AN EVOLUTIONARY APPROACH TO VALUE CREATION BY MULTIPLE CRITERIA DECISION MAKING IN R&D PROJECTS

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ABSTRACT

The increase of uncertainty and rapidly changing business environment requires taking appropriate value-added actions and it is continuously necessary to produce new products and processes for survival. The authors present an evolutionary approach to value creation in the development projects by taking the above description of necessity of project execution with alignment through the series of multiple criteria decision making. A method of evolutionary approach to multiple criteria decision making based upon human-machine interaction is proposed. The analysis of value creation process reveals that the value-added activities in the basic research and commercialization stages are respectively value chain activities and the activities in the applied research phase are spiral type value creating activities which is differ to the original value chain concept.

INTRODUCTION

The necessity of maximizing value addition in business operation is widely accepted and the execution of strategic management for accomplishing this objective is required. The value chain concept originated by M.E.Porter[1] is still valid in general discussions of its applicability, though other types of value creation concepts such as value network or value shop[2] have been proposed. The increase of uncertainty and rapidly changing business environment requires taking appropriate value-added actions and it is continuously necessary to produce new products and processes for survival. In order to make efficient operations, it is a common way for development activities to implement by organizing projects. As well known, more than three decades have been elapsed since the notion of project management began to be recognized and now have been spread out into other business areas such as IT related industries and production industries of various products and services with new products development work. The development projects are characterized by the higher degrees of uncertainty and in reality the practical ways of decision making under uncertainty are not well investigated and practiced. It is widely observed for decision makers to make decision on their own past experiences and intuitive judgment. As the results, the business strategy and the intention of executives to each development project are not reflected to the final decisions on investments. It is important to ensure alignment and consistent execution of strategic priorities through the diagnosis of situations in every occasion. In addition, subject to the uncertain business environments with rapid change, it is necessary to take this situation into consideration in the final decision.

The quality of upstream activities in development projects affects every downstream activities, so that it is necessary to make decision on maximizing the value addition through the project lifecycle. The value involves both tangible and intangible measures so that decision should be made on multiple criteria.

The authors present an evolutionary approach to value creation in the development projects by taking

the above description of necessity of project execution with alignment through the series of multiple criteria decision making to cope with uncertain and rapid changing business situations. This concept has been developed by the experiences of conducting the R&D Project Portfolio Management which are described in detail in [4].

VALUE ADDED ACTIVITIES IN R&D PROJECTS

The lifecycle of development projects consists of exploratory or basic research phase, applied research phase and commercialization phase. The exploratory and basic researches are usually carried out to have more usable information from which the status toward the final products development becomes clearer and the portfolio management in this phase is premature for the decision making, though the screening of research results based on the visual portfolio matrix is conducted with careful consideration of risks on deleting prospective seeds of future products development. It is required to make value addition throughout the lifecycle. The activities in these phases are mutually dependent to contribute the value creation as a whole. The degrees of uncertainty are decreased phase by phase in the lifecycle. According to Courtney et al[3], the degrees of uncertainty are classified into four levels: Level 1-Creal-Enough Future, Level 2-Alternative Futures, Level 3-A Range of Futures, and Level 4-True Ambiguity. It may be possible to relate the above-mentioned three stages to the Four levels. The Commercialization phase corresponds to Level 1, Applied research phase and Basic research phase correspond respectively to Level 3 and 2 and most research and development work before commercialization are classified into the situation of Level 2 and 3. Due to specific characteristics of research and development work, it is not generally expected to foresee the results and therefore it is necessary to take action based upon the current results obtained in the immediate past. The series of these actions may be called evolutionary in the meaning of seeking incrementally the better results on the exploratory basis in that the decisions are sequentially made on the current results until the final results being obtained.

The analysis of value creation process reveals that the value-added activities in the commercialization stages are value chain activities and the activities in the basic research phases are spiral type value creating activities which is different from the original value chain concept. The schematic diagram of a series of value creation in the lifecycle is depicted in Fig.1.

