Indian J.Sci.Res. 17(2): 533-538, 2018
ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

INVESTIGATING FACTORS FOR ERP SELECTION: AN INTEGRATED DECISION MAKING METHODOLOGY

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Abstract

It has become the need of the time that the enterprises should become more and more agile and responsive to ever changing customer demands and to cope with the global competition. The nature of the market is unpredictable and diverse. This has lead to emergence of a need for an enterprise to select a competent and suitable ERP system for the existing environment or with minor change in environment. An Enterprise Resource Planning (ERP) system deployment is a critical investment for an organization that may significantly affect competitiveness and performance of a company in future, as well as in monitoring the resources. For the purpose, it is vital to select suitable and competitive partners during its development. In the present work, with a target to attain success in implementation of an ERP, a comprehensive ERP system selection framework with pertinent attributes has been addressed to evaluate the selection of an ERP system, keeping in mind that the factors that have been extended due importance in available literature. The methodology based on SWARA (Stepwise Weight Assessment Ratio Analysis) technique to evaluate weight of the criteria, integrated with PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) for alternative ranking has been proposed, to produce a framework for selection of an ERP system.

Keywords: Supplier Selection; ERP; MCDM methods; SWARA; PROMETHEE;

Introduction

It is need of the time that companies should become more and more responsive to customer demands at minimum cost with maximum return on investment to remain competitive in business scenario. Enterprise Resource Planning (ERP) encompasses the capabilities to achieve such goals.ERP has been described by APICS dictionary (1998), as a framework for organizing, defining and standardizing the business processes necessary to effectively plan and control an organization so that organization can use its internal knowledge to seek external advantage.ERP strives to focus on the planning and scheduling of internal resources as well as supplier resources. It includes even the 'back-office' functions such as order management, financial management, warehousing, distribution production, quality control, asset management and human resources management. The evolution of extended-ERP systems has further expanded to include more "front-office" functions, such as sales and marketing automation, electronic commerce and supply chain management systems.

Suppliers are the critical link to any supply demand chain and play a vital role in achieving corporate competition (Shukla and Mishra, 2016). Hence, selecting the right supplier is a vital component in ERP implementation.In the issue of supplier selection most of the approaches examine the problem based on selection criteria. In practice, there can be several criteria adopted by anorganization for its software supplier selection, such as price, upgradability,ease of learning, after-sales services, supplier market share and supplier's financial status. Apparently, supplier selection is a multi-criteria problem that includes both quantitative and qualitative factors (Yadav et al. 2012). It is necessary to make trade-off between these tangible and intangible factors while considering a suitable supplier.

Decision Criteria for Supplier Selection

Despite ERP selection criteria seem less influential to ERP success, they crucially impact the ERP success indirectly through software quality and information quality. Hence ERP success measures cannot be analyzed and understood without adapting suitable software and hence selection criteria play a major role. Supplier selection decisions are thorny by the fact that huge number of criteria should be considered for making a decision. While considering the views of literature and of the experts and decision makers from areas of academics, finance and production & material management, a comprehensive ERP system selection framework with a set of 8 pertinent attributes has been addressed to evaluate the selection of an ERP system keeping in mind that the factors that have been extended due importance in available literature.The hierarchical

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criteria model has been presented in Table 1.1(Shukla et al., 2016).

Table 1.1: Enterprise Selection Factors

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)

Criteria prioritization

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 (Kersuliene et al., 2010). Using his or her own implicit knowledge, information and experience the expert from project team evaluate each criterion, hence this method can be defined as an expert-oriented method (Zolfani et al., 2013). It is capable to estimate the differences of significance of attributes. 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 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;

$$Kj = Sj + 1 \qquad (1.1)$$

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

$$Wj = \frac{Xj - 1}{Kj} \qquad (1.2)$$

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

$$qj = \frac{Wj}{\sum Wj} \qquad (1.3)$$

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.

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 and further extended by Brans and Mareschal (1994). 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). The evaluation Table, where the alternatives are evaluated on the different criteria, is the starting point of the PROMETHEE method. The PROMETHEE I method can provide the partial ordering of the decision alternatives, whereas, PROMETHEE II method can derive the full ranking of the alternatives.

