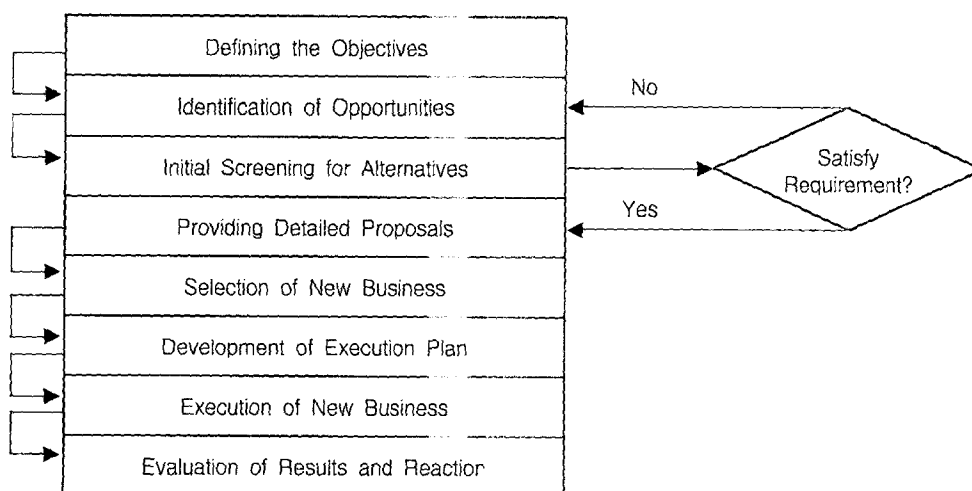
General procedures of new business planning are composed of six phases [24] : (1) define the objectives of new business, (2) identify the new

business opportunities, (3) screen and select the alternatives, (4) develop the execution plans, (5) execute the new business project, and (6) evaluate the results and provide reactions. At the screening and selection phase, each proposal for new business is to be screened initially. The detailed proposal will be then developed if the initial screening indicates that it would be worthwhile to consider the initial proposal in depth. The evaluation and selection of new business will be performed after detailed proposals have been provided. As mentioned above, we assumed that the proposals for new business have been initially screened. The basic ideas in the initial proposal are to be screened prior to the development of full-blown proposal [23]. This initial screening process would reduce the burden to develop the detailed plans for all ideas submitted [4].

The procedure of new business planning may be described as follows : ({Figure 1})

2.2 Evaluation Criteria

The screening of new product proposals is a



[Figure 1] Procedures of New Business Planning and Evaluation

very critical consideration since the failure rates of new products are high. According to Cooper [9], the main reason for new product failures were (1) underestimated comprehensive strength and/or comprehensive position in market, (2) overestimated number of potential users, (3) product price set too high, and (4) technical difficulties/deficiencies with the product. Therefore, corporate managers should perform sound evaluation of these issues and determine which factors would lead them to the success of new products.

The most critical determinants of new product success identified by Cooper [10] were : (1) having a unique or superior product in the eyes of the customer, (2) having marketing knowledge and proficiency, and (3) having technical and production synergy and proficiency.

As an extension of this study, Cooper [11] identified the three dimensions of new product performance and the factors affecting each performance dimension : (1) Financial Performance to captures the overall financial success of the product. This dimension is comprised of the relative profits and sales, meeting profits and sales objectives, profitability level, and payback period. Well-defined project definition, product superiority and synergy were the key factors to a strong financial performance. (2) Opportunity Window to portrays the degree to which the new product opened up new opportunities to the company in terms of a new category of products and a new market area for the company. The product uniqueness and new/advanced technologies were the key factors to a strong opportunity window. (3) Market Impact to describes the impact of the product in both domestic and foreign markets, domestic market share and

foreign market share, and to a lesser extent, relative sales, and meeting sales and profit objectives. The key factors to a strong market impact include a superior product, a high quality product, a product featuring unique customer benefits, a product that solved a customer's problem, and a product that made use of advanced technology.

From the analysis of factors that had contributed to the success of new product projects, Cooper [12] identified the following dominant screening criteria have been determined to make a GO/NO GO decision for new product development projects : (1) Financial potential : expected ROI, profit and sales growth, market share expectation, the likelihood of success, and market growth, (2) Corporate synergy : a fitness in terms of distribution channels and sales-force, business, customers, marketing research resources, organization, managerial capabilities, corporate strategy, and top management preference, (3) Technological and production synergy : a fitness in terms of engineering/design skills and resources, production facilities and knowledge, and in-house availability of component parts, and (4) Product differential advantage : first introduced product to market, contribution to leadership position, innovativeness, technological strength, quality, economic advantage for the customer.

With respect to secondary screening factors related to project GO/NO GO decisions, a product which had following attributes was rated highly [12] : (1) product life : long expected life, and clear and predic : development pattern for future (2) market maintenance strategy : defensive product, product for survival in a business, and replacement or update of current product, (3) size of market : mass market, large dollar volume,

large long term potential, and broad geographically, (4) diversification strategy : new product class to the company, new product or new technology, and (5) domestic market : domestic market with domestic competition.

From the series of studies on performance of new product projects, Cooper and Kleinschmidt [13] proposed an arena assessment diagram to evaluate and select the new market for a company to enter. This diagram comprises two axes, the arena attractiveness and the business strength. The arena attractiveness consists of (1) Market attractiveness : the size of markets, potential customers, product life and growth rate, and (2) Technological sophistication : the level of technologies involved in product, the use of leading/state-of-art technologies and the level of technology sophistication. The business strength consists of (1) Technological synergy : a fitness in terms of production processes, R&D skills/resources, and engineering/design skills required, (2) Marketing synergy : a fitness in terms of sales-force/channels of distribution, and advertising/promotion approach/skills required, and (3) Differential product advantage : the products impact on customer use behavior, the uniqueness of products, the extent to which the product meets the customer needs.

