INTEGRATION OF PROMETHEE, SWARA AND KANO MODEL FOR SELECTING THE ERP SYSTEM

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ABSTRACT

It is important for an organization to select a robust and appropriate ERP system for the existing environment with a scope for minor changes in the environment. The present work provides a comprehensive ERP system selection framework involving a set of 30 most important attributes. The SWARA (Stepwise Weight Assessment Ratio Analysis) technique is applied to evaluate the weight of the criteria. The Kano model has been found to be a useful tool to adjust the weight and establish the relationship between performance criteria and customer satisfaction. To achieve the desired customer satisfaction weight of each product criteria is determined by using Kano model and integrated with PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) for alternative ranking. The selection of an ERP system has been made keeping in view the aspect of software and vendors related criteria. The proposed comprehensive framework may facilitate the decision makers with a methodology to select an appropriate ERP system for their organization.

KEYWORDS: ERP System, SWARA, Kano Model & PROMETHEE

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INTRODUCTION

Enterprise Resource Planning (ERP) is increasingly important in the modern business scenario because of its ability to integrate the flow of material, finance, and information to support organizational strategies in such dramatically changing business environment (Perez-Salazar et al. 2013).

Owing to the complexity of the business environment, the limitations in available resources and the diversity of ERP alternatives, the selection of an ERP system has become risky, tedious and time-consuming (Wei et al. 2005). The present study proposes a comprehensive framework to select an ERP system in which 30 attributes have been addressed under 8 constructs to provide detailed guidance for ERP system evaluation in view of software and vendor aspect. The application of the proposed model has been illustrated by a case study. An empirical case of a leading electronics company of Asia is described to demonstrate the practical viability of the proposed method.

LITERATURE REVIEW

Liao et al. (2007) have developed a model based on the linguistic information processing. They have proposed a similarity degree based algorithm to aggregate the objective information about ERP systems and a linear programming model for selecting the most suitable ERP system. In this model, 22 selection factors have been

classified into three main groups. Badri et al. (2001) presented a 0–1 goal programming model to select an Information System considering multiple criteria, including benefits, hardware, software, risk factors, preferences of decision makers and users, completion time, and training time constraints. Although goal programming incorporates multiple objectives and arrives at an optimal solution, its major drawback is that the decision makers are compelled to specify goals and priorities in prior. In order to overcome this problem, group discussion is needed. In the queue of qualitative methods, Analytic Hierarchy Process (AHP) has also been adopted due to its unique ability to deal with intangible attributes and to monitor the consistency with which a decision maker makes his decisions (Gupta 2010). AHP directs how to determine the priority of a set of alternatives and the relative importance of attributes in a multiple criteria decision-making problem (Saaty 1980). This method structures the problem in the form of a hierarchy to capture the criteria, sub-criteria and the alternatives (Yadav et al. 2012a; Yadav et al. 2012b; Sharma et al. 2014). Schniederjans and Wilson (1991) have utilized the AHP method to determine the relative weights of attributes and applied these weights to a goal programming model for Information System selection. Wei et al. (2005) have proposed a systematic procedure to construct the objective structure taking into account company strategies and thus extract the associated attributes for evaluating ERP systems. The study adopted the analytical framework of AHP to synthesize decision makers' tangible and intangible measures with respect to numerous competing objectives inherent in ERP system selection. While applying AHP most critical task in the evaluation of the ERP implementation readiness is to determine the index weights of the criteria and their index value (Lee et al. 2011).

