SELECTION OF ERP VIA COST-BENEFIT ANALYSIS UNDER UNCERTAINTY CONDITIONS

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Abstract: Enterprise resource planning systems are used to collect wide range of data and to manage different business processes in any organization. The selection of most suitable system for the need of the enterprise is a challenge due the dynamic and competitive environment and variety of such systems. Another important issue in the selection process is the perspective of company development. In this regard, the paper considers the problem of enterprise resource planning system when uncertainty conditions are available. Some well-known optimization strategies are used to overcome the uncertainty considering different possible company perspectives. For the goal, utility function based on cost-benefit analysis is introduced and is used for estimation of uncertainty conditions. The results of numerical testing show the applicability of the proposed approach in selection of the enterprise resource planning system under uncertainty conditions.

Keywords: *Enterprise resource planning systems, cost-benefit analysis, uncertainty conditions, optimal decision making.*

1. INTRODUCTION

Due to the dynamic and competitive environment, evaluating the return on an IT project becomes a complex problem. This is related with estimation of pros of IT project's return before the project is undertaken including cost benefit

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calculations [Murphy & Simon, 2001]. The systems for enterprise resource planning (ERP) are complex business management systems that integrate applications across different aspects of business processes into one powerful software system. The usage of most suitable ERP system helps to the success the company and makes possible to stay the competitive on the market.

The rapid development of IT industry significantly influence on all aspects of life. This also impact on the progress and development of ERP systems. ERP systems can be classified depending on its hosting: traditional ERP, on-premises ERP and most recent cloud ERP or a combination some of them. On-premise ERP systems are installed and run (in the building) of the organization, while hosted ERP is defined as service and involve an organization's ERP software applications on a vendor's servers. A very promising trend of computing and in the software industry is the cloud computing [Elmonem et. al., 2016]. Cloud computing and Software as a Service (SaaS) are two terms used synonymously, they are different, but closely related. Although SaaS ERP is a type of cloud computing, not all cloud ERP can be considered as SaaS [Knox, 2016]. ERP in SaaS means, to deliver an ERP system "as a service" [Johansson & Ruivo, 2013]. Despite the potential and attractiveness of cloud computing some issues in this model needs to be resolved like: security, temporary loss of service (outages) and interoperability are the most important among them [Sultan, 2013].

Many vendors of ERP systems claim that their software is universal and configurable to the needs of any business organization, but some contextual factors, such as company size and location or nationality play important roles in the selection and adoption process [Aslan et al., 2015]. ERP systems today integrated different functional modules to support business processes and to reflect different aspects of organization including related activities business intelligence to provide dynamic reports. All of this requires carefully analyzing the advantages and disadvantages of proposed ERP systems to make the right choice in respect to the objectives of organization. For example, different customizations of on-site ERP software can be done, but they are related with current software version and could be difficult to re-implement in future versions. Cloud applications built upon on previously implemented customizations and integrations are updated automatically without the need of additional changes. The choice of the most suited ERP system is a challenge due different performance indicators that should to be considered. In this respect, there exist different approaches to tackle with the problem of ERP system selection as: integrated fuzzy multi criteria group decision making [Efe, 2016]; hybrid MCDM methodology for ERP selection problem with interacting criteria [Gurbuz, et. al., 2012]; artificial neural network based on analytic network process [Yazgan et al., 2009]; integrated decision making approach [Karsak & Ozogul, 2009], etc. Boillat and Legner synthesize the strategic choices for enterprise software vendors and provide guidelines for designing viable business models [Boillat & Legner, 2013]. It describes perspective on cloud-based enterprise software as enterprise SaaS and identifies the emerging enterprise software platforms as additional business model configuration. The problem of ERP selection can be done by hybrid multicriteria decision making model based on analytic network process, choquet integral and measuring attractiveness by a categorical based evaluation technique. It start with the identification of most prevailing criteria, using a fuzzy analytic hierarchy process to obtain the relative importance of the criteria and then rank the decision alternatives via technique for order preference by similarity to ideal solution [Kilic et. a., 2014]. Lopeza and Ishizak [Lopez & Ishizaka, 2017] propose a group analytic hierarchy process sorting method for sorting the problems with a large number of alternatives. A group decision-making approach integrated simple multi-attribute rating techniques and combinatorial optimization contribute also to the process of selection [Borissova, et al., 2016; Mustakerov & Borissova, 2014]. Furthermore, some intelligent approaches to optimal strategy defining based on costs-benefit analysis could be viewed as appropriate tool for selection of ERP [Mustakerov & Borissova, 2013].

Unlike the described selection techniques for ERP, none of them take into account uncertainty conditions in regard to the perspective of company development. Thus, the paper aims to propose an approach for selection of ERP system under uncertainty conditions. Four well-known optimization strategies are used to overcome the uncertainty considering different possible states. The main idea is to illustrate how overcome the uncertainty conditions in selection of ERP and how the selected strategy to deal with uncertainty influence on the selection of ERP system. The evaluation of ERP systems is done by using of cost-benefit relation in regard to the different possible perspectives of company. The rest of the paper is organized in 5 sections concerning: 1) description of the problem, 2) decision making under uncertainty conditions, 3) numerical testing, 4) result analysis and discussion, and 5) conclusion.

2. DESCRIPTION OF THE PROBLEM

The right choice of ERP system should integrate various business processes from different functions and activity of the company. In this process of ERP selection an authorized committee identifies all requirements toward different functional modules like procurement, sales, production, accounting, warehouse, dynamic reporting all of them, etc. All of these considerations are to be taken into account together with company perspective and its business strategies.

Due the competitive and dynamic economy it is necessary to consider different perspectives of the company's development before purchasing the ERP system. In this regard, the problem is how to select the ERP system when uncertainty conditions are available. There is no single answer, but some well-known optimization strategies could be used to overcome the uncertainty considering different possible perspectives. The ