Evaluating New Service Development Performance Based on Multigranular Linguistic Assessment

Wen-Pai Wang, Mei-Ching Tang

***Abstract*—**The service sector continues to grow and the percentage of GDP accounted for by service industries keeps increasing. The growth and importance of service to an economy is not just a phenomenon of advanced economies, service is now a majority of the world gross domestic products. However, the performance evaluation process of new service development problems generally involves uncertain and imprecise data. This paper presents a 2-tuple fuzzy linguistic computing approach to dealing with heterogeneous information and information loss problems while the processes of subjective evaluation integration. The proposed method based on group decision-making scenario to assist business managers in measuring performance of new service development manipulates the heterogeneity integration processes and avoids the information loss effectively.

***Keywords*—**Heterogeneity, Multigranular linguistic computing, New service development, Performance evaluation.

I. Introduction

WITH the emergence of heightened competition, increased heterogeneity of customer demands, and shortened product life cycles, service firms across many industries are increasingly faced with the challenge of determining how best to manage their development of new service offerings. Additionally, the criticality of new services in the portfolio of offerings of traditional manufacturers has noticeably increased. In response, service management scholars have recognized the importance of, and need for, new service development (NSD) research that addresses how firms' service offerings and delivery systems remain attuned to the constantly changing marketplace demands and competitive environment [1].

Services constitute a major part of total economic activity and employment in most developed countries. A large share of innovative efforts in business is related to the development of new services. Accordingly, many service firms still struggle with their innovative efforts [2]–[4]. Moreover, many service entrepreneurs refrain from explicitly organizing NSD. Not only can the customer potentially articulate the preferences, needs and wants that NSD process attempts to respond to through the service's core benefits, but the customer can certainly communicate preferences on how the service is delivered.

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Rather than developing more formal structures to elicit ideas for new services, develop and select among them concurrently, service entrepreneurs regard it as an *ad hoc* process [5]. However, the selection of a designated service system for the enterprise is a major strategic initiative, which involves a large capital investment. Each system has specific advantages and disadvantages and each is most suited to a particular set of operational conditions [6].

Innovation is the commercial application of a new idea, or is ″changing the value and satisfaction obtained from resources by the consumer″. As regards NSD is a complex, elusive, and uncertainty concept that is difficult to determine. To perceive and to measure the performance of NSD effectively are real challenging tasks for company managers. It involves a search of the environment of opportunities, the generation of project options, and the evaluation by different experts of multiple attributes, both qualitative and quantitative. The decision-making domain of NSD is therefore highly complex and uncertain due to a demanding environment characterized by increased globalization and segmentation of service markets, changing customer needs, and differentiating the recognition of the customers' perception of quality [7]–[9]. The influence of customers and frontline employees on performance outcomes is indirect and mediated by new service development success factors. In order to evaluate the performance of NSD more appropriately, it should consider not only quantitative index but also qualitative dimensions or factors which are evaluated by multiple experts or customers. Consequently, the evaluation of NSD performance should be regarded as a group multiple criteria decision-making problem as well.

Decision makers devote to judge by their experiential cognition and subjective perception in the decision-making process of measuring NSD performance. However, there exist considerable extent of uncertainty, fuzziness and heterogeneity.

This is not a seldom situation. In addition, it is prone to information loss happen during the integration processes, and gives rise to the evaluation result of performance level may not be consistent with the expectation of evaluators. Consequently, developing an easy way to calculate the performance ratings while the processes of evaluation integration and appropriately to manipulate the operation of qualitative factors and evaluator judgment in the evaluation process of NSD could brook no delay. The purpose of this paper is to propose a suitable model based on 2-tuple fuzzy linguistic information to evaluate the NSD performance. The proposed approach not only inherits the existing characters of fuzzy linguistic assessment but also overcomes the problems of information loss of other fuzzy linguistic approaches [10]–[11].