AHP approach achieves pairwise comparisons among factors or criteria in order to prioritize them at each level of the hierarchy using the eigenvalue calculation. But this eigenvector method is not monotonic. AHP also suffers some theoretical disputes of rank reversal problem (Ren et al. 2007; Shin and Lee 2013). The assumption of criteria independence (no correlation) may also be considered as the limitation of AHP (and other MCDM methods). Hence, AHP is not able to address the issue of interdependencies among and between different levels of attributes. The Analytic Network Process (ANP), a generalization of AHP with feedbacks to adjust the weights, may be a viable solution. In addition to AHP, ANP technique is a general form that allows interdependencies, outer dependencies, and feedbacks among decision elements in the hierarchical or nonhierarchical structures (Gorener 2012). A fuzzy set theory has been used to aggregate the linguistic evaluation descriptions and weights. The fuzzy set theory is developed for solving problems in which description of activities and observations are imprecise, vague and uncertain (Huang and Wu 2005; Golghate and Pawar 2013). Wang and Lin (2003) have proposed a fuzzy multi-criteria group decision-making approach to select configuration items for software development. A fuzzy cognitive map based approach has been developed by Bueno and Salmeron (2007) for selecting ERP systems and the selection process has been studied in a local construction company (Yang et al. 2007) which gave coverage of the main concepts of ISO 9126 (International Standard 9126 1991). Quality function deployment (QFD) has been a successful methodology to translate the voice of the customer into final product specifications (Yadav et al. 2013a; & Yadav, et al. 2013b). Ghapanchi et al. (2008) developed a Fuzzy-Data Envelopment Analysis model to evaluate the value of each ERP software for selection. Kazemi et al. (2014) proposed a methodology for suitable ERP package selection for an Iranian enterprise using multi-criteria decision making technique and combining them with goal programming and fuzzy theory.

Buckley (1985) has incorporated the fuzzy set theory into the traditional AHP and established FAHP as a suitable tool to solve the real-world MCDM problems. Ayag and Ozdemir (2007) have introduced a fuzzy ANP model that includes 22 criteria considering quantitative and qualitative elements to evaluate ERP software alternatives. Kaur and Mahanti

(2008) brought in a fuzzy ANP based approach for ERP vendor selection. They have explained their concept by a practical example and also made a comparison of results with crisp ANP. Other fuzzy set theories are also popularly adopted. In the study of Sevkli (2009) his aim was to compare the crisp and fuzzy ELECTRE methods for ERP system selection. The proposed methods have been used for a manufacturing company in Turkey. According to Lee et al. (2011) the subjective methods relies on the experts' experience too much. Whereas, the objective methods can avoid the man-made influence as they function according to the interrelationship of the indices and their variant degree of the samples to determine the indices weight. But, objective methods are affected easily by the random error of the samples. In order to avoid these influences, they have combined the fuzzy synthetic evaluation method with the entropy method to get an entropy- fuzzy synthetic evaluation method.

Razmi and Sangari (2008) have developed a hybrid multi-criteria decision-making model in two stages using TOPSIS and PROMETHEE to evaluate and rank the alternatives. According to them, the proposed model was practically and quite simple for real-world problems in selecting the most appropriate ERP system for an organization. The proposed model has been applied to an Iranian power holding company to select the most appropriate ERP software system allowing trade-offs among ERP selection factors results in improper ERP system selection. PROMETHEE avoids trade-offs between good scores on some criteria and bad scores on some other criteria. It means an extremely bad score on a criterion cannot be compensated by good scores on other criteria. Therefore, important information about an alternative with respect to a particular criterion is never overruled or dominated by any other criterion score. Therefore, PROMETHEE was used in the second stage of the model to aggregate the results obtained from separate evaluations and for the final ranking of the alternatives (Razmi and Sangari 2008).

PROMETHEE (Preference Ranking Organization Method for Enrichment for Evaluations) is a preference function based outranking method used to provide a ranking of decision alternatives considering quantitative as well as qualitative criteria, sometimes conflicting criteria too. It is an interactive multi-criteria decision-making approach capable to handle decision situations of prioritization, choice, ranking, conflict-resolution, etc. Considering the viability of PROMETHEE and to avoid trade-offs between shortlisted ERP selection criteria, the authors have adopted PROMETHEE method for the purpose of ranking of the alternatives found eligible to provide a suitable ERP system for an organization. Brans et al. (1986) have described that features of PROMETHEE are simplicity, clearness, and stability. They applied PROMETHEE method in their study to establish the manner to select and rank projects. In the opinion of Goumas and Lygerou (2000), PROMETHEE is a ranking method quite simple in conception and application compared to other methods for multi-criteria analysis and well adapted to problems where a finite number of alternative actions are to be ranked considering several criteria. They have applied the method for evaluation and ranking of alternative energy exploitation projects. Macharis et al. (2004) have proposed a design of operational synergy to strengthen PROMETHEE method with useful AHP features such as a design of the decision-making hierarchy and determination of weights. Bogdanovic et al. (2011) have developed an integrated AHP and PROMETHEE approach for mining method selection and acclaimed that the proposed integrated method can be successfully used in solving mining engineering problems. Tuzkaya (2009) has developed a decision making methodology using PROMETHEE to choose the environmentally convenient transportation mode for Marmara Region of Turkey. Alp et al. (2011) have proposed a fuzzy AHP-PROMETHEE methodology to select a bus garage location through a case study for a firm in the urban passenger transport sector in Istanbul considering numerous criteria that must be taken into account to minimize the dead kilometers.