Instead of statistical analysis to derive a set of screening criteria, Ram and Ram [25] used the Delphi technique to extract those criteria. Their criteria were similar to those of Coopers : (1) Market features : total market size, growth rate, susceptibility to the economy, and seasonality of demand, (2) Financial expectations : volume of business, gross margin, ROI, and pay-back period, (3) Product features : distinctiveness, ease of imitation, and contribution to image,

(4) Corporate fit : compatibility with existing products, financial outlay, changes in organizational structure, fit with current marketing skills, and fit with current product development skills, and (5) Competition : number of competitors, quality of competitors, and vulnerability of competitors.

2.3 Subcriteria for Market and Financial Features

When seeking the new market to enter, the company should assess market attractiveness. Although market size, expected market share and market growth serve as major criteria in determining the market attractiveness, there are a number of other important criteria to be evaluated against for market attractiveness. For basic market attractiveness assessment, Corey [14] recommended following four criteria : (1) Does the market have high growth potential? (2) Is the market currently dominated by large and powerful competitors, or is it still possible to claim a large market share? (3) Is the market easy or difficult for competitors to enter? and (4) How high is the value added by manufacturer, or conversely how low is the ratio of the cost to the selling price?

More specifically, Day [15] provided following detailed criteria : (1) the contribution rate of new business to whole revenue or profit, (2) barriers to entry, (3) cyclicality of sales, (4) the rate of capacity utilization, (5) sensitivity of sales to change in price, promotional activities, service levels, etc, (6) the extent of captive business, (7) the nature of technology to be used, (8) availability of production and process opportunities, and (9) social, legal, governmental and union

pressures and opportunities.

For detailed consideration of financial criteria, the following financial factors should be considered in determining the financial value of new product idea [17] : (1) Cash outflow : R&D costs, marketing costs, capital equipment costs, and other costs, (2) Cash inflow : sales of new product, effect on additional sales of existing products, and salvageable value, (3) Net cash flow : maximum exposure, time to maximum exposure, duration of exposure, total investment, and maximum net cash in a single year, (4) Profit : profit from new product, profit affecting additional sales of existing products, and fraction of total company profit, (5) Relative return; return on shareholder's equity (ROE), return on investment (ROI), cost of capital, present value(PV), discounted cash flow (DCF), return on asset (ROA), and return on sales (ROS), and (6) Compared to other investments : compared to other product opportunities, compared to other investment opportunities.

2.4 Analytic Hierarchy Process

For screening and evaluation of alternatives, a number of normative approaches have been proposed. These include (1) portfolio models based on linear, integer or dynamic programming, (2) benefit contribution methods such as check lists, scoring models and paired comparisons, (3) financial return models both deterministic and probabilistic, and (4) market research approaches [2, 33]. Among these approaches, the benefit contribution method has been proved to be more preferred and regularly used by corporate managers [3]. The benefit contribution is deemed most appropriate for screening, where only rough

distinctions among projects are required. At the screening phase of the new business proposals, relatively less reliable information is only available. Therefore mathematical methods may not work properly in this situation. To evaluate the proposals of new business, we adopted the analytic hierarchy process(AHP).

AHP was developed and introduced by Saaty [27]. It is a general theory of measurement and used to derive ratio scales from both discrete and continuous paired comparisons. In general, AHP consists of five steps [5] : (1) breaking down the decision into a hierarchy of decision elements, (2) collecting input data by pairwise comparison of decision elements, (3) checking the consistency of the input data using the maximum eigenvalue method, (4) computing the relative weights of the decision elements as the eigenvector of the pairwise matrix, (5) aggregating the relative weights of the decision elements in order to obtain a numerical outcome. The simplest hierarchy structure of AHP may have three levels : objective(or goal), criteria, alternatives. One of the distinguishing features of AHP is the hierarchic structure to represent the decision problem, independent of problem complexity or the number of criterion [35]. Hierarchical decomposition is one of the most commonly used methods by which decision-makers factor complex problem into more manageable subproblems [30].

Data for AHP analysis can be obtained by the process of pairwise comparison in which the subject is asked to compare entities at the same hierarchical level with each other regarding their relative importance with respect to a specific entity at the next higher level. This results in questions which take the following form : "With respect to the best overall manufacturing system,

how important do you think production lead time reduction compared with quality improvement?” and at the level of the alternatives, “With respect to production lead time reduction, how strongly do you prefer alternative 1 to alternative 2?” The scale used in comparison is identified in <Table 1> [28].

The resulting matrix from any set of pairwise comparisons can be written as follows :

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}$$

where a_{ij} is the relative importance or preference for i to j , $a_{ij} = 1/a_{ji}$ and $a_{ii} = 1$.

The matrix A is called perfectly consistent if $a_{ik} / a_{ij} = a_{jk} \quad \forall i, j, k$. This is equivalent to saying that, ‘with respect to a specific criterion, if one prefers alternative 1 to alternative 2 by twice and he/she prefers alternative 1 to 3 by four times, he/she then must prefer alternative 2 to alternative 3 by twice. AHP allows variation from perfect consistency and defines the procedures for measuring the degree of consistency in a

given set of answer [28]. To measure the deviation from consistency, the consistency index (C.I.) of each matrix can be used. It can be obtained by following equation :

$$C.I. = (\lambda_{\max} - n) / (n - 1)$$

where λ_{\max} is the largest eigenvalue of \hat{A} and n is the number of activities in the matrix.

The consistency index of a randomly generated reciprocal matrix is called the random index (R.I.). <Table 2> gives the order of matrix and the average R.I. of 500 samples. The ratio of C.I. to the average R.I. for the same order matrix is called consistency ratio (C.R.) A consistency ratio of 0.10 or less is considered acceptable, and 0.20 or less may be tolerable [28]. The great strength of AHP is its ability to incorporate systematic checks on the consistency of judgments in the pairwise comparison matrices because other approaches to multi-attribute decision theory fail to incorporate consistency check [5]. When the decision-maker inputs his/her preference on the pairwise basis, it is assumed that he/she does not know the vector of weights that

<Table 1> Scale of Relative Importance [29]

Intensity of Importance	Definition
1	Equal Importance
3	Moderate importance of one over another
5	Essential of strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two

<Table 2> Random Index [29]

Order	1	2	3	4	5	6	7	8	9	10	11
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

characterizes the relative strength of each entity. The estimation of \mathbf{W} , the vector of weights, is the solution to

$$\hat{\mathbf{A}} \cdot \hat{\mathbf{W}} = \lambda_{\max} \cdot \hat{\mathbf{W}}$$

where $\hat{\mathbf{A}}$ is the observed matrix of pairwise comparisons, λ_{\max} is the largest eigenvalue of $\hat{\mathbf{A}}$, and $\hat{\mathbf{W}}$ is the estimation of \mathbf{W} .

At any level in the hierarchy, the vector of weights indicates the relative weights of elements at that level with respect to the corresponding upper level element. For example, each local priority at alternative level represents the relative scores of alternatives with respect to the upper level criterion used for obtaining the corresponding pairwise matrix. A vector of global priority is defined as the overall score of alternatives at top level. The process of obtaining the vector of global priority is called the synthesis. Synthesis multiplies all local priorities that are related across the links in the hierarchy from bottom level to top level and sums up the results to obtain the global priorities.

As shown above, AHP requires some level of mathematical complexity in deriving the vector of weights. Using automated AHP tools such as Expert Choice [16] would solve this problem. If an automated AHP tool were not available, the following algorithm would provide good approximation of the vector of weights [7]. The vector of local priority can be approximated as follows :

Approximation of Vector of weights

$$= [B_1 / \sum_{i=1}^n B_i, B_2 / \sum_{i=1}^n B_i, \dots, B_n / \sum_{i=1}^n B_i]^T$$

where $A_j = \sum_{i=1}^n a_{ij}$, $B_i = \sum_{j=1}^n (a_{ij} / A_j)$, and a_{ij} is an element in the pairwise comparison

matrix ($n \times n$).

In addition, the approximation of the consistency ratio of pairwise comparisons is

$$C.R. = C.I. / R.I., \text{ where } C.I. = (\lambda_{\max} - n) / (n - 1), \text{ and } R.I. \text{ is given by } \langle \text{Table 2} \rangle. \lambda_{\max} \text{ can also be approximated as } \lambda_{\max} = \sum_{i=1}^n (C_i / B_i) / n, \text{ where } C_i = \sum_{j=1}^n a_{ij} B_j.$$

AHP has been used extensively in practice, especially for the priority setting in budget allocation and R&D projects. There are a number of multi-attribute evaluation models applicable to screening of new business proposal. The reasons for adopting AHP as a tool for new business evaluation are : (1) AHP provides more sound comparison through the pairwise comparison, (2) it better fits the human cognitive style because the hierarchical structure of AHP decomposes the complex problem into sub-problems and synthesizes the results, (3) it supports group decision-making using geometric-mean without tedious process such as Delphi, and (4) it checks the consistency of evaluation.

3. Development of Evaluation Model

The evaluation of new business requires many pieces of information and management interactions among various organizational levels. This is a typical semi-structured (or unstructured) decision problem. If anyone wishes to use computing technology in this type of evaluation, a decision support system would be the most appropriate solution because its fundamental characteristics are (1) dealing with the semi-

structured and unstructured problems, (2) combining the models with data, (3) emphasizing flexibility and adaptability, and (4) focusing on user friendliness through an interactive mode [31].

In our framework of new business evaluation, there should be more than one alternative to apply pairwise comparison. This assumption is *affordable because a company would not consider only one alternative, rather it would like to compare various alternatives available when it seeks its new business area. Moreover, even if there were only one business area that the company plans to enter, there would be various entry options under consideration.*

3.1 Hierarchy Structure for AHP Evaluation

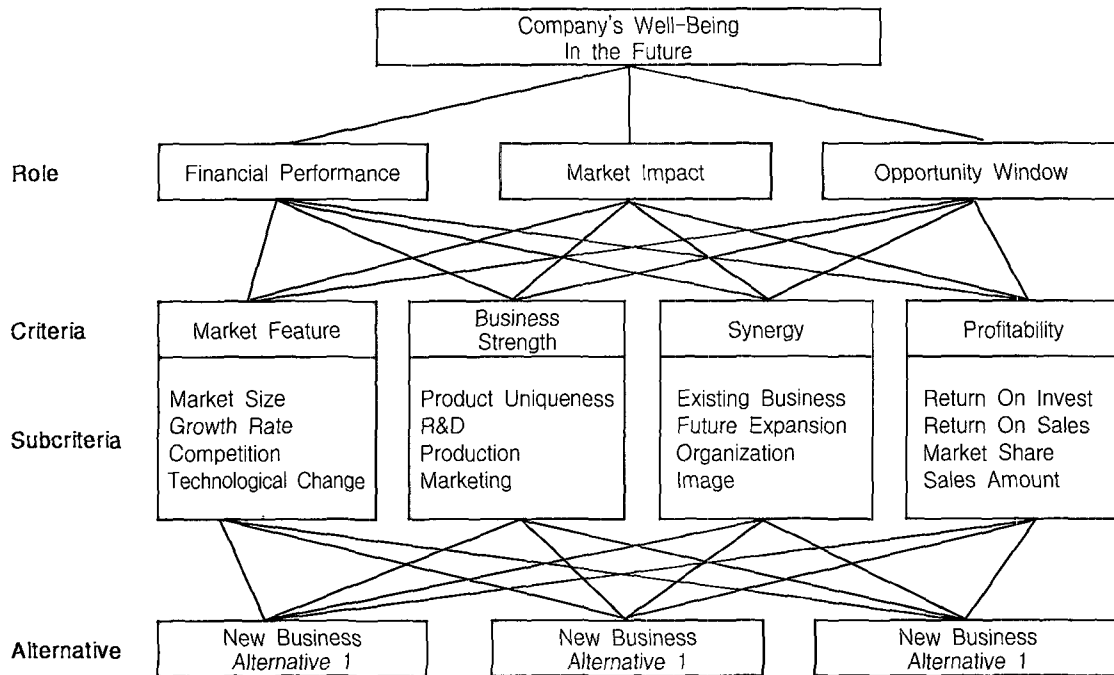
There are various options in hierarchical structure of AHP. Various hierarchy structures include three level structure such as goal-criteria-alternatives, four level structure such as goal-criteria-subcriteria-alternatives, and other variations such as goal-criteria-scenarios-alternatives and goal-players-scenarios-criteria-alternatives.

