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UNIFICATION OF ERP SYSTEM SELECTION FACTORS: AN INTEGRATED DECISION MAKING APPROACH

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Abstract:
Enterprise Resource Planning is a commercial software package that encompasses such a set of standard functional modules that enables a company to manage its resources (finance, material, human resource, etc.) efficiently by providing a flawless integration of all the enterprise information and information-processing. It is necessary for an enterprise to select a competent and suitable ERP system for the existing environment or with minor change in environment. Present study proposes a comprehensive framework to select 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. SWARA and PROMETHEE have been used to develop a hybrid multi-criteria decision making (MCDM) model for selection of an ERP system. The application of the proposed model has been illustrated by a case study.
Keywords: ERP; MCDM methods; Supplier Selection; SWARA; PROMETHEE.

I. Introduction

ERP system integrates all the enterprise functions to provide services to all departments in an organization. It provides methods and ways to the enterprise with their existing capacity to plan and manage its resources based on an integrated approach [1]. Among the most important attributes of ERP are its abilities to (1) automate and integrate an organization's business processes; (2) share common data and practices across the entire enterprise; and (3) produce and access information in a real-time environment [2].

Successful deployment and use of ERP systems are critical to organizational performance and survival [3]. Qualitative methods are widely used in the past for selection of ERP or other information system (IS) including scoring, ranking, mathematical optimization, and multi-criteria decision analysis. Other techniques and mathematical modeling tools like nominal group technique, analytic hierarchy process, analytic network process, Entropy, ELECTRE etc. have also been employed for ERP system selection. Instead of hierarchical, the relationship between the criteria is more like a network. 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 [4] [5] [6]. A 3-level hierarchical criteria model has been proposed in this study (Table 1).

II. Methodology

A. ERP selection procedure:

Following steps have been evolved to select an ERP system:
Step 1. Project initiation by forming decision making team.
Step 2. Identification of decision elements about ERP systems and vendors.
Step 3. Search alternative ERP systems
Step 4. To evolve selection criteria set.
Step 5. Determination of criteria value using SWARA method.
Step 6. Ranking the alternatives using PROMETHEE method to get the best alternative.

A. Formation of decision making team

The decision making team consists 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 [7].

B. Identification of decision elements

The ERP system is selected based on distinct objectives of the companies. It is necessary to identify the relevant decision elements for successful adoption and implementation of alternatives, objective of the project, project risks, managing the ever-changing business process etc.

C. Alternative ERP systems

The project team goes through the feasible alternatives for smooth processing of the selection procedure. Some of the known providers of ERP systems are; SAP-AG, Oracle, JD Edwards, PeopleSoft, Baan, QAD, BPCS [8][9].

D. Selection criteria Set

An ERP system is selected normally based on budgetary and technical requirements. The success of an ERP system is not only a matter of budget, functionality, and technical requirement but due considerations should be extended to human resistance, business complexities, and other organizational issues also, so that obstacles in implementation of ERP in future are easily resolved.

E. Criteria value

SWARA Method

The Stepwise Weight Assessment Ratio Analysis (SWARA) is adapted for decision making problems to prioritize and calculate the relative importance of decision making issues. SWARA was used for the selection of rational dispute resolution method [10]. In SWARA, the experts evaluate and estimate the weight and they rank the criteria based on their evaluation. The rank of experts is accumulated and their mediocre value is selected as rank of the criteria. In the proposed study it has been used to calculate the weights of

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Table 1 Enterprise Selection Factors

ERP System Selection	• Software Related Factors	• Cost (C)	• License fee (C1) • Infrastructure Costs(C2) • Maintenance Costs(C3) • Consultant Expenses(C4)
		• Usability (U)	• Handiness of operation(U1) • Ease of Learning (U2) • Easy manual for users (U3) • Provision of relevant papers (U4)
		• Functionality (F)	• Function Fitness (F1) • Modularity(F2) • Security Level(F3) • Compliance with demands(F4)
		• Flexibility (Fe)	• Upgrade Ability (Fe1) • Cross module Integration(Fe2) • System expansibility(Fe3) • Capability of integration with previous systems (Fe4)
		• Reliability (R)	• Stability (R1) • Recovery Ability (R2)
	• Vendor Related Factors	• Reputation (Re)	• Financial Stability (Re1) • Scale matching (Re2) • Market Share (Re3)
		• Technical Capability (T)	• R & D capability (T1) • Technical support capability (T2) • Implementation ability (T3) • Advisor's professional knowledge (T4)
		• Service (S)	• Warranties (S1) • Holistic Service (S2) • Local Support (S3) • Service speed (S4) • Expense of long-term system maintenance (S5)

factors related to software and vendor to select suitable ERP software. Following are the 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 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 criteria as;

$$Kj = Sj + 1 \quad (1)$$

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

$$Wj = \frac{Xj - 1}{Kj} \quad (2)$$

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

$$qj = \frac{Wj}{\sum Wj} \quad (3)$$

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.