The experts from the decision-making team evaluate each criterion hence this method can be defined as an export-oriented method (Zolfani et al. 2013a). Kersuliene et al. (2010) have developed a decision-making model applying SWARA method in the selection of rational dispute resolution method. Kersuliene and Turskis (2011) have introduced SWARA for most eligible architect selection among feasible candidates. Zolfani et al. (2013b, 2013c, 2013d, 2013e) have applied SWARA method, for sustainable development of rural areas' building structures considering local climate, for selection of optimal alternative for mechanical longitudinal ventilation of tunnel pollutants, in investigation of the success factors of explorer based online games, in the design of products using Ying-Yang balance theory. Aghdaie et al. (2013) have developed an integrated approach with SWARA and COPRAS-G for appropriate machine tool selection. Nabian (2014) has developed a personnel selection framework based on SWARA-VIKOR operational synergy.

McCall et al. (1977) have proposed a software quality model containing 11 criteria. Boehm et al. (1978) have expanded the characteristics of software and incorporated 19 criteria. Grady and Caswell (1987) have proposed FURPS model which included five major factors containing 24 attributes for software quality. Bernroider and Koch (2001) have discussed the results from an empirical study of Austrian companies in which 29 different ERP selection criteria have been identified. The analysis showed that there is a significant influence of organizational size on the selection of software packages. Even in the selection of suitable ERP implementation process, there is a significant influence on organizational size. SAP systems are selected more often by large organizations, while small or medium-sized companies often choose software supplied by Baan (Bernroider and Koch 2001). It can be seen that the size of the organization has an important role in the selection of an ERP system.

Verville and Halington (2002) have investigated the decision process for selecting an ERP system through a case study. They have reported three distinct types of the ERP system evaluation method adopted by the organization based on vendor, functional and technical evaluation. During the vendor evaluation, they have considered vendor reputation, financial stability, long-term viability and the vendor's vision as criteria. Wei and Wang (2004) have added three categories of attributes to select an ERP system that includes project factors, software system factors, and vendor factors. Everdingen et al. (2000) have explored that a software system and supplier are the major criteria which contain 10 sub-criteria for selecting an ERP system.

Wei et al. (2005) suggested a hierarchical attribute structure model to evaluate the ERP alternatives systematically. He has used two separate network model for criteria categorization, one as system factor network and the other as a vendor factor network. Razmi et al. (2008) proposed a model with 41 criteria under four major categories that are vendor related, system related, project related and financial. A total of 27 factors was identified in the study of Bueno et al. (2008) directly obtained from interviews of experts and ERP users. Among those 27 factors, 17 factors were related to the system, while 10 others were organizational factors. It is difficult to choose a suitable ERP system from the available systems as most of the criteria inherent in them are contradictory in nature and it is devoid of some of the criteria. Wu et al. (2009) identified a set of evaluating variables within three categories as; supplier, product functionality, and technical capacity. Instead of hierarchy, the relationship between the criteria is more like a network. This makes the decision even more complicated (Siswanto and Utomo 2008).

In the present work, the selection criteria have been classified as Software related factors and Vendor related factors. These criteria have been given due importance in available literature too (Wei et al. 2005; Razmi et al. 2008; Bueno et al. 2008; Wu et al. 2012). A 2-level hierarchical criteria model has been proposed in this study (Table 1).