II. Literature Review

It is widely recognized that all services are not the same. For example, they vary considerable in terms of the nature of the service act and on the degree of interaction between the service organization and the customers. The marketing literature suggests that being close to the customer can benefit a firm's innovation and competitive advantage [12]. Firms that are closer to their customers are in an excellent position to receive feedback and learn more from these customers, enabling them to react more quickly and more efficiently to customers' changing wants and needs. These firms may even engage in close cooperation or co-creation for new product or service development with key customers. The objective of this paper is to provide conceptual understanding in the new service development process. Service firms represent an increasingly important business sector. Services are unique in that usually they are intangible actions or performances. They often involve customer participation and inputs are variable, thus service experiences are heterogeneous and more difficult to evaluate; and they are typically delivered in real time and thus cannot be stockpiled. This inseparability element means that customers play a more active role in the service development process, leading to the supposition that service firms are, by nature, more market-oriented than product firms. The highly active role of the customer in the service development process has implications for innovation [13]. Service innovations are therefore ubiquitous and their role in creating economic growth and wellbeing is increasingly acknowledged. Customers, in a number of industries, are constantly bombarded with run-of-the-mill product and service offerings [14]. As a result, customers both desire and more often demand innovative alternatives. In response, many service- oriented firms are striving to integrate novel features into their product-service offerings [15]. Service is intangible. When the customer interacts with the service provider, the personnel, process, and physical features are the evidence of service. For decades, the importance of services to the global economy has grown steadily while the importance of goods has declined [16]. Companies are constantly seeking to provide better services, regardless of whether they are in a "pure" service business or in a manufacturing industry that must increasingly rely on its service operations for continued profitability. Most improvements to service activities are incremental, and are useful and indeed necessary. Nevertheless, they are limited in the kind of returns they can produce. Only rarely does a company develop a service that creates an entirely new market or so reshapes a market that the company enjoys unforeseen profits for a considerable length of time. As with products, the innovativeness of a new service idea may be defined by the degree of newness it has relative to the firm and to the outside world, and new service ideas may be dichotomized into incremental and discontinuous innovations. Incremental innovations are based on improvements to existing technology, whereas discontinuous innovations incorporate substantially different technology into services that satisfy customer needs better than existing services. The diversity of service activities means that service innovations and innovation processes take various forms [17].

Berry et al. [16] stated that service innovations that create new markets differ from each other along two primary dimensions: the type of benefit offered and the degree of service "separability". On the first dimension, businesses can innovate by offering an important new core benefit or a new delivery benefit that revolutionizes customers' access to the core benefit. The second dimension concerns whether the service must be produced and consumed simultaneously. Health care has traditionally been an "inseparable" service. Executives who attempt to create a new market through service innovation must concentrate on the tasks that determine success or failure.

New service/goods product development is at the heart of most business strategies and marketing plans among others. It is hard to conceive a successful corporation where a new product, service, or process is absent from its business approach. New services come up with opportunities for organizations but the risk associated with these services always exists. The success rate for new service projects is on average 58%, in other words four out of ten new services fail in the market place. It is therefore obvious that management is highly interested in learning about those factors which influence the success of new services. However, NSD remains among the least studied and understood topics in the service management [1]. Typical service firms incur a 25-35% penalty cost as a result of poor quality [13]. One important lesson learned from the quality movement is that the prevention of service failure, resulting in large part from design excellence, is the most effective and efficient route to achieving higher levels of quality and customer satisfaction. Poor planning or performance evaluation not only impacts initial service quality but also contributes to cycle of service failure. Accordingly, performance measurement plays an important role in ensuring the success of any project, and a reliable performance measurement system is essential for sound management decisions and company growth [18]–[20].