F. 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 [11]. The procedural steps as involved in PROMETHEE method are enlisted as given below

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

$$NDM_{ij} = [\, Z_{ij} - \min (Z_{ij})] / [\, \max (Z_{ij}) - \min (Z_{ij}))] \quad (4)$$
$$(\, i = 1,2,\ldots,n;\ j = 1,2,\ldots,m)$$

where Xij is the performance measure of *i*th alternative with respect to *j*th criterion.

For non-beneficial criteria, Equation (4) can be rewritten as follows:

$$NDM_{ij} = [\, \max (Z_{ij}) - Z_{ij}\,] / [\, \max (Z_{ij}) - \min (Z_{ij}))] \quad (5)$$

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

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

$$Pf_i\,(i, i') = 0, \quad \text{if } NDM_{ij} \leq NNDM_{ij} \quad (6)$$

$$Pf\,(i, i') = (NDM_{ij} - NDM_{i'j}), \quad \text{if } NDM_{ij} \geq NNDM_{ij} \quad (7)$$

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

$$APf\,(i,i') = \left[\sum_{j-1}^{m} wj \text{ x } Pfi\,(i,i')\right] \Big/ \sum_{j=1}^{m} wj \quad (8)$$

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

$$\psi^{+}(i) = \frac{1}{n-1}\sum_{i'=1}^{n} APf\,(i,i') \quad (9)$$

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

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

where n is the number of alternatives.

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

$$\psi\,(i) = \psi^{+}(i) - \psi^{-}(i) \quad (11)$$

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.

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. It has about 5300 employees in the unit and composed of 7 different functional departments. Various requirements of data and technology regarding our objective have been determined through several structured interviews with the stakeholders and experts from all departments. The final requirement list has been obtained after integrating the results of interviews and activities performed in the organization.

The selection factors have been weighted using SWARA method on the basis of the responses of experts. Five potential alternatives V1, V2, V3, V4, V5 have been taken for the evaluation on behalf of 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.

SWARA method is used for finding the weight of the criteria in the model. . Table 2 depicts the weight of all criteria and sub-criteria all together following the specific steps of the methodology (Equation (1)-(3)). Using equation (4) - (11) we ranked the five available alternatives through PROMETHEE method. The alternatives were denoted as V1, V2, V3, V4 and V5.

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Table 2 The weights of criteria and sub-criteria of the model

	Criteria and Sub-criteria	Final Weights
C:	Cost	0.181
C_1:	License fee	0.058
C_4:	Consultant Expenses	0.051
C_2:	Infrastructure Costs	0.047
C_3:	Maintenance Costs	0.026
U:	Usability	0.132
U_1:	Handiness of operation	0.046
U_4:	Provision of relevant papers	0.035
U_2:	Ease of Learning	0.027
U_3:	Easy manual for users	0.024
F:	Functionality	0.361
F_4:	Compliance with demands	0.116
F_1:	Function Fitness	0.105
F_3:	Security Level	0.075
F_2:	Modularity	0.065
Fe:	Flexibility	0.235
Fe_1:	Upgrade Ability	0.071
Fe_2:	Cross module Integration	0.063
Fe_3:	System expansibility	0.052
Fe_4:	Capability of integration with previous systems	0.049
R:	Reliability	0.091
R_1:	Stability	0.051
R_2:	Recovery Ability	0.040
Re:	Reputation	0.211
Re_1:	Financial Stability	0.091
Re_3:	Market Share	0.072
Re_2:	Scale matching	0.048
T:	Technical Capability	0.487
T_2:	Technical support capability	0.175
T_4:	Advisor's professional knowledge	0.164
T_3:	Implementation ability	0.085
T_1:	R & D capability	0.063
S:	Service	0.302
S_3:	Local Support	0.077
S_1:	Warranties	0.074
S_2:	Holistic Service	0.066
S_5:	Expense of long-term system maintenance	0.045
S_4:	Service speed	0.040

Table 3 depicts the aggregated preference matrix for software related factors. Table 4 shows the rank of alternatives evaluated on the basis of software related factors. Amongst the five alternatives propounded in table 4, we selected the first three alternatives with higher Net Flow values in order to evaluate them on the basis of vendor related factors.

Similarly equation (8) is applied to generate the aggregated preference matrix for vendor related factors (Table 5). Equation (9) and (10) are used to determine leaving and entering outranking flows and the Net outranking flow is calculated through equation (11). As a result it is found that alternative V2 exhibits maximum Net Flow value, consequently it became the most suitable option. (Table 6).