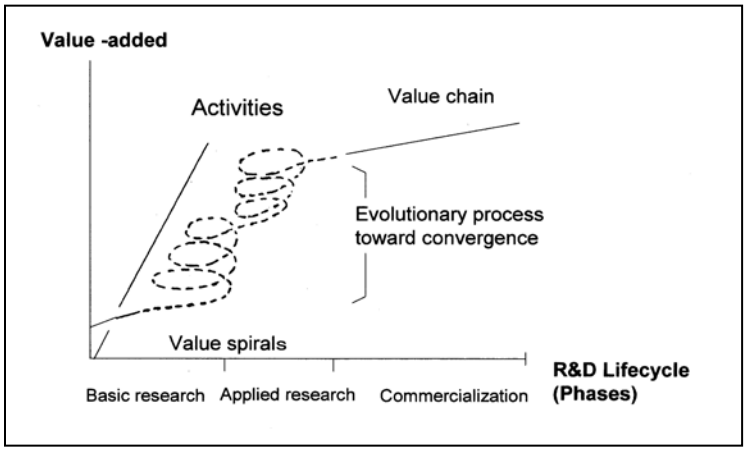

Fig.1 Value Creation of R&D Project Lifecycle

The value creating activities in the basic and applied research constitute spiral type evolutionary value

addition, followed by the value chain activities in the commercialization phase. The value creating activities in the basic research phase aims to find limited number of prospective candidates. As schematically shown in Fig.1, the size of dotted circles decreases evolutionarily in the basic research phase and it means that the number of candidates is selectively decreased. The value creating activities in the applied research phase aims to increase evolutionarily the amount of information necessary enough to get into the commercialization phase. The situational transition is depicted by increasing the size of dotted circles in Fig.1 The alignment with revised trials of research items is based on the estimation of the results among the decision makers including the executives in charge of basic research and applied research phases. A series of the alignment corresponds to the spiral type value adding activities.

According to Webster's Third New International Dictionary, the "Evolution" means "a series of related change in a certain direction and a process of continuous change from a lower or worse conditions to a higher or better states" .An evolutionary approach follows from the generation of a good basic scheme on decision making and make small changes a few at a time to improve the scheme incrementally. The evolutionary decision making in this stage generates the additional value sequentially by generating alternate and selecting decision schemes until the results of a series of actions being satisfied. The evolutionary approach is described in the later section.

EVOLUTIONARY PORTFOLIO MANAGEMENT IN DEVELOPMENT PROJECTS

As pointed out elsewhere [4], there are many research work and guidance on the methods of portfolio management for more than thirty years, the applications are not always successful from the viewpoint of congruence with corporate or business strategies and further efforts on executing effective portfolio management are needed. Among the issues remained unresolved suggested by Cooper and his colleagues[5] based upon the results of their investigations as cited in Table 1, it is considered to be necessary to make analysis of the intangible part or implicit knowledge on implementing the portfolio management.

Table 1 Findings, Conclusions, Challenges, and Issues in Designing an Effective Portfolio Management Process[5]

Specific Conclusions:

1. There are three main goals in portfolio management.
2. Goal 1: maximizing the value of the portfolio against objectives.
3. Goal 2: seeking the right balance or mix of projects.
4. Goal 3: the link to your business strategy.
5. Gate decisions must be integrated with portfolio decisions.
6. Portfolio management must consider all types of projects that compete for resources.
7. There is information overload in portfolio management.

Challenges and Issues:

1. Are there too many projects, not enough resources?
2. Once made, how firm are resource commitments?
3. Are there too many projects on hold?
4. Why have a prioritized or rank-ordered list at all?
5. Is there imaginary precision: is the quality of information of input data lacking?
6. How should needed information on projects be gathered?
7. Are project selection methods discriminating between projects?
8. Are there too many small projects, too few major hits?
9. Are the Portfolio Reviews monitoring reviews or project selection meetings?
10. When should the Portfolio Management Process kick in?
11. Should portfolio models provide information display or be decision models?
12. What problems do financial analysis methods pose?

Business strategy is first translated into measurable results in the form of comprehensive views of investments, such as portfolio matrix, resource allocation, budget and other necessary information for the complete lifecycle of each investment. It is necessary to achieve the right balance and mix of investments to reach business goals, prioritizing and funding the valuable investments to generate maximum benefits, reconciling portfolio and organization budgets to align strategic and operational objectives, increasing visibility on head-count requirements and optimizing resource and skills usage to keep cost down and ensuring that actual execution, achievement of benefits and overall performance are in line with objectives. It also allows investment risk to be identified, quantified and tracked.