The PROMETHEE methods are an interactive multi-criteria decision-making approach designed to handle quantitative as well as qualitative criteria with discrete alternatives. In this method, pair-wise comparison of the alternatives is performed to compute a preference function for each criterion. Based on this preference function, a preference index between alternatives has been computed. The PROMETHEE methods can classify the alternatives which are difficult to be compared because of a trade-off relation of evaluation standards as non comparable alternatives and the PROMETHEE methods has significant advantages over the other MCDM approaches (Athawale & Chakraborty, 2010).

In the proposed study, 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 (Doumpos and Zopounidis, 2004):

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

$$NDM_{ij} = [\ Z_{ij} - \min(Z_{ij})] \ / \ [\ \max(Z_{ij}) - \min(Z_{ij})] \quad (1.4)$$

where (i = 1,2,…,n; j = 1,2,…,m)

And Zij 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:

$$NDM_{ij} = [\ \max(Z_{ij}) - Z_{ij}\ ] \ / \ [\ \max(Z_{ij}) - \min(Z_{ij})] \quad (1.5)$$

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

Step3: Calculate the preference function pf_j (i, i').

There are mainly six types of generalized preference functions (Athawale & Chakraborty, 2010). These preference functions require the definition of some preferential parameters, such as the preference and indifference thresholds. However, in real time applications, it may be difficult for the decision maker to specify which specific form of preference function is suitable for each criterion and also to determine the parameters involved. In consultation with decision makers, the following simplified preference function is adopted here:

$$Pf_i\,(i, i') = 0, \qquad \text{if } NDM_{ij} \le NNDM_{ij} \quad (1.6)$$

$$Pf\,(i, i') = (NDM_{ij} - NDM_{i'j}), \qquad \text{if } NDM_{ij} \ge NNDM_{ij} \quad (1.7)$$

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

$$APf(i, i') = \left[\sum_{j-1}^{m} wj x Pfi(i, i')\right] \Big/ \sum_{j=1}^{m} wj \quad (1.8)$$

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

$$\psi^+(i) = \frac{1}{n-1} \sum_{i'=1}^{n} APf\,(i, i') \quad (1.9)$$

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

$$\psi^-(i) = \frac{1}{n-1} \sum_{i'=1}^{n} APf\,(i', i) \quad (1.10)$$

where n is the number of alternatives.

Here, each alternative faces (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.

$$\psi(i) = \psi^+(i) - \psi^-(i) \quad (1.11)$$

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.

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 pair-wise comparisons to be completed (Macharis et al., 2004). Outranking methods like PROMETHEE are better suited to perform extensive sensitivity analysis (Turcksin et al., 2011; Jain, 2012; Yadav et al. 2013).

The complete framework for a competent ERP system selection proposed in this study from the very beginning of formation of decision maker's team to the selection of final alternative has been shown in the following flow chart (Figure 1.1).

Case Study

The proposed framework was applied for ERP system selection at a production unit of a leading asian electronics company. 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.

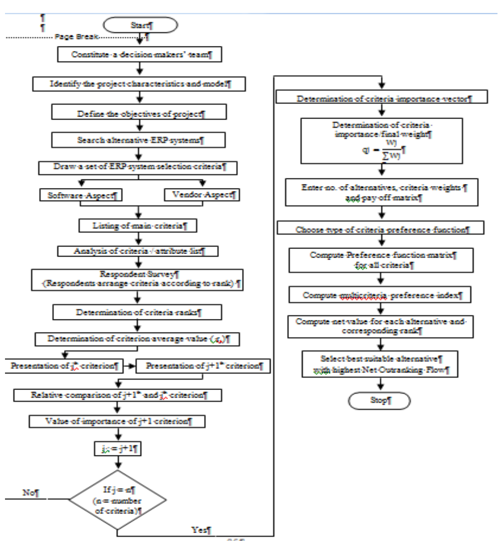

Figure 1.1: ERP system selection framework (Shukla et al. 2016)