The goal-criteria-alternative structure is adopted for this study because it has been a widely used structure for investment evaluation [8, 20]. In our evaluation framework, there are many criteria to be evaluated at the same time such as market size, growth rate, competition, synergies, quality, image, and so on. Therefore, we did not consider simple three-level hierarchy structure because the number of elements compared at the same time should be small (no more than 9) to improve consistency and the corresponding accuracy of measurement [22]. The one method to avoid this problem is clustering. Clustering is a process of grouping elements with respect to a

common priority [29]. Based on the AHP literature, we carefully grouped related subcriteria into one criteria to control the number of factors in a cluster and avoid the overlapping of factors. Our hierarchy structure had to be at least four levels, goal-criteria-subcriteria-alternatives.

The company's new business is primarily to grow and to respond to competitive pressures. The criteria and their priorities may change according to the company's main reason for initiating new business. While the main reason for new business may be strongly related to profits, the success of new business cannot be measured solely by its profitability. For example, if a new product project earned less profit than expected, but resulted in great improvement of corporate image, can anyone easily say that the project ended up with failure?

Therefore, we set the highest level in the hierarchy as 'company's future well-being'. We then considered main objectives of new business at the second level in the hierarchy, 'the expected role of new business.' As criteria at this level, adopted the performance categories defined by Coopers and Kleinschmidt [13]. They classified the resulting effects of new product projects into following categories : (1) financial performance : captures the overall financial success of the product, (2) the opportunity window : portrays the degree to which the new product opened up new opportunities to the company in terms of a new category of products and a new market area for the company, and (3) market impact : describes the impact of the product in markets. The next level in the hierarchy is the criteria followed by subcriteria. In summary, our hierarchy is composed of : (Figure 2)



[Figure 2] AHP Hierarchy for New Business Evaluation

- Goal : Company's well-being in the future.
- Role : Expected role of new business to accomplish goal.
- Screening criteria : Factors affecting the achievement of role.
- Subcriteria : Sub sets of screening criteria.
- Alternatives : New business alternatives

3.2 Evaluation Criteria

According to Booz [6], the most important factors in successful new products are the fits of the product with market needs and with internal functional strengths. In general, the studies on product portfolio models such as growth/share matrix, business assessment array, business profile matrix, and directional policy matrix have employed these two dimensions, i.e. (1) market attractiveness and (2) business strength [34]. We

included these two dimensions in our screening criteria.

The main purpose of using market attractiveness and business strength dimensions is to assess the company's current situations and decide the future direction of the company. Besides these dimensions, the profitability issues such as expectations of ROI and sales amounts should be considered in new business evaluation. Most of studies related to new product and new business evaluation regarded the profitability issues as very important [4, 17, 21, 32]. Although the business strength dimension may imply the future gain from the new business from the viewpoint of current competence of the company, the profitability issues should be considered separately because competitive strength does not always guarantee high profitability, which is more related to the cost structure and type of new

business. Therefore, we added the profitability dimension in our hierarchical structure.

As for the fourth dimension of screening criteria, we addressed the issues related to synergy effects that could be obtained from interactions of new business with existing business. The rationale for this dimension was that new business project should contribute to the future value creation of the company and also help the promotion of existing business. In conclusion, our AHP hierarchy has four screening dimensions, each of which has four subcriteria.

3.3 Evaluation Subcriteria

We used four subcriteria for each criterion and therefore the total number of element at subcriteria level is sixteen. Through literature review and discussion with project evaluation experts and corporate managers, we derived the subcriteria. With respect to the subcriteria for market feature dimension, we adopted (1) market size, (2) market growth, (3) degree of competition, and (4) degree of technological change. The importance of market size and growth has been emphasized by [11, 12, 13, 25, 32]. The degree of competition refers to the potential number of competitors and qualities of competitors [14, 24, 25]. The degree of technological change means the expected life of current technology that is to be applied to new product [11, 24]. This criterion was reported highly correlated with the success of new product in [12].

As regards the subcriteria for business strength, we adopted (1) the perceived product uniqueness, and the perceived level of competence in (2) R&D, (3) production, and (4) marketing. The product uniqueness means the level of the differentiation

from the existing products in the same market and class. It was identified as the most important requirement for success by [12]. The level of competence in R&D, production, marketing skills can be measured by comparing the alternatives from the view point of their fitness to those of the company's [4, 10, 12, 25].

The subcriteria for the synergy dimension are (1) impact on current business, (2) impact on provisions of other business opportunities, (3) impact on image, and (4) impact on organization. Impact on current business can be measured by the extent to which the new business would help the marketing, manufacturing, and design of products for existing business [24]. The impact on provisions of other business opportunities means the extent to which the new business can be applied to other businesses, that is, the potential applicability of new business to other area [24]. The impact on image is one of widely used criterion in the screening [4, 11, 25]. Cultural and administrative aspects of new business may help the company to improve its ways of doing business. In contrast, the differences in formality, communication openness, how mistakes are treated, attitudes toward customers, and internal competitiveness could cause serious problems to current business operations [4, 24, 25].

The last dimension is financial profitability. There are a number of financial measures for profitability indicators. It cannot be questioned that one of the most frequently used measures is Return on Invest (ROI). We also adopted Return on Sales (ROS), which is widely used with ROI [17, 18]. ROS is important to new business evaluation because it indicates the amounts of value added. Value added criterion was considered in [14, 32]. We did not consider

discounted cash flow methods such as NPV (Net Present Value) and IRR (Internal Rate of Return) in our framework because the expected life of new business cannot be estimated easily. Instead, we adopted sales amounts and market share criteria, which were suggested by [4, 12, 25].

3.4 Quantitative Criteria

As shown in [Figure 2], our AHP framework includes quantitative criteria such as market size, growth rate and the profitability measures. AHP was originally designed to handle both qualitative and the quantitative criteria at a time. For quantitative criteria, an analyzer is allowed to evaluate each alternative by qualitative pairwise comparison. That is to say, a qualitative question such as "Given the NPV criterion, how much larger is one alternative than another for that criterion?" could be used to evaluate the alternatives. However, if he/she is able to calculate or estimate the values of alternatives directly against quantitative criteria, he/she can evaluate the alternatives directly without pairwise comparison. For example, consider a quantitative criteria like cost saving. Assume that the alternative 1 through 4 will result in cost saving of \$10, 50, 20 and 30, respectively. In this situation, the dollar values can be used directly to create the pairwise comparison matrix; the resulting score of each alternative is then $0.09(= 10/110)$, $0.45(= 50/110)$, $0.18(= 20/110)$, and $0.27(= 30/110)$, respectively.

The same quantitative evaluation procedure was employed in our evaluation framework. For market size, growth rate, sale amounts and market share, we considered the average of five-year values as an input to quantitative evaluation. Although it was possible for us to consider longer

period, the rationale for considering only next five years was that the estimation of far future event would be too unreliable to be incorporated into the evaluation. The shorter period than 5 years may be possible. However it might not project the market attractiveness properly because the emerging market generally takes a certain amount of years until its saturation and market features have tendency to change quickly in early stage. Similarly, all other quantitative criteria in our framework are evaluated within the time windows of five years.

3.5 Financial Criteria

ROI is the income divided by the amount of investment. To generate ROI estimates, it is essential to estimate amounts of incomes and investments for projected years. To estimate the income for a specific year, we were required to make a pro-forma income statement for that year. Making the pro-forma income statement included the estimation of sales volume, cost, depreciation, tax, and so on. The format of pro-forma income statement is shown <Table 3>. For simplicity, we assumed that the value of some items could be expressed as a fixed portion of sales amount. For example, operating cost can be obtained by multiplying certain portion to sales in our framework. This reduced the burden to estimate all future values. Therefore, the estimation of net income required the estimation of future sales and the cost factors as portions of sales only.

In our framework, the depreciation was calculated based on the amount of investment in fixed assets to be used in producing the new product. The depreciation of investments de-

〈Table 3〉 Pro-forma Income Statement

Item	Source
Sales (S)	Company's expectation
Costs (C)	$C = CE + OE + I + D$
CGS, excluding depreciation (CE)	Expected portion of S
Operating costs, excluding depreciation (OE)	Expected portion of S
Interest expenses (I)	Expected portion of S
Depreciation cost (D)	From the asset investment
Operating income (OI)	$I - S - C$
Income taxes (T)	$T = I * \text{tax rate}$
Net income (NI)	$NI = S - C - T$

depends on a company's depreciation policy. There are various depreciation policies such as straight-line method, decline-balance method, declining-balance switching to straight-line, and so on. We adopted the straight-line method with an assumption that the salvage value would be zero and the projected life is five years. This assumption was the very conservative and risk averse view against uncertain future events. From this assumption, the depreciation of the investment for a specific year was allocated to the cost of items for the next five years.

ROI and ROS were also considered within the time window of five years. There are several different definitions of investment. These include (1) total asset available, (2) total assets employed, (3) working capital (current asset minus current liabilities) plus other assets, and (4) stockholders equity. Among these definitions, most companies tend to employ (1) total assets available or (2) working capital plus other assets as a definition of the ROI denominator [18]. As new business is only a part of the company's entire business, it would be unacceptable to employ the former definition. Therefore we adopted the latter definition and simply assumed that the investments

in new business would be classified into two types, e.g. working capital and fixed asset. From this viewpoint, we requested the company under our case study to make an investment schedule for the next five years according to these two types.

To simplify the estimation of ROI, we were required to add more assumptions. These were (1) the time when investments would occur was assumed to the beginning of each year, (2) the investment in fixed asset would be depreciated for next five years and their salvage values would be zero, and (3) the amount of working capital would remain constant over a year. The investment over a specific year could then be calculated from <Table 4>. The investment in fixed assets at beginning of year t , refers to the initial investment at the start point of new business *plus* the capital expenditures in other previous years. The capital expenditures include additional investments to improve the estimated life of assets, and/or quality and quantity of production. At the end of each year, the amounts of fixed assets can be calculated by subtracting the depreciation from fixed assets which are the amounts of fixed assets carried forward from the

〈Table 4〉 Calculation of Annual Investment

Investments on Fixed Assets at Beginning of Year t	IF_t
Carried Fixed Assets at Beginning of Year t	BF_t
Amounts of Working Capital Invested in Year t	IW_t
Depreciation of Fixed Assets in Year t	D_t
Amounts of Fixed Assets at End of Year t	$AF_t = IF_t + BF_t - D_t$
Total Investments in Year t	$TI_t = (IW_t + AF_t)/2$

〈Table 5〉. Calculation of Depreciation

	Year 1	Year 2	Year 3	Year 4	Year 5
Depreciation for IF_1	$IF_1/5$	$IF_1/5$	$IF_1/5$	$IF_1/5$	$IF_1/5$
Depreciation for IF_2	-	$IF_2/5$	$IF_2/5$	$IF_2/5$	$IF_2/5$
Depreciation for IF_3	-	-	$IF_3/5$	$IF_3/5$	$IF_3/5$
Depreciation for IF_4	-	-	-	$IF_4/5$	$IF_4/5$
Depreciation for IF_5	-	-	-	-	$IF_5/5$
D_t for Year t	Sum of Each Column				

last year and capital expenditures at the beginning of the year.

The remaining task for obtaining ROI estimates, was the calculation of depreciation. Our framework uses a straight-line method with five-year lifetime and no salvage value. With this policy, we could calculate the depreciation of investments in fixed assets. This is explained in <Table 5>.

We were also required to calculate the tax in the pro-forma income statement. The Korean tax rate is variable according to the amount of earnings before tax (EBT), e.g., 18% if EBT is less than one-billion won, and otherwise, 32%. These rates are subject to annual change. There is also a resident tax which is 7.5% of tax. For simplicity, we ignored the resident tax and simply assumed that the tax rates be fixed at 18% and 32% for the next five years of new business.