The success of a newly-designed service is heavily dependent upon a customer's perception of the service as well as the service delivery system. This includes the operations personnel, who interact with the customers during the service, technology, service facilities, etc. Comprehending what customers really expect, what factors influence customer expectations and how service providers fulfill the variable needs are becoming important issues. Accordingly, there have been previous studies focusing on the issue and the factors of customer expectations that influenced customer expectations. However, customer expectations are multifaceted and capricious, and service providers should obtain a comprehensible approach about how to practice proper services in terms of diverse customer expectations. In other words, there is a strong need of explicit methods for providers to utilize the existing findings for establishing strategies of service operation that can facilitate their business in accelerating the degree of customer satisfaction. Melton [21] summarized five success factors to better analyze the impact of project activities and characteristics on the success and failure of NSD initiatives. The five success factors are service marketability, service deliverability, interfunctional teamwork, launch preparation, and launch effectiveness, respectively.

It is however difficult and laborious to measure NSD performance using traditional crisp value directly as the process of NSD performance measurement is possessed of many intangible or qualitative factors and items. Linguistic variable representation is therefore favorable for evaluators to express and evaluate the ratings of NSD project under such situation [8]. The fundamentals of 2-tuple fuzzy linguistic approach are to apply linguistic variables to stand for the difference of degree and to carry out processes of computing with words easier and without information loss during the integration procedure [10]–[11]. That is to say, decision participators or experts can use linguistic variables to estimate measure items and obtain the final evaluation result with proper linguistic variable. It is an operative method to reduce the decision time and mistakes of information translation and avoid information loss through computing with words.

III. The Proposed Method

Fuzzy set theory is first introduced by Zadeh in 1965 [22]. Fuzzy set theory is a very feasible method to handle the imprecise and uncertain information in a real world [23]. Especially, it is more suitable for decision-maker to express his subjective judgment and qualitative assessment in the evaluation processes of decision making [24]. It not only represents vague knowledge but also allows mathematical operators and programming to apply to the fuzzy domain.

A fuzzy set Ã in a universe of discourse X is characterized by a membership function $\mu_{\tilde{A}}(x)$, which associates with each element x in X a real number in the interval [0,1]. The function value $\mu_{\tilde{A}}(x)$ is termed the grade of membership of x in Ã. A fuzzy number is a fuzzy subset in the universe of discourse X that is both convex and normal [24]. (See Fig. 1)

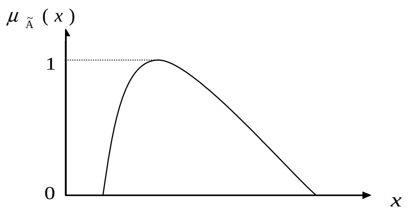

Fig. 1 Fuzzy number Ã

A linguistic variable is a variable whose values are expressed in linguistic terms. In other words, variable whose values are not numbers but words or sentences in a nature or artificial language [22]. For example, “weight” is a linguistic variable whose values are very low, low, medium, high, very high, etc. These linguistic values can also be represented by triangular fuzzy numbers. It is suitable to represent the degree of subjective judgment in qualitative aspect than crisp value.

Decision makers can apply 2-tuple linguistic variables to express their opinions and obtain the final evaluation result with appropriate linguistic variable. It is an effective method to reduce the mistakes of information translation and avoid information loss through computing with words.

Therefore, the experts’ opinions are expressed by 2-tuple linguistic variables in this paper.

Let $S=\{s_0, s_1, s_2,..., s_n\}$ be a finite and totally ordered linguistic term set. A 2-tuple linguistic variable can be expressed as (s_i, α_i) where s_i denotes the central value of the i^{th} linguistic term, and α_i indicates the distance to the central value of the i^{th} linguistic term. For example, a set of five terms S could be given as follows:

$$S=\{s_0{:}VL,\ s_1{:}L,\ s_2{:}A,\ s_3{:}H,\ s_4{:}VH\}$$

It means that a linguistic term set S contains five linguistic terms, ″Very Low″, ″Low″, ″Average″, ″High″, and ″Very High″, which are denotes s_0, s_1, s_2, s_3, and s_4, respectively. (See Fig. 2)