Table 1

ERP System Selection	Software Related Factors	Cost (C)
		Usability (U)
		Functionality (F)
		Flexibility (Fe)
		Reliability (R)
	Vendor Related Factors	Reputation (Re)
		Technical Capability (T)
		Service (S)

METHODOLOGY

Formation of Decision Making Team

The decision-making team consisted of experts, ERP consultants, and stakeholders. Their selection is carried out based on their expertise to understand the relationships among different objectives, criteria, and capability to assess the influence of each factor while modeling them to the hierarchical structures (Qui et al. 2007).

Identification of Decision Elements

It is necessary to identify the relevant decision elements for successful adoption and implementation of alternatives, an objective of the project, project risks, managing the ever-changing business process etc.

Alternative ERP Systems

The project team went through the feasible alternatives for smooth processing of the selection procedure.

Selection Criteria Set

The selection of an ERP system should be made comprehensible based on these technical and nontechnical issues (Siswanto and Utomo 2008). In this study, A 3-level hierarchical criteria model has been proposed (Table 1) comprising of Software related factors and Vendor related factors that comprise of 8 constructs accommodating 30 micro issues under these constructs.

Criteria Value

SWARA Method

SWARA was used for the selection of rational dispute resolution method (Kersulienė et al. 2010). Using his or her own implicit knowledge, information and experience the expert from project team evaluated each criterion, hence this method can be defined as an expert-oriented method (Zolfani et al. 2013a). Following steps to evaluate the weights after the mediocre values are achieved by experts:

Step 1: Compute the overall ranks of criteria on the basis of the mediocre value of ranks given by experts of the team.

Step 2: Calculate the comparative importance of average value (S_j) using the mediocre values.

Step 3: Determine the coefficient K_j for each criterion as;

$$K_j = S_j + 1 \quad (1)$$

Step 4: Calculate the recalculated weight W_j using equation (2)

$$W = \frac{X_j - 1}{K_j} \quad (2)$$

Step 5: Using equation (3) the final weight q_j is obtained.

$$q_j = \frac{W_j}{\sum W_j} \quad (3)$$

This final criteria weight signifies the role of a particular criterion in the ERP selection procedure. The larger the final weight the better is the attribute significance.

Kano Model of Customer Satisfaction

It is important to identify which product criteria create more satisfaction than others. Kano et al. (1984) thoroughly addressed and developed the two-dimensional nonlinear relationship between qualities attributes performance and overall satisfaction of the customer. They have suggested that quality attributes can be classified into five categories as shown in figure 1

Figure 1: Kano's Model of Customer Satisfaction

Each quality attributes affects the customer in a different way. The five different quality attributes are:

Must-be Quality

Customers will accept the product if this quality attribute is provided, otherwise they will feel extremely dissatisfied.

One-Dimensional Quality

Here, customer satisfaction is a linear function of the quality attribute performance. High attribute performance leads to higher customer satisfaction and vice-versa.

The attractive quality

Customers will be extremely satisfied if the quality attribute is provided; otherwise, they will be accepting the product without dissatisfaction.

Indifference Quality

Customer satisfaction will not be affected no matter whether this attribute is provided or not.

Reversal Quality

Customer will be dissatisfied if this quality attribute is provided; otherwise, they will be satisfied.

A simple way of identifying different Kano categories, one-dimensional, attractive and must be qualities, is to use a Kano questionnaire (Annexure-1) (Kano et al., 1984). In the questionnaire, customers indicate if they feel satisfied or dissatisfied with a given situation. First, a situation supposes the quality (criterion) is presently or sufficient. The customer must choose one of the following answers to express his feelings:

- Satisfied
- Must-be
- Indifferent
- Live with it
- Dissatisfied

A second situation assumes the quality attribute is absent or insufficient. Again, the customer must choose one of the above-mentioned feeling responses. By combining the two answers in the Kano evaluation table (Table 1), the product criterion can be identified as attractive, must-be, one-dimensional, indifference or reversal.

Table 2: Kano Table for Attribute Classification

Criteria/Attributes		Insufficiency				
		Satisfied	Must-be	Indifferent	Live with it	Dissatisfied
Sufficiency	Satisfied	Q	A	A	A	O
	Must-be	R	I	I	I	M
	Indifferent	R	I	I	I	M
	Live with it	R	I	I	I	M
	Dissatisfied	R	R	R	R	Q

A-attractive, O-one-dimensional, M-must-be, I-indifference, R-reversal, Q-questionable.