So far, we have mentioned all our assumptions

and strategies that were used to obtain ROI estimates. 'However there still remains one question : How to incorporate five ROI estimates for five years into one AHP value for ROI criterion?' The simplest answer to this question is the use of average of those five ROI estimates. However, this method may be unreasonable because there must be the relative importance among these five estimates according to the amounts of investments. For example, the ROI for a one million-dollar investment is much more important than one for thousands of dollars. Therefore, we devised the incorporated ROI measure for the multi-period investment as follows :

$$ROI = \frac{\sum_{i=1}^5 (ROI_i * TI_i)}{\sum_{j=1}^5 TI_j}$$

where TI and ROI_i is the total investments and ROI of year i .

Similarly, the ROS value for the ROS criterion in the AHP was calculated by the weighted sum of each year's ROS for same reason above.

$$ROS = \frac{\sum_{i=1}^5 (ROS_i * S_i)}{\sum_{j=1}^5 S_j}$$

where ROS_i is the ROS of year i and S_i is sales amounts of year i .

The use of total investments and sales amount for the weighed sums of ROI and ROS respectively is based on the implicit notion that the limited resources should be optimally allocated.

4. Case Study

In this section, we will explain how our proposed framework worked in the evaluation and selection of new product project. The company, which requests anonymity, is an electronic equipment manufacturer whose major business area is the telecommunication equipment. The company's concern was where to allocate more resources between two new product plans that had been screened initially. The company also wanted

to find out the less attractive one so that it could determine the cancellation of one project in worst case such as budget limitation. The new product projects under our evaluation were (1) security system (SS) and (2) VDT (Video Dial Tone). Security system refers to a set of system which monitors a specific site or a person. VDT refers to a device by which people use video-on-demand.

4.1 Financial Data

To compare these two alternatives, we requested the relevant financial data to the company. The requested data items were as same as explained in the previous section. The expected market sizes for five business years of each alternative are listed <Table 6>. The market size data were provided by market research agencies, and the company made the forecasts of its future sales from these figures. The figure in the parentheses shows the expected sales. To make the pro-forma income statements for next five years, the company provided the estimates of cost items as portions of total sales, as shown in <Table 7>.

<Table 6> Market Size and Sales

	(in billion)				
	Year 1	Year 2	Year 3	Year 4	Year 5
Security System	1200 (10.00)	1500 (50.00)	2000 (100.00)	2500 (150.00)	2500 (200.00)
VDT	45 (9.00)	150 (30.00)	300 (60.00)	600 (120.00)	1200 (240.00)

<Table 7> Portions of Costs to Sales

Item	Security System	VDT
CGS, excluding depreciation	70% of Sales	75% of Sales
Operating cost, excluding depreciation	10% of Sales	10% of Sales
Interest cost	1% of Sales	1% of Sales

For the depreciation cost and ROI items, we asked the company to estimate the amount of working capital for each year and annual investment as capital expenditures to keep the quality and quantity of the product required. The resulting figures for two alternatives are

shown in <Table 8>. The row 'Fixed Asset', represents the amounts of capital expenditures for each year. From these investment schedules, we could calculate the depreciation costs. The procedures and results are shown in <Table 9>. From these tables, we could make

<Table 8> Investment Schedule for Security System and VDT

(in billion)

	Year 1		Year 2		Year 3		Year 4		Year 5	
	SS	VDT	SS	VDT	SS	VDT	SS	VDT	SS	VDT
Working Capital	6.00	5.00	30.00	18.00	60.00	36.00	90.00	72.00	120.00	144.00
Fixed Asset	5.00	5.00	3.00	3.00	5.00	2.00	10.00	5.00	20.00	3.00
Beginning of year	5.00	5.00	7.00	7.00	10.40	7.40	17.80	10.40	33.20	10.40
End of year	4.00	4.00	5.40	5.40	7.80	5.40	13.20	7.40	24.60	6.80
Average	4.50	4.50	6.20	6.20	9.10	6.40	15.50	8.90	28.90	8.60
Annual Investment	10.50	9.50	36.20	24.20	69.10	42.40	105.50	80.90	148.90	152.60

<Table 9> Depreciation Schedule for Security System and VDT

(in billion)

	Year 1		Year 2		Year 3		Year 4		Year 5	
	SS	VDT	SS	VDT	SS	VDT	SS	VDT	SS	VDT
For year 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
For year 2	-	-	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
For year 3	-	-	-	-	1.00	0.40	1.00	0.40	1.00	0.40
For year 4	-	-	-	-	-	-	2.00	1.00	2.00	1.00
For year 5	-	-	-	-	-	-	-	-	4.00	0.60
Depreciation	1.00	1.00	1.60	1.60	2.60	2.00	4.60	3.00	8.60	3.60

<Table 10> Pro-forma Income Statement for Security System and VDT

(in billion)

	Year 1		Year 2		Year 3		Year 4		Year 5	
	SS	VDT	SS	VDT	SS	VDT	SS	VDT	SS	VDT
Sales	10.00	9.00	50.00	30.00	100.00	60.00	150.00	120.00	200.00	240.00
Cost of good sold	7.00	6.75	35.00	22.50	70.00	45.00	105.00	90.00	140.00	180.00
Other cost excl. dep.	1.50	1.35	7.50	4.50	15.00	9.00	22.50	18.00	30.00	36.00
Interest cost	0.10	0.09	0.50	0.3	1.00	0.6	1.50	1.2	2.00	2.4
Depreciation (dep.)	1.00	1.00	1.60	1.60	2.60	2.00	4.60	3.00	8.60	3.60
Earning before tax	0.40	0.19	5.40	1.10	11.40	3.40	16.40	7.80	19.40	18.00
Net income	0.35	- 0.19	3.67	0.75	7.75	2.31	11.15	5.30	13.19	12.24
ROS	0.04	0.02	0.07	0.02	0.08	0.04	0.07	0.04	0.07	0.05
ROI	0.03	0.02	0.10	0.03	0.11	0.05	0.11	0.07	0.09	0.08

pro-forma income statements for next five years. In addition, we calculated the ROI (net income/investment) and the ROS (net income/sales). When we calculated the tax, two tax rates were applied ; If $EBT \geq 1$, then tax rate = 0.32, else tax rate = 0.12. The resulting income statements are shown in <Table 10>.