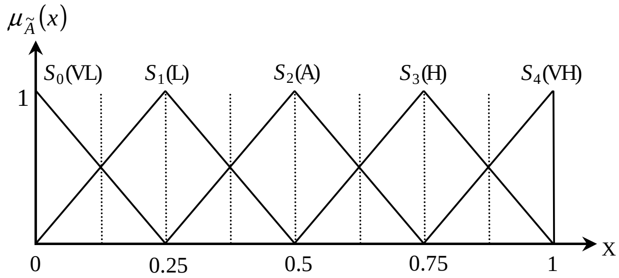

Fig. 2 Linguistic term set of five labels with its semantics

The symbolic translation function Δ is presented to translate β into a 2-tuple linguistic variable [10]. Then, the symbolic translation process is applied to translate β ($\beta\in$ [0, 1]) into a 2-tuple linguistic variable. The generalized translation function (Δ) can be represented as [8]:

$$\Delta : [0, 1] \rightarrow S \times [-\frac{1}{2g}, \frac{1}{2g})$$

$$\Delta(\beta) = (s_i, \alpha_i) \text{ with } \begin{cases} s_i, & i = round(\beta \bullet g) \\ \alpha_i = \beta - \frac{i}{g}, & \alpha_i \in [-\frac{1}{2g}, \frac{1}{2g}) \end{cases} \quad (1)$$

On the contrary, the 2-tuple can be converted into an equivalent numeric value β ($\beta\in$ [0, 1]) by the following formula.

$$\Delta^{-1}(s_i, \alpha) = \frac{i}{g} + \alpha = \beta \quad (2)$$

Δ and Δ^{-1} transform numerical values into a 2-tuples and vice versa without loss of information. According to an ordinary lexicographic order we may complete the comparison of linguistic information represented by 2-tuples. Let (s_i, α_i) and (s_j, α_j) be two 2-tuples, with each one representing a counting of information as follows:

1. If $i > j$ then (s_i, α_i) is better than (s_j, α_j) ;
2. If $i = j$ and $\alpha_i > \alpha_j$ then (s_i, α_i) is better than (s_j, α_j) ;
3. If $i = j$ and $\alpha_i < \alpha_j$ then (s_i, α_i) is worse than (s_j, α_j) ;
4. If $i = j$ and $\alpha_i = \alpha_j$ then (s_i, α_i) is equal to (s_j, α_j), i.e. the same information.

Suppose $L_1=(s_1, \alpha_1)$ and $L_2=(s_2, \alpha_2)$ are two 2-tuples. The main algebraic operations are shown as follows:

$$L_1 \oplus L_2 = (s_1, \alpha_1) \oplus (s_2, \alpha_2) = (s_1 + s_2, \alpha_1 + \alpha_2) \quad (3)$$

$$L_1 \otimes L_2 = (s_1, \alpha_1) \otimes (s_2, \alpha_2) = (s_1 s_2, \alpha_1 \alpha_2) \quad (4)$$

Where ⊕ and ⊗ stand for the addition and multiplication operations of parameters, respectively. Symbolic translation functions, Δ and Δ^{-1}, are applied in the process of information aggregation to guarantee the aggregation of 2-tuple linguistic variables can be a 2-tuple and without any information loss. Let $S=\{(s_1, \alpha_1),\ldots,(s_n, \alpha_n)\}$ be a 2-tuple linguistic variable set and $W=\{w_1, \ldots, w_n\}$ be the weight set of linguistic terms, their arithmetic mean $\bar{S}$ is calculated as

$$\bar{S} = \Delta[\frac{1}{n}\sum_{i=1}^{n}\Delta^{-1}(s_i,\alpha_i)] = \Delta(\frac{1}{n}\sum_{i=1}^{n}\beta_i) = (s_m,\alpha_m) \quad (5)$$

The 2-tuple linguistic weighted average $\bar{S}^w$ is computed as

$$\bar{S}^w = \Delta\left(\frac{\sum_{i=1}^{n}\Delta^{-1}(s_i,\alpha_i)\cdot w_i}{\sum_{i=1}^{n}w_i}\right) = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i\cdot w_i}{\sum_{i=1}^{n}w_i}\right) = (s^w,\alpha^w) \quad (6)$$

Furthermore, let $W=\{(w_1, \alpha_{w1}), \ldots, (w_n, \alpha_{wn}\}$ be the linguistic weight set of linguistic terms. Such linguistic weighted average operator is extended from weighted average operator and can be computed as

$$\bar{S}^w = \Delta\left(\frac{\sum_{i=1}^{n}\Delta^{-1}\beta_i\cdot\beta_{wi}}{\sum_{i=1}^{n}\beta_{wi}}\right) = (s^w,\alpha^w) \quad (7)$$

with $\beta_i = \Delta^{-1}(s_i, \alpha_i)$ and $\beta_i^w = \Delta^{-1}(s_i, \alpha_i)$

Moreover, let $W = \{(w_1,\alpha_{w1}), (w_2,\alpha_{w2})\ldots,(w_n, \alpha_{wn})\}$ be the linguistic weight set of each 2-tuple linguistic variable. The linguistic weighted average $\bar{S}^{LW}$ can be computed as

$$\bar{S}^{LW} = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i\times\beta_{w_i}}{\sum_{i=1}^{n}\beta_{w_i}}\right) = (s^{LW},\alpha^{LW}) \quad (8)$$

with $\beta_i = \Delta^{-1}(s_i,\alpha_i)$ and $\beta_{w_i} = \Delta^{-1}(w_i,\alpha_{w_i})$

Transforming a crisp number β ($\beta \in [0, 1]$) into i^{th} linguistic term (s_i, α_i) $(s_i^{n(t)},\alpha_i^{n(t)})$ of type t as

$$\Delta_t(\beta) = (s_i^{n(t)},\alpha_i^{n(t)}) \quad (9)$$

where $i = round(\beta\times g_t)$, $\alpha_i^{n(t)} = \beta - \frac{i}{g_t}$, $g_t = n(t)-1$ and $n(t)$ is the number of linguistic variable of type t.

Transforming i^{th} linguistic term of type t into a crisp number β ($\beta \in [0, 1]$) as

$$\Delta_t^{-1}(s_i^{n(t)},\alpha_i^{n(t)}) = \frac{i}{g_t} + \alpha_i^{n(t)} = \beta \quad (10)$$

where $g_t = n(t)-1$ and $\alpha_i^{n(t)} \in [-\frac{1}{2g_t},\frac{1}{2g_t})$.

Therefore, the transformation from i^{th} linguistic term $(s_i^{n(t)},\alpha_i^{n(t)})$ of type t to k^{th} linguistic term $(s_k^{n(t+1)},\alpha_k^{n(t+1)})$ of type t+1 at interval [0, 1] can be expressed as

$$\Delta_{t+1}(\Delta_t^{-1}(s_i^{n(t)},\alpha_i^{n(t)})) = (s_k^{n(t+1)},\alpha_k^{n(t+1)}) \quad (11)$$

where $g_{t+1} = n(t+1)-1$ and $\alpha_k^{n(t+1)} \in [-\frac{1}{2g_{t+1}},\frac{1}{2g_{t+1}})$.

IV. Algorithm of The Proposed Approach

In general, decision makers will use the different types of 2-tuple linguistic variables based on their knowledge or experiences to express their opinions. Each 2-tuple linguistic variable can be represented as a triangle fuzzy number. In order to aggregate the evaluation ratings of all decision- makers, a transformation function is needed to transfer these 2-tuple linguistic variables from different linguistic sets to a standard linguistic set at unique domain. According to the method of Herrera and Martinez [10], the domain of the linguistic variables will increase as the number of linguistic variable is increased. To overcome this drawback, a new translation function is applied to transfer a crisp number or 2-tuple linguistic variable to a standard linguistic term at the unique domain [8]. Suppose that the interval [0, 1] is the unique domain. The linguistic variable sets with different semantics (or types) will be defined by partitioning the interval [0, 1] (see Table I).