Matzler and Hinterhuber (1998) have proposed a methodology, based on the Kano model of customer satisfaction, to explore customers' stated needs and unstated desires and to resolve them into different categories that have a different impact on customer satisfaction. The Kano model can also be used to establish the importance (weight) of individual product criterion in multiple criteria decision.

In the present work, the Kano questionnaire was prepared and later to discuss with the project team in the company, a number of ERP consultants and also ERP vendors for each requirement importance were calculated and multiplied by 4, 2 or 1 that have been assigned the attractive, one-dimensional and must-be categories, respectively depending on its classification in the Kano model. The integrative approach provides a basis to decide the relative importance of improving ERP attributes based on Kano categories.

The weight adjustment process involves identifying the proper Kano category for each aesthetic attribute related to the customer satisfaction based on the Kano questionnaire results. The purpose is to magnify the weights of the high-return aesthetic parameter. True weights obtained in equal weighting method were then adjusted by multiplying the adjustment coefficient (K) for each Kano category. Values of "4", "2", "1" and "0" were assigned to the attractive, one-

dimensional, must-be and indifference categories, respectively. The adjusted weight of aesthetic attribute can be calculated by equation 4.

$$w_{i_adj} = \frac{W_i K_i}{\sum_{i=1}^n W_i K_i} \quad (4)$$

Where w_{i_adj} is the final adjusted weight for the i^{th} aesthetic attribute, W_i is the true weight of the i^{th} aesthetic parameter on the basis of SWARA and K_i is the adjustment coefficient according to its Kano quality classification.

The difference between the equal weighting method and the method based on the Kano model is that the former represents the importance of the customer requirements while the latter represents the importance of the customer satisfaction.

Ranking of Alternatives

PROMETHEE Method

The PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) is preference function-based outranking method to provide ranking/ordering of the decision alternatives. The PROMETHEE method was developed by Brans and Vincke in 1985 (Athawale and Chakraborty 2010). It belongs to the methods of partial aggregation, also called outranking methods, and was partly designed as a reaction to the complete aggregation (MAUT) methods (De Brucker et al. 2004). In this paper, the PROMETHEE II method is employed to obtain the full ranking of the alternatives selected to facilitate the organization with competent ERP system. The procedural steps as involved in PROMETHEE II method are enlisted as given below (Hajkowicz and Higgins 2008; Avikal et al. 2014):

Step 1: Normalize the decision matrix using the following equation:

$$NDM_{ij} = [Z_{ij} - \min(Z_{ij})] / [\max(Z_{ij}) - \min(Z_{ij})] \quad (i = 1, 2, \dots, n; j = 1, 2, \dots, m) \quad (5)$$

Where X_{ij} is the performance measure of i^{th} alternative with respect to j^{th} criterion.

For non-beneficial criteria, Equation (5) can be rewritten as follows:

$$NDM_{ij} = [\max(Z_{ij}) - Z_{ij}] / [\max(Z_{ij}) - \min(Z_{ij})] \quad (6)$$

Step 2: Calculate the evaluative differences of i^{th} alternative with respect to other alternatives. This step involves the calculation of the differences in criteria values between different alternatives pairwise.

Step 3: Calculate the preference function $pf_j(i, i')$.

There are mainly six types of generalized preference functions (Athawale and Chakraborty 2010). But it may be difficult for the decision-maker to specify which specific form of preference function is much suitable for each criterion and also to determine the parameters involved. Athawale and Chakraborty (2010) proposed the following simplified preference functions:

$$Pf_i(i, i') = 0, \quad \text{if } NDM_{ij} \leq NDM_{i'j} \quad (7)$$

$$Pf(i, i') = (NDM_{ij} - NDM_{i'j}), \quad \text{if } NDM_{ij} \geq NDM_{i'j} \quad (8)$$

Step 4: Calculate the aggregated preference function taking into account the criteria priority aggregated preference function,

$$APf(i, i') = [\sum_{j=1}^m w_j \times Pfi(i, i')] / \sum_{j=1}^m w_j \quad (9)$$

Where w_j is the relative importance (priority) of j^{th} criterion.