4.2 Prioritizing the Criteria

We developed an AHP questionnaires for pairwise comparison. We performed the interview

using the questionnaires to obtain input values for pairwise comparison matrices. The subjects for this survey were fifteen executives and managers. We used the geometric mean technique to unify fifteen answers for the purpose of group decision making. The geometric mean is uniquely the most appropriate rule for combining judgments in AHP [1]. Resulting matrices and priorities of each element in our hierarchy structure, consistency indices, and consistency ratios are shown in <Tables 11> to <Table 18>.

<Table 11> Priorities of Roles for Goal

CI : 0.00 CR : 0.00

	FP	MI	OW	Priority
Financial Performance (FP)	1.00	0.96	0.62	0.28
Market Impact (MI)	1.04	1.00	0.77	0.30
Opportunity Window (OW)	1.60	1.30	1.00	0.42

<Table 12> Priorities of Criteria for Financial Performance

CI : 0.08 CR : 0.09

	MF	BS	SN	PR	Priority
Market Feature (MF)	1.00	0.82	0.49	0.63	0.18
Business Strength (BS)	1.21	1.00	2.57	0.66	0.28
Synergy (SN)	2.04	0.39	1.00	0.48	0.20
Profitability (PR)	1.58	1.51	2.09	1.00	0.34

<Table 13> Priorities of Criteria for Market Impact

CI : 0.09 CR : 0.10

	MF	BS	SN	PR	Priority
Market Feature (MF)	1.00	0.17	0.80	1.42	0.16
Business Strength (BS)	5.84	1.00	2.04	1.88	0.47
Synergy (SN)	1.24	0.49	1.00	0.67	0.17
Profitability (PR)	0.70	0.53	1.49	1.00	0.20

<Table 14> Priorities of Criteria for Opportunity Window

CI : 0.02 CR : 0.02

	MF	BS	SN	PR	Priority
Market Feature (MF)	1.00	0.31	1.00	0.68	0.16
Business Strength (BS)	3.19	1.00	1.58	2.04	0.42
Synergy (SN)	1.00	0.63	1.00	1.14	0.22
Profitability (PR)	1.47	0.49	0.88	1.00	0.21

〈Table 15〉 Priorities of Subcriteria for Market feature

CI : 0.01 CR : 0.02

	MS	GR	CP	TC	Priority
Market Size (MS)	1.00	0.44	0.58	0.31	0.13
Growth Rate (GR)	2.27	1.00	1.42	1.00	0.31
Competition (CP)	1.72	0.70	1.00	1.00	0.25
Technological Change (TC)	3.23	1.00	1.00	1.00	0.31

〈Table 16〉 Priorities of Subcriteria for Business Strength

CI : 0.02 CR : 0.02

	PU	RD	PD	MK	Priority
Product Uniqueness (PU)	1.00	1.99	3.60	2.36	0.45
R&D (RD)	0.50	1.00	1.72	0.58	0.19
Production (PD)	0.28	0.58	1.00	0.51	0.12
Marketing (MK)	0.42	1.72	1.94	1.00	0.24

〈Table 17〉 Priorities of Subcriteria for Synergy

CI : 0.03 CR : 0.04

	EB	FE	IM	OG	Priority
Existing Business (EB)	1.00	0.35	2.57	4.37	0.27
Future Extension (FE)	2.89	1.00	4.81	4.26	0.53
Image (IM)	0.39	0.21	1.00	1.17	0.10
Organization (OG)	0.23	0.23	0.85	1.00	0.09

〈Table 18〉 Priorities of Subcriteria for Profitability

CI : 0.07 CR : 0.08

	SA	MH	ROI	ROS	Priority
Sales Amount (SA)	1.00	1.99	0.37	0.46	0.17
Market Share (MH)	0.50	1.00	0.35	0.49	0.11
ROI	2.67	2.86	1.00	3.73	0.48
ROS	2.20	2.03	0.27	1.00	0.23

4.3 Evaluating the Alternatives

To prioritize the alternatives, we asked five middle-level managers to fill in the qualitative pairwise comparison questionnaires. The reason why we selected middle-level managers as subjects for evaluation of alternatives was that they had more practical knowledge in the characteristics of alternatives than top management. Again, the answers were unified by geometric

mean.

Among sixteen subcriteria, six subcriteria were manipulated directly from quantitative data without pairwise comparisons. Such subcriteria were market size, growth rate, sales amount, market share, ROI, and ROS. Therefore, only ten remaining qualitative subcriteria required the pairwise comparisons. The results of pairwise comparisons are shown <Table 19>.

〈Table 19〉 Priorities of Alternatives from Pairwise Comparisons

	CP	TC	PU	RD	PD	MK	EB	FE	IM	OG
Security System	0.25	0.14	0.77	0.86	0.29	0.12	0.20	0.68	0.78	0.75
VDT	0.75	0.86	0.23	0.14	0.71	0.88	0.80	0.32	0.22	0.25

〈Table 20〉 Priorities of Alternatives for Quantitative Criteria

	MS	GR	SA	MH	ROI	ROS
Security System	0.81	0.14	0.47	0.21	0.60	0.61
VDT	0.19	0.86	0.53	0.79	0.40	0.39

We calculated the priorities of alternatives against quantitative criteria as described earlier. The priorities against market size, growth rate, sales amounts and market share were calculated by averaging the values of five years. The priorities against ROI and ROS were obtained from weighted average of five-year values. The results are shown in <Table 20>. By synthesizing all local priorities, we obtained the global priorities of the alternatives. The final ranks of the alternatives were 0.51 and 0.49 for Security system and VDT respectively. There was no significant difference between two alternatives.

5. Conclusion

New business plan is very important but risky decision-making to companies. Although there are a number of studies and guidelines for the evaluation of new business, most of them were devoted to the identification of important screening criteria itself without details in how to apply these criteria. Of course, there is no unique evaluation framework that can be applied universally. Any reader may disagree with the framework and criteria used in this study. This is because any approach to semi/unstructured decision-making

problem always includes some degree of the subjective aspects.

The contribution of this study is that it has suggested one alternative way of new business evaluation in a systematic and consistent manner. Although a number of assumptions were made in our framework, the suggested approach to consider profitability has its own meaning in that it proposed the systematic procedures to deal with the profitability issues. There are several limitations in our framework. The first is that it requires a number of questionnaires to generate pairwise comparison matrices. The second limitation is that the performance of the model relies heavily on the accuracy of input values. Any faults in estimating the quantitative values could result in wrong screening of new business alternatives. If there is no reliable quantitative information of new business area/market available, it might be impossible for a company to follow our framework. In this case, the information of the company and industry where the new business area belongs could be used at the expense of reliability. The third limitation is that our framework employed a number of assumptions for simplicity. Our case study was initiated mainly for research purposes to verify the applicability

of our framework in real business situation. Therefore, more detailed financial analysis is required for more sound evaluation.

REFERENCES

- [1] Aczel, J. and T.L. Saaty, "Procedures for Synthesizing Ratio Judgments," *J. Mathematical Psychology*, 27(1983), 93-102.
- [2] Baker, N.R., "R&D Project Selection Models : An Assessment," *IEEE Trans. on Engineering Management*, EM-21, (1974), 165-171.
- [3] Baker, N.R. and J. Freeland, "Recent Advances in R&D Benefit Measurement and Project Selection Methods," *Management Science*, 21, (1975), 1164-1175.
- [4] Block, Z. and I.C., MacMillan, Corporate Venturing, Harvard Business School Press, 1993.
- [5] Boucher, T.O. and E.L., MacStravic, "Multiattribute Evaluation within a Present Value Framework and Its Relation to the Analytic Hierarchy Process," *Engineering Economist*, 37(1), (1991), 1-32.
- [6] Bussy, L.E., The Economic Analysis of Industrial Projects, Prentice Hall, 1978.
- [7] Canade, J.R. and W.G., Sullivan, Economic and Multiattribute Evaluation of Advanced manufacturing Systems, Prentice-Hall, 1989.
- [8] Choi, H., The Development of the Evaluation Model and Case Study for e-Business Company Using AHP, Master Thesis, KAIST Graduate School of Management, 2001.
- [9] Cooper, R.G., "Why New Industrial Products Fail," *Industrial Marketing Management*, 4, (1975), 315-326.
- [10] Cooper, R.G., "Project New Prod : Factors in New Product Success," *European J. Marketing*, 14(5/6), (1980), 277-292.
- [11] Cooper, R.G., "Defining the New Product Strategy," *IEEE Trans. on Engineering Management*, EM-34(3), (1987), 184-193.
- [12] Cooper, R.G. and U., Brentani, "Criteria for Screening New Industrial Products," *Industrial Marketing Management*, 13, (1984), 149-156.
- [13] Cooper, R.G. and E.J., Kleinschmidt, "Success Factors in Product Innovation," *Industrial Marketing Management*, 16(3), (1987), 169-184.
- [14] Corey, E.R., "Key Options in Market Selection and Product Planning," *Harvard Business Review*, (1975), September-October, 119-128.
- [15] Day, G.S., "Diagnosing the Product Portfolio," *J. Marketing*, (1977), April, 29-38.
- [16] Expert Choice, Inc., Expert Choice ver. 8 User Manual, Expert Choice, Inc., 1993.
- [17] Hirish, R.D. and M.P., Peters, Marketing Decisions for New and Mature Products 2/e, MacMillan College Publishing Co., 1991.
- [18] Horngren, C.T., G. Foster, and S., Datar, Cost Accounting 8/e, Prentice-Hall, 1994.
- [19] Kleinschmidt, E.J. and R.G., Cooper The Relative Importance of New Product Success Determinants-Perception Versus Reality, *R&D Management*, 25(3), (1995), 281-298.
- [20] Lee, H., W., Kwak, and L., Han, "Designing a Comprehensive Business Performance Evaluation System : An Analytical Hierarchical Model," *Engineering Economist* 40(4), (1995), 343-357.
- [21] McGrath, R.G. and I.C., MacMillan, "Discovery-Driven Planning," *Harvard Business Review*, (1995), July-August, 44-54.

- [22] Miller, G.A., "The Magical Number Seven Plus or Minus Two : Some Limits on Our Capacity for Processing Information," *The Psychological Review*, (1956), March, 81-97.
- [23] Mukherjee, T.K. and G.V., Henderson, "The Capital Budgeting Process : Theory and Practice," *INTERFACES*, 17(2), (1987), 78-90.
- [24] Park, C.Y. and S.H., Kim, New Business : Strategy and Practice, AO Pub, 1993.
- [25] Ram, S. and S., Ram, "Expert Systems : An Emerging Technology for Selecting New Product Winners," *J. Product Innovation Management*, (1989), 6, 89-98.
- [26] Roberts, E.B. and C.A., Berry, "Entering New Businesses : Selecting Strategies for Success," *Sloan Management Review*, (1985), Spring, 3-17.
- [27] Saaty, T.L., "A Scaling Method for Priorities in Hierarchical Structures," *J. Mathematical Psychology*, 15, (1977), 234-281.
- [28] Saaty, T.L., "Priority Setting in Complex Problems," *IEEE Trans. on Engineering Management*, EM-30(3), (1983), 140-155
- [29] Saaty, T.L., "How to Make a decision : The Analytic Hierarchy Process," *European J. Operational Research*, 48, (1990), 9-26.
- [30] Simon, H.A., "The Architecture of Complexity," *Proceedings of American Philosophical Society*, 106, (1962), 467-482.
- [31] Sprague, L.W. and E.D., Carlson, Building Effective Decision Support Systems, Prentice-Hall, 1982.
- [32] Timmons, J.A., New Venture Creation 4/e, IRWIN, 1994.
- [33] Urban, G.L. and J.R., Hauser, Design and Marketing of New Products, Prentice-Hall, 1980.
- [34] Wind, Y. and V., Mahajan, "Designing Product and Business Portfolios," *Harvard Business Review*, (1981), January-February, 155-165.
- [35] Wind, Y. and T.L., Saaty, "Marketing Applications of the Analytic Hierarchy Process," *Management Science*, 26(7), (1980), 641-658.