TABLE I
SELECTABLE CATEGORY OF LINGUISTIC TERMS FOR EACH EVALUATOR

Type	# OF LINGUISTIC	Linguistic variable
A	3	Poor (s_0^3), Average (s_1^3), Good (s_2^3)
B	5	Very poor (s_0^5), Very Poor (s_1^5), Poor (s_2^5), Average (s_3^5), Good (s_4^5)
C	7	Very poor (s_0^7), Poor (s_1^7), Fair (s_2^7), Average (s_3^7), Good(s_4^7), Very Good (s_5^7), Extremely Good (s_6^7)

A 2-tuple-based evaluation model in accordance with concepts of fuzzy linguistic computing approach is proposed in this paper to measure the performance level of the NSD project. The algorithm procedure for the proposed evaluation approach is organized sequentially into following six steps.

Step 1: Form an experts committee who are concerned and familiar with customer features and needs, market, characteristics competitive environment and potential impact of technical services. Assume that there are n criteria C_i(i =1, 2, …, n) and each criterion contains several sub-criteria in an evaluation framework of the NSD project performance. Identify and divide the evaluation criteria into positive criteria (the higher the rating, the greater the preference) and negative criteria (the lower the rating, the greater the preference).

International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:6, No:7, 2012

Step 2: Selectable categories of linguistic terms in Table I are prepared for evaluators when they apply the linguistic importance variables to represent the weight of each criterion and employ the linguistic rating variables to evaluate the performance of sub-criteria with respect to each criterion.

Step 3: Aggregate the fuzzy linguistic assessments of the N evaluators for each criterion by Eq. (5).

$$\bar{S}_{ij} = \Delta\left(\frac{1}{N}\sum_{n=1}^{N}\Delta^{-1}(s_{ijn},\alpha_{ijn})\right) = \Delta\left(\frac{1}{N}\sum_{N=1}^{N}\beta_{ijn}\right) = (s_{ij},\alpha_{ij})$$

$$\overline{W}_{ij} = \Delta\left(\frac{1}{N}\sum_{n=1}^{N}\Delta^{-1}(s^{w}_{ijn},\alpha^{w}_{ijn})\right) = \Delta\left(\frac{1}{N}\sum_{n=1}^{N}\beta^{w}_{ijn}\right) = (s^{w}_{ij},\alpha^{w}_{ij})$$

$$\overline{W}_{i} = \Delta\left(\frac{1}{N}\sum_{n=1}^{N}\Delta^{-1}(s^{w}_{in},\alpha^{w}_{in})\right) = \Delta\left(\frac{1}{N}\sum_{n=1}^{N}\beta^{w}_{in}\right) = (s^{w}_{i},\alpha^{w}_{i})$$

where, s_{ijn} is the fuzzy rating of sub-criteria j with respect to C_i of the n^{th} evaluator, s^{w}_{ijn} is the fuzzy importance of sub-criteria j with respect to C_i of the n^{th} evaluator;

Step 4: Apply Eq. (7) to obtain the fuzzy aggregated rating of $C_i(\bar{S}_i)$;

$$\bar{S}^{w}_{i} = \Delta\left(\frac{\sum_{j=1}^{l_i}\Delta^{-1}\beta_{ij}\cdot\beta^{w}_{ij}}{\sum_{j=1}^{l_i}\beta^{w}_{ij}}\right) = (s^{w}_{i},\alpha^{w}_{i}) \quad \text{with } \beta_{ij}$$

$$= \Delta^{-1}(r_{ij}, \alpha_{ij}) \quad \text{and } \beta^{w}_{ij} = \Delta^{-1}(w_{ij}, \alpha^{w}_{ij})$$