Table 3 Aggregated preference function considering software factors

	V1	**V2**	**V3**	**V4**	**V5**
V1	0	0.114	0.078	0.299	0.187
V2	0.084	0	0.072	0.245	0.163
V3	0.120	0.144	0	0.326	0.239
V4	0.051	0.027	0.035	0	0.073
V5	0.051	0.057	0.060	0.186	0

Table 4 Leaving and entering flow for different alternatives (Software factors)

	Leaving	**Entering**	**Net Flow**	**Rank**
V1	0.169	0.077	0.093	***2***
V2	0.141	0.086	0.055	***3***
V3	0.207	0.061	0.146	***1***
V4	0.046	0.264	-0.218	***5***
V5	0.089	0.166	-0.077	***4***

Table 5 Aggregated preference function considering vendor factors

	V1	**V2**	**V3**
V1	0	0.183	0.166
V2	0.350	0	0.429
V3	0	0.095	0

Table 6 Leaving and entering flow for different alternatives (Vendor factors)

	Leaving	**Entering**	**Net Flow**	**Rank**
V1	0.175	0.175	0	***2***
V2	0.389	0.139	0.250	***1***
V3	0.048	0.297	-0.249	***3***

Conclusion:

A suitable ERP system can radically improve the future competitiveness and performance of a firm. The diversity of

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requirements makes an ERP system more complex which in turn makes its selection complicated. The selection of an ERP system has been made keeping in view the aspect of software and vendors, that consists of 30 criteria merged into 8 constructs. These all criteria have been given due importance in the literature.

The proposed comprehensive framework may facilitate the corporate decision makers with a methodology to select a suitable ERP system for their organization. The approach consists of an integrated approach of SWARA and PROMETHEE. SWARA has been used for weight assessment, conceding that it is expert-oriented weight assessment approach with ability to estimate the differences of significance of attributes, whereas PROMETHEE method avoids trade-offs between scores on criteria. The contributions concerned are: The analytic results depict that Functionality and flexibility of software are more important criteria than the costs incurred.

1. Regarding system vendors, good technical capability and service support are key factors.
2. A systematic mode of assessing and selecting ERP system via an integrated approach using SWARA and PROMETHEE aims to serve as the references to enterprises in need of an ERP systems for successful introduction of other e-systems.
3. The relative importance of the ERP selection criteria should be investigated with different constructs in future work.

References:

[1] E.Turban, E.Mclean, and J. Wetherbe, "*Information technology for management*", MN:Wiley, 2003, USA.

[2] F.F.H.Nah, and J.L.S.Lau, "Critical factors for successful Implementation of enterprise Systems", *Business Process Management Journal*, Vol. 7, No. 3, 2001, pp. 285-296.

[3] M.L.Markus, S.Axline, D.Petrie, and C.Tanis, "Learning from adopters' experiences with ERP: problems encountered and success achieved", *Journal of Information Technology*, Vol. 15, 2000, pp. 245-265.

[4] J.Razmi, and Md.S.Sangari, "A hybrid multi-criteria decision making model for ERP system selection", *IEEE*, 2008, ICIAFS08.

[5] S.Bueno, and J.L.Salmeron, "Fuzzy modeling enterprise resource planning tool selection", *Computer Standards and Interfaces*, Vol. 30, No. 3, 2008, pp. 137-147.

[6] C.Y.Wu, H.T.Chan, and S.H.Wang, "A Study of Applying Modified Grey Relational Analysis Approach to Assessment Enterprise Resource Planning System Providers", *Journal of Convergence Information Technology*, Vol. 7, No. 1, 2012, pp. 368-379.

[7] Y.F.Qui, Y.P.Chui, and M.G.Helander, "A cognitive approach to understanding knowledge-based virtual team decision making in product design", *Inernational. Journal. of Intelligent Enterprise*, Vol. 1, 2007, pp.45 – 64.

[8] V.A. Mabert, A. Soni, and M.A. Venkataramanan, "Enterprise resource planning: common myths versus evolving reality", *Business Horizons*, Vol. 44, No. 3, 2001, pp. 69-76.

[9] E.M.Shehab, M.W.Sharp, L. Supramaniam, and T.A. Spedding, "Enterprise resource planning An integrative review", *Business Process Management Journal*, Vol. 10, No. 4, 2001, pp. 359-386.

[10] V. Kersuliene , E.K. Zavadskas, and Z. Turskis, "Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA)", *Journal of Business Economics and Management*, Vol. 11, No. 2, 2010, pp. 243–258.

[11] V.M.Athawale, and S.Chakraborty, "Facility Location Selection using PROMETHEE II Method", *In Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management*, Dhaka, Bangladesh, 2010, January 9–10.