1. Application of SWARA Method

SWARA method is used for finding the weight of the criteria in the model. The results of SWARA are shown in the table1.2 and table 1.3. The method is established based on experts' ideas. Table 1.2 consists of the weights of software related factors and table 1.3 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 1.2: Weights of Software related factors

Criterion	Comparative importance of average value (S_j)	Coefficient (K_j)	Recalculated Weight (W_j)	Weight (q_j)
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 1.3: Weights of Vendor related factors

Criterion	Comparative importance of average value (S_j)	Coefficient (K_j)	Recalculated Weight (W_j)	Weight (q_j)
T		1	1	0.487
S	0.613	1.613	0.620	0.302
Re	0.431	1.431	0.433	0.211

2.Supplier's ranking using PROMETHEE

The criteria for supplier selection have been categorized and their importance weights have been identified (Table 1.4) using SWARA method. A pool of 5 suppliers is now rated on the basis of selected criteria. The alternatives were denoted as V1, V2, V3, V4 and V5. Each supplier is rated on a scale 0-1 for each criterion. The alternative evaluation matrix for software related factors and vendor related factors are shown in Table 1.5 and Table 1.6 respectively. To rank the five available alternatives using PROMETHEE method equation (1.4) - (1.11) are used. To start with the procedure first of all the supplier scores for software related factors have been normalized with reference to benefit and loss criteria. Equation (1.4) was used to generate normalized decision matrix for software related factors and vendor related factors.

The final weights of the criteria and adopted preference function is used to generate aggregated preference function matrix using equation (1.8). Table 1.7 depicts the aggregated preference matrix for software related factors. Aggregate preference functions for alternatives are calculated and using equation (1.9) and (1.10) the leaving and entering outranking flows is computed.

Table 1.7: Aggregated preference function considering software factors

Table 1.7: Aggregated preference function considering software factors

	V1	V2	V3	V4	V5
V1	0	0.114	0.078	0.300	0.188
V2	0.076	0	0.071	0.234	0.165
V3	0.113	0.145	0	0.316	0.241
V4	0.054	0.027	0.035	0	0.073
V5	0.043	0.057	0.060	0.174	0

Equation (1.11) 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 1.8 shows the rank of alternatives evaluated on the basis of software related factors. Amongst the five alternatives propounded in table 1.8, we selected the first three alternatives with higher Net Flow values in order to evaluate them on the basis of vendor related factors.

Table 1.8: Leaving and entering flow for different alternatives (Software factors)

	Leaving	Entering	Net Flow	Rank
V1	0.170	0.071	0.098	*2*
V2	0.137	0.086	0.051	*3*
V3	0.204	0.061	0.143	*1*
V4	0.047	0.256	-0.209	*5*
V5	0.083	0.167	-0.083	*4*

For the three alternatives with higher Net Flow values, normalized decision matrix for vendor related factors was generated using equation (1.4). Similarly equation (1.8) is applied to generate the aggregated preference matrix for vendor related factors (Table 1.9). Equation (1.9) and (1.10) are used to determine leaving and entering outranking flows and the Net outranking flow is calculated through equation (1.11). As a result it is found that alternative V2 exhibits maximum Net Flow value, consequently it became the most suitable option (Table1.10).

Table 1.9: Aggregated preference function considering vendor factors

	Leaving	Entering	Net Flow	Rank
V1	0.170	0.071	0.098	*2*
V2	0.137	0.086	0.051	*3*
V3	0.204	0.061	0.143	*1*
V4	0.047	0.256	-0.209	*5*
V5	0.083	0.167	-0.083	*4*

Table 1.10: Leaving and entering flow for different alternatives (Vendor factors)

	Leaving	Entering	Net Flow	Rank
V1	0.165	0.178	-0.014	*2*
V2	0.392	0.134	0.258	*1*
V3	0.046	0.290	-0.245	*3*

Conclusion

Due to uncertainty in the judgments there is no amicable way to evaluate and select suppliers, that's why organizations use a variety of different approaches, implementing the one that suits best depending on the company's particular requirements. In the present case, we adapted SWARA,to evaluate the criteria and then PROMETHEE to rank the available alternatives respectively.

Based on literature review, views of experts from areas of academics and ERP experts from industries, criteria and sub criteria for supplier selection were selected. The criteria are classified into two categories and further under 8 constructs. Cost, usability, functionality, flexibility, reliability are identified as software related factors whereas reputation, technical capability and service as vendor related factors. It was found that amongst software related factors the criteria 'functionality' possesses highest importance with 36.1% followed by 'flexibility' 23.5%. For vendor related factors criterion 'technical capability' and 'service' are the criteria of prime importance with weights 48.7% and 30.2% respectively.

References

[1] APICS Dictionary, 1998. APICS. *The Educational Society for Resource Management. Alexandria, Virginia, 9th edition.*

[2] Athawale, V.M. and Chakraborty, S., 2010. Facility location selection using PROMETHEE II method. *Proceedings of the 2010 international conference on industrial engineering and operations management*, pp. 9-10.

[3] Brans, J.P. and Mareschal, B., 1994. The PROMCALC & GAIA decision support system for multicriteria decision aid. *Decision support systems,* 12(4/5), pp. 297-310.

[4] De Brucker, K., Verbeke, A. and Macharis, C., 2004. The applicability of multicriteria-analysis to the evaluation of intelligent transport systems (ITS). *Research in Transportation Economics,* 8, pp. 151-179.

[5] Doumpos, M. and Zopounidis, C., 2004. A multicriteria classification approach based on pairwise comparisons. *European Journal of Operational Research,* 158(2), pp. 378-389.

[6] Jain R., 2012. Supplier selection in SCM using integrated Data mining-MCDM approach in context of Indian manufacturing industry *(Doctoral dissertation).*

[7] Kersuliene, V., Zavadskas, E.K. and Turskis, Z., 2010. Selection of rational dispute resolution method by applying new stepwise weight assessment ratio analysis (SWARA). *Journal of*

Business Economics and Management, 11(2), pp. 243-258.

[8] Macharis, C., Springael, J., De Brucker, K. and Verbeke, A., 2004. PROMETHEE and AHP: The design of operational synergies in multicriteria analysis: Strengthening PROMETHEE with ideas of AHP. *European Journal of Operational Research,* 153(2), pp. 307-317.

[9] Shukla, S. and Mishra, P. K., 2016. Unification of ERP system selection factors: an integrated decision making approach. *ELK Asia Pacific Journals (Special Issue),* ISBN: 978-81-930411-8-5.

[10] Shukla, S., Jain, R. and Mishra, P.K., 2016. An integrated approach for Identification of Critical Factors for ERP Implementation using Entropy and WASPAS method. *MIT International Journal of Mechanical Engineering,* 6 (2), pp. 80-89.

[11] Shukla, S., P.K. Mishra, Jain R. and Yadav, H. C., 2016. An integrated decision making approach for ERP system selection using SWARA and PROMETHEE method. *International Journal of Intelligent Enterprise (IJIE),* 3 (2), pp. 120-147.

[12] Turcksin, L., Bernardini, A. and Macharis, C., 2011. A combined AHP-PROMETHEE approach for selecting the most appropriate policy scenario to stimulate a clean vehicle fleet. *Procedia-Social and Behavioral Sciences,* 20, pp. 954-965.

[13] Yadav, H.C., Jain, R., Shukla, S. and Mishra, P.K., 2012. Prioritized aesthetic attributes of product: A fuzzy-AHP approach. *International Journal of Engineering Science and Technology,* 4(4), pp. 1281-1291.

[14] Yadav, H.C., Jain, R., Shukla, S., Avikal, S. and Mishra, P.K., 2013. Prioritization of aesthetic attributes of car profile. *International Journal of Industrial Ergonomics,* 43(4), pp. 296-303.

[15] Zolfani, S.H., Aghdaie, M.H., Derakhti, A., Zavadskas, E.K. and Varzandeh, M.H.M., 2013. Decision making on business issues with foresight perspective; an application of new hybrid MCDM model in shopping mall locating. *Expert systems with applications,* 40(17), pp. 7111-7121.