Step 5: Compute the overall performance level (OPL) of the NSD project, the linguistic term s_T, can be applied to represent the control and management performance level of NSD projects as well as being the improve- ment index directly.

$$OPL = \Delta\left(\frac{\sum_{i=1}^{n}\beta_i\cdot\beta_{w_i}}{\sum_{i=1}^{n}\beta_{w_i}}\right) = (s_T,\alpha_T) \quad \text{with } \beta_i$$

$$= \Delta^{-1}(r_i, \alpha_i) \quad \text{and } \beta_{w_i} = \Delta^{-1}(w_i, \alpha_{w_i})$$

Step 6: Conclude from the results to develop and manage the strategic partnership through NSD programs,

V. Exemplification

Suppose after preliminary sifting the related information that a marketing committee of three experts, E_1, E_2 and E_3, has been formed to evaluate the NSD performance of three service projects, P_1, P_2 and P_3. Five thoughtful criteria are considered: service marketability (C_1), service deliverability (C_2), interfunctional teamwork (C_3), launch preparation (C_4) and launch effectiveness (C_5), respectively. At the outset, they make their individual opinion in accordance with own knowledge, expertise, as well as experience to infer the overall performance level of NSD projects. The proposed method is applied to solve this problem, the computational procedure of which is summarized as follows:

Step 1: The experts refer to the linguistic labels (shown in Table I) to assess the importance of the criteria and the linguistic rating of the projects with respect to each criterion. Afterward the rating outcome is shown in Tables II and III.

TABLE II
SELECTABLE CATEGORY OF LINGUISTIC TERMS FOR EACH EVALUATOR

Criteria	*Project*	*Expert* E_1	E_2	E_3
Service marketability (C_1)	P_1	VG	A	P
	P_2	VG	A	VG
	P_3	A	A	VG
Service deliverability (C_2)	P_1	G	VG	A
	P_2	VG	G	A
	P_3	G	VG	P
Interfunctional teamwork (C_3)	P_1	A	VG	A
	P_2	VG	G	A
	P_3	G	A	VG
Launch preparation (C_4)	P_1	VG	A	VG
	P_2	P	VG	VG
	P_3	A	VG	VG
Launch effectiveness (C_5)	P_1	G	A	VG
	P_2	VG	G	A
	P_3	A	VG	A

TABLE III
LINGUISTIC EVALUATIONS OF EACH EXPERT FOR THE IMPORTANCE OF EACH CRITERION

Criteria	*Expert* E_1	E_2	E_3
Service marketability (C_1)	VI	A	I
Service deliverability (C_2)	I	VI	A
Interfunctional teamwork (C_3)	I	VI	VI
Launch preparation (C_4)	VI	A	VI
Launch effectiveness (C_5)	A	VI	VI

Step 2: The 2-tuple fuzzy linguistic aggregation method is used to compute fuzzy evaluation weighting and rating values of each criterion for projects. For example, fuzzy rating and weighting value of expert 1 for criterion "Launch effectiveness" with respect to project 2 are computed as

$$\bar{S}_{15} = \Delta\left[\frac{1}{4}\left(\Delta^{-1}(s_3,0)+\Delta^{-1}(s_4,0)+\Delta^{-1}(s_2,0)+\Delta^{-1}(s_4,0)\right)\right]$$

$$= \Delta\left[\frac{1}{4}\left(0.75+1+0.5+1\right)\right] = \Delta\,(0.8125) = (s_3, 0.0625)$$

$$\overline{W}_{15} = \Delta\left[\frac{1}{4}\left(\Delta^{-1}(s_2,0)+\Delta^{-1}(s_4,0)+\Delta^{-1}(s_2,0)+\Delta^{-1}(s_2,0)\right)\right]$$

$$= \Delta\left[\frac{1}{4}\left(0.5+1+0.5+0.5\right)\right] = \Delta\,(0.625) = (s_2, 0.125)$$