The evolutionary approach to multiple criteria decision making here uses project portfolio matrix in that the positioning candidate projects with resource allocation are shown in the framework of strategy, business and technology. The evolutionarily changing positions of candidate development projects can be depicted in the framework. Portfolio management by the evolutionary approach may be called "Evolutionary Portfolio Management". A series of incremental multiple criteria decision making corresponds to project alignment as described in detail elsewhere.[4].

A METHOD OF EVOLUTIONARY APPROACH TO MULTIPLE CRITERIA DECISION MAKING

The method is characterized by the roles of human decision makers and support function of machines. The interaction between the two should be clearly defined. Refer to Steps1 to 4 that are explained in the following. The basis of method is pairwise comparison to obtain the Parato Optimum Solutions (POS).

At First, the problem of multiple criteria decision making is defined by:

$$\underset{(v)}{\text{Maximize}} \; [\, V_1(v), V_2(v), \ldots V_n(v) \,] \qquad (1)$$

subject to $v \; E \; Rp$

where Rp is the regional space of Portfolio Matrix Framework.

Due to the incommensurable multiple criteria, the method for determining the Parato Optimum Solutions (POS) based on the pairwise comparison is used to solve the problem. Regarding the methods for solution, one of the authors has reported in 1980s[6, 7] and experienced the usefulness of its applications in the area of chemical process engineering. The direct search method such as the simplex method[8] has been well suited to the pairwise comparison among the alternatives. The search algorism based on the simplex method provides iteratively the sets of alternatives involving the currently generated a set of alternatives to decision makers asking the pairwise comparison among the sets of alternatives, where the number of alternatives in a set is n+1 or more according to the simplex method. The generation of next alternative reflects the preference of decision makers and the new simplex is constituted. This iteration of comparisons will be terminated when the preset convergent condition based on the contraction of simplex is satisfied. A course of repetition corresponds to evolutionary decision making since the algorism shows the decision makers better alternatives than before each time until the termination of pairwise comparison. Due to the space limit, the summary of algorithm based upon the interactive procedure between decision makers (DM) and machines or computers(MC) is described in the following:

Step1(MC). Set up a initial POS set
Step2(DM). Sort members of the POS set over a preference by repeating pairwise comparisons.

Step3(MC). Estimate a POS as close as possible to the goal vector of the decision maker.
Step4(DM). If the estimated POS is satisfactory, terminate the interaction process. Otherwise, merge it with the ordered POS set over a preference by repeating pairwise comparisons. Go to Step3.

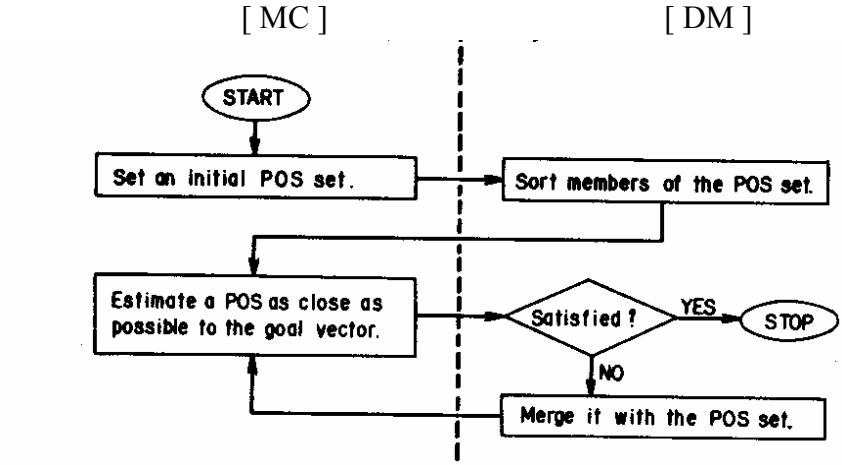

Fig.2 DM-MC Interactive Procedure

To realize the procedure, it is necessary to solve the following problems:
(1) obtain a certain POS
(2) estimate a more preferable POS than any member of the POS subset
(3) sort the member of the subset by minimum pairwise comparisons
(4) merge a new solution with the ordered subset by minimum pairwise comparisons

These problems can be solved by applying the following techniques: scalarization, the simplex, the minimum comparison sorting, and minimum comparison, respectively. In order to reflect the DM's preference, the problem is reformulated to minimize the summation of weighted difference between the points generated and the utopia point.

$$\text{Minimize} \sum_{(vi)} W_i [V_i(vi) - Up_i] \qquad (2)$$

$W_i > 0, \quad \sum W_i = 1$
where Up_i is a utopia point.
subject to $v \in Rp$
where Rp is the regional space of Portfolio Matrix Framework.

The problem (2) gives one to one correspondence between the POS of problem (1) and weight set, so that if some set of weight is specified, a unique POS is correspondingly obtained by solving the problem (2).The weights are generated by the use of the simplex method. The decision making problem under consideration is to find the POS for selecting preferable R&D projects.

A SCHEMATIC ILLUSTRATION OF EVOLUTIONARY VALUE ADDITION

For the purpose of describing basic concept of human-machine interactive method of decision making guided by the simplex method, the two dimensional problem of decision making is considered. The problem is to find the POS in the space of business and technology characteristics by minimizing the

weighted sum of the distance from a utopia point that is the objective function. In order to make the main procedure understood, the mart of the procedure, that is, the simplex method is described in the following. The minimization problem is solved for each vertex of the simplex in the space of the weights, where the objective function is estimated at each vertex. The DM is required to sort the POSs by the pairwise comparisons. The simplex is continuously revised by replacing the most un-preferred vertex by a new estimated one. A new simplex is formed by replacing the most un-preferred vertex by its reflection in the centroid of the remaining points of the vertex. This procedure is continued until a stopping criterion is satisfied. [9,10] For one particular project, the results of continuous estimations on the preference of business and technology characteristics is shown in Fig. 3,where the final results in the business and technology characteristics space are shown instead of corresponding weight space. In real situations, there are several R&D projects running simultaneously and the evolutionary value additions from all projects are conducted. The business and technology characteristics have to be expressed by numerical index (for example, Vl, L, M, H, VH), respectively, for ranking the decision makers' preference. Each step of decision making process corresponds to a vertex in Fig.3. The detailed description of those characteristics with numerical index in the case of pharmaceutical products R&D projects is given elsewhere [4].The brief description of evaluation items referred from Table 1 in [4] on technological business, and strategy adjustment is listed as follows :

Technological evaluation

Technological dimension, Presentation of patent, and Period to market

Business evaluation

NTV

Strategy adjustment

Location seen from the entire company

Valuation standard fro each item is classified into VL, L, M, H, VH, where V, L, and H stand for very, low, and high, respectively.

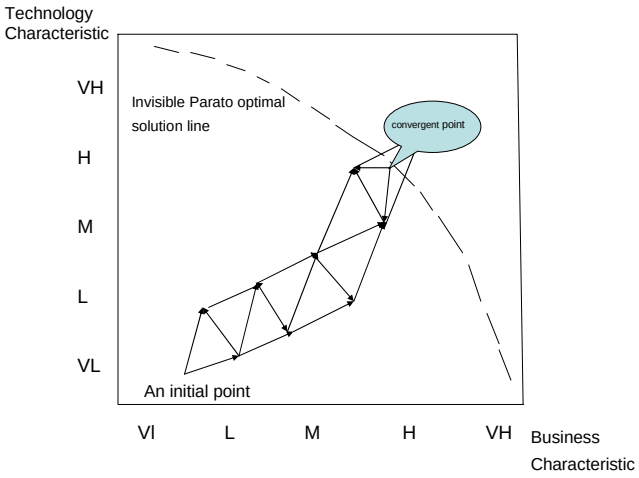

Fig.3 An Illustrative Example of Two Dimensional Value Addition

DISCUSSIONS AND CONCLUDING REMARKS

An evolutionary approach to multiple criteria decision making in the R&D projects is presented. In order to be congruent with the business strategy, the value addition is selected as the criteria that involve both tangible and intangible values. In addition to the value chain concept, the value network and value shop, another concept of value creation called Value Spiral" is proposed along the line of evolutionary characteristic.

The approach to decision making is based upon the search method with pairwise comparison among the sets of portfolio alternatives. The method is applied to one project at a time and as the results, the resource allocation problem among the R&D projects involved in the business unit should be resolved to finalize the problem solving.

The development of decision support system based on the decision procedure along the line of the presentation is under way and using the system, it is expected to accumulate the related knowledge of judgment by analyzing the course of pairwise comparisons and it may be used to align the portfolios corresponding to changing internal capabilities and business environment.

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