Step 5: Determine the leaving and entering outranking flows as follows:

Leaving (or positive) flow for i^{th} alternative

$$\psi^+(i) = \frac{1}{n-1} \sum_{i'=1}^n APf(i, i') \quad (10)$$

Entering (or negative) flow for i^{th} alternative

$$\psi^-(i) = \frac{1}{n-1} \sum_{i'=1}^n APf(i', i) \quad (11)$$

Where n is the number of alternatives.

Here, each alternative face $(n-1)$ number of other alternatives. The leaving flow expresses how much an alternative dominates the other alternatives, while the entering flow denotes how much an alternative is dominated by the other alternatives. Based on these outranking flows, the PROMETHEE I method can provide a partial preorder of the alternatives, whereas, the PROMETHEE II method can give the complete preorder by using a net flow, though it loses much information of preference relations.

Step 6: Calculate the net outranking flow for each alternative.

$$\psi(i) = \psi^+(i) - \psi^-(i) \quad (12)$$

Step 7: Determine the ranking of all the considered alternatives depending on the values of $\psi(i)$. The higher the value of $\psi(i)$, the better is the alternative. Thus, the best alternative is the one having the highest $\psi(i)$ value.

The PROMETHEE methodology and outranking methods, in general, have several advantages over the MAUT approach (Macharis et al. 2004). First of all, the PROMETHEE I method avoids trade-offs between scores on criteria, that is likely to happen in AHP. Secondly, PROMETHEE achieves a synthesis indirectly and only requires evaluations to be performed on each alternative for each criterion. Conversely, in Fuzzy AHP, the synthesis builds directly on the information included in the evaluation matrix which might lead to a substantial amount of pairwise comparisons to be completed (Macharis et al. 2004). Outranking methods like PROMETHEE are better suited to perform extensive sensitivity analysis (Turcksin et al. 2011).

Case Study

The proposed framework was applied for ERP system selection at a production unit of a leading Asian electronics company. The company designs and manufactures various electronic household appliances but is having a renowned name in the field of cellphone manufacturing. It has about 3500 employees in the unit and composed of nine different functional departments. Various requirements of data and technology regarding our objective have been determined through several structured interviews/survey questionnaire with the 90 stakeholders and experts from all departments.

The weights of selection factors have been calculated using SWARA method on the basis of the responses of experts. The weight obtained using SWARA method has been further adjusted using Kano classification of criteria. Five potential alternatives V1, V2, V3, V4, V5 have been taken for the evaluation on behalf of the combined result obtained from questionnaires and interviews with the project team in the company, a number of ERP consultants and also ERP

vendors. PROMETHEE method is used to get the final ranking for the respective alternatives.

Experts' Information

The qualification of experts is one of the decisive factors that can enhance the quality of results of the MCDM problem. Those experts were targeted who were having implicit knowledge about the ERP system and its requirements irrespective of their inclinations. In this study, experts participated in three stages. At initial stage, they were required to select the relevant criteria, the design of the model and evaluate possible alternatives. Then they have been requested to evaluate the alternatives prioritized by Kano model supplemented by SWARA and PROMETHEE together to their expectations.

SWARA Results

SWARA method is used for finding the weight of the criteria in the model. The results of SWARA are shown in the tables 2-11. The method is established based on experts' ideas. Table 2-7 consist of the weights of software related factors and table 8-11 consists of weights of vendor-related factors. Weight computation for both the aspect has been separately dealt in SWARA methodology. The rank of criteria is shown in the first column and the last column exhibits weight of relative criteria. Table 3 shows the weight of software related factors.

Table 3: Weights of Software Related Factors

Criterion	Comparative Importance of Average Value (S_i)	Coefficient (K_i)	Recalculated Weight (W_i)	Weight (q_i)
F		1	1	0.361
Fe	0.536	1.536	0.651	0.235
C	0.298	1.298	0.501	0.181
U	0.371	1.371	0.366	0.132
R	0.451	1.451	0.252	0.091

Table 4 consists of the weight of vendor-related factors.