Step 3: The aggregated weighting value of each criterion can be calculated as follows, "Service marketability" for example.

$$\overline{W}_{1} = \Delta\left[\frac{1}{4}\left(\Delta^{-1}(s_3,0)+\Delta^{-1}(s_4,0)+\Delta^{-1}(s_4,0)+\Delta^{-1}(s_4,0)\right)\right]$$

$$= \Delta\left[\frac{1}{4}\left(0.75+1+1+1\right)\right] = \Delta\,(0.9375) = (s_4, -0.0625)$$

Step 4: The weighted rating can be calculated as, "Launch preparation" for example.

$$\bar{S}^{w}_{4} = \Delta\left[\frac{\Delta^{-1}(s_3,0.125)\cdot\Delta^{-1}(s_3,0)+\Delta^{-1}(s_3,0)\cdot\Delta^{-1}(s_3,-0.0625) + \Delta^{-1}(s_3,0.125)\cdot\Delta^{-1}(s_3,-0.0625)}{\Delta^{-1}(s_3,0)+\Delta^{-1}(s_3,-0.0625)+\Delta^{-1}(s_3,-0.0625)}\right]$$

$$= \Delta\left[\frac{0.875\cdot 0.75 + 0.75\cdot 0.6875 + 0.875\cdot 0.6875}{0.75 + 0.6875 + 0.6875}\right]$$

$$= \Delta(0.83456) = (s_3, 0.08456)$$

Step 5: According to values of the weighted rating and aggregated weighting of each criterion to compute the overall performance level (*OPL*) of NSD project 1 as

$$OPL = \Delta \frac{\begin{pmatrix} \Delta^{-1}(s_4, -0.0625) \times \Delta^{-1}(s_3, 0.0625) + \\ \Delta^{-1}(s_4, -0.0625) \times \Delta^{-1}(s_3, 0.0221) + \\ \Delta^{-1}(s_4, -0.125) \times \Delta^{-1}(s_3, 0.079) + \\ \Delta^{-1}(s_3, 0.125) \times \Delta^{-1}(s_3, 0.0846) \end{pmatrix}}{[\Delta^{-1}(s_4, -0.0625) + \Delta^{-1}(s_4, -0.0625) + \Delta^{-1}(s_4, -0.125) + \Delta^{-1}(s_3, 0.125)]}$$

$$= \Delta\left(\frac{0.8125 \times 0.9375 + 0.7722 \times 0.9375 + 0.829 \times 0.875 + 0.8346 \times 0.875}{0.9375 + 0.9375 + 0.875 + 0.875}\right)$$

$$= \Delta(0.8114) = (s_3, 0.0614)$$

Step 6: Comprehend and rank the performance of each project. i.e. P_1 is the most preferable NSD project, P_2 is the worst one, and P_3 is moderate, respectively. Afterward managers are capable of concluding from the results to develop and manage the strategic partnership through NSD programs,

VI. Conclusion

The benefits of new service development are apparent. What is not as clear is how managers should decide on which innovations to implement. Innovative service offerings are not only necessary just to maintain a firm's current market share but also may enhance service differentiation and induce financial gains. The performance evaluation process of NSD problems generally involves uncertain and imprecise data. This paper proposes a novel group multi-criteria decision-making model, based on linguistic computing, which is capable of dealing with the evaluation of NSD performance effectively. According to the OPL, decision makers can determine not only the level of NSD but also the ranking order of all feasible NSD projects. Obviously the evaluation criteria and the membership functions of linguistic labels should be determined by considering the factual requirements of the practical scenario.

Acknowledgment

The research in this paper was partially supported by the National Science Council of Taiwan under grant NSC101-2914 -I-167-002-A1.

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