Table 4: Weights of Vendor Related Factors

Criterion	Comparative Importance of Average Value (S_i)	Coefficient (K_i)	Recalculated Weight (W_i)	Weight (q_i)
T		1	1	0.487
S	0.613	1.613	0.620	0.302
Re	0.431	1.431	0.433	0.211

A Kano questionnaire survey was then conducted to classify the aesthetic attributes. Table 5 shows the result of the Kano questionnaire that provides information for classifying the factor. The factor cost, usability, and flexibility may be considered as must-be requirements; reliability can be considered one dimensional and functionality can be classified as an attractive factor that customer needs and for the vendor-related factors reputation is one-dimensional, atechanical capability is attractive while service is the must-be attribute. The efforts were directed to meet out the attractive and one-dimensional attribute. The Kano classification corresponding to each attribute was then integrated to adjust the attribute weights by multiplying the adjustment coefficient (K) with each Kano category. The adjusted weights of factors have been shown in Table 7 and Table 8.

Table 5: The Kano Classification of Software-Related Factors

Factor	A	O	M	N	R	Total	Kano Category
Cost	10	15	50	9	6	90	M
Usability	18	44	20	5	3	90	M
Functionality	40	23	15	7	5	90	A
Flexibility	11	12	52	8	7	90	M
Reliability	24	43	20	2	1	90	O

A-attractive, O-one-dimensional, M-must-be, I-indifference, R-reversal

Table 6: The Kano Classification of Vendor Related Factors

Factor	A	O	M	N	R	Total	Kano Category
Reputation	20	46	14	7	3	90	O
Technical Capability	42	18	23	5	2		A
Service	13	22	48	4	3	90	M

Table 7: Result of the Determined Software Related Factors' Weight

	Cost	Usability	Functionality	Flexibility	Reliability
The Adjusted Factor's Weights					
Kano Category	M	O	A	M	O
Adjustment ratio (K)	1	2	4	1	2
SWARA weight	0.361	0.235	0.181	0.132	0.091
Adjusted weight	0.189	0.246	0.379	0.138	0.048

Table 8: Result of the Determined Vendor Related Factors' Weight

	Reputation	Technical Capability	Service
The Adjusted Factor's Weights			
Kano Category	O	A	M
Adjustment ratio (K)	2	4	1
SWARA weight	0.211	0.487	0.302
Adjusted weight	0.158	0.729	0.113

PROMETHEE Results

In this section, using equation (5) - (12) we ranked the five available alternatives using PROMETHEE method. The alternatives were denoted as V1, V2, V3, V4, and V5. Experts evaluated each alternative and we came up with the decision matrix shown in table 9-10. After creating decision matrix, Equation (5) was used to generate normalized decision matrix for software related factors (Table 11).

Table 9: Objective Data for Alternative Evaluation of Software-Related Factors

	C	U	F	Fe	R
	Min	Max	Max	Max	Max
V1	0.74	0.50	0.95	0.56	0.95
V2	0.25	0.25	0.86	0.75	0.78
V3	0.52	0.84	0.78	0.95	0.98
V4	0.30	0.32	0.26	0.26	0.63
V5	0.75	0.24	0.75	0.23	0.91

Table 10: Objective Data for Alternative Evaluation for Vendor Related Factors

	Re	T	S
	Max	Max	Max
V1	0.84	0.78	0.72
V2	0.70	0.81	0.85
V3	0.65	0.52	0.60
V4	0.81	0.92	0.45
V5	0.85	0.83	1.00

Table 11: Normalized Matrix for Alternative Evaluation for Software Related Factors

	C	U	F	Fe	R
	Min	Max	Max	Max	MAx
V1	0.34	0.60	1	0.60	0.97
V2	1.00	0.30	0.91	0.80	0.80
V3	0.48	1	0.82	1	1
V4	0.83	0.38	0.27	0.27	0.64
V5	0.33	0.29	0.79	0.24	0.93

The final weights of the criteria using SWARA and Kano model with adopted preference function is used to generate aggregated preference function matrix using equation (9). Table 12 depicts the aggregated preference matrix for software related factors using SWARA and Kano model weight. Through equation (10) and (11) the leaving and entering outranking flows is determined.

Table 12: Aggregated Preference Function Considering Software Factors

Using SWARA weight	V1	V2	V3	V4	V5	Using weight by Kano Model	V1	V2	V3	V4	V5
V1	0	0.103	0.103	0.253	0.162	V1	0	0.118	0.068	0.388	0.207
V2	0.265	0	0.203	0.256	0.337	V2	0.153	0	0.130	0.350	0.249
V3	0.204	0.046	0	0.373	0.311	V3	0.185	0.039	0	0.478	0.301
V4	0.179	0.020	0.127	0	0.185	V4	0.094	0.020	0.067	0	0.099
V5	0	0.012	0	0.119	0	V5	0	0.007	0	0.206	0

Equation (12) was then applied to calculate Net outranking flow for each shortlisted alternative. Then these alternatives are ranked with respect to the value of net outranking flow. Table 13 shows the rank of alternatives evaluated on the basis of software related factors using SWARA and Kano Model weight. Amongst the five alternatives propounded in table 13, we selected the first three alternatives with higher Net Flow values in order to evaluate them on the basis of vendor-related factors.

Table 13: Leaving and Entering Flow for Different Alternatives (Software Factors)

Using SWARA weight	Leaving	Entering	Net Flow	Rank	Using Weight by KanoModel	Leaving	Entering	Net Flow	Rank
V1	0.155	0.162	-0.007	3	V1	0.195	.0108	0.087	3
V2	0.265	0.045	0.220	1	V2	0.220	0.046	0.174	2
V3	0.233	0.108	0.125	2	V3	0.251	0.066	0.184	1
V4	0.128	0.250	-0.123	4	V4	0.070	0.355	-0.265	5
V5	0.033	0.249	-0.249	5	V5	0.053	0.214	-0.161	4

For the three alternatives with higher Net Flow values, normalized decision matrix for vendor-related factors were generated using equation (5) (Table 14). Similarly, equation (9) is applied to generate the aggregated preference matrix for vendor related factors (Table 15). Equation (10) and (11) were used to determine to leave and to enter outranking flows and the Net outranking flow is calculated by equation (12). As a result, it is found that alternative V1 exhibited maximum Net Flow value while SWARA weight is considered and V2, when Kano weight has been considered consequently V1, is most suitable when SWARA (objective weight) viewpoint considered but V1 is the most suitable option when customer satisfaction perspective is considered (Table 16).

Table 14: Normalized Matrix for Alternative Evaluation of Vendor Related Factors

	Re	T	S
	Max	Max	Max
V1	0.99	0.85	0.72
V2	0.82	0.88	0.88
V3	0.76	0.57	0.60

Table 15: Aggregated Preference Function Considering Vendor Factors

Using SWARA Weight	V1	V2	V3	Using Weight by Kano Model	V1	V2	V3
V1	0	0.08	0.177	V1	0	0.026	0.267
V2	0.037	0	0.177	V2	0.038	0	0.267
V3	0	0	0	V3	0	0	0

Table 16: Leaving and Entering Flow for Different Alternatives (Vendor Factors)

Using SWARA Weight	Leaving	Entering	Net Flow	Rank	Using Weigh by Kano Model	Leaving	Entering	Net Flow	Rank
V1	0.128	0.019	0.110	1	V1	0.147	0.019	0.127	2
V2	0.107	0.04	0.067	2	V2	0.153	0.013	0.140	1
V3	0	0.177	-0.177	3	V3	0	0.267	-0.267	3

CONCLUSIONS

The present study has utilized the application of Kano's model in SWARA and PROMETHEE with an objective to provide an appropriate ERP system which can radically improve the competitiveness and performance of any firm using the proposed model. SWARA has been used for weight assessment, conceding that it is export-oriented weight assessment approach with an ability to estimate the differences of the significance of attributes, whereas PROMETHEE method avoids trade-offs between scores on criteria.

The proposed approach has offered a structured and organized outline of the decision-making for the selection of ERP tools and further it is also possible that it may be applied in other equally relevant decision-making process and that occur in the stages of pre-implementation and implementation of ERP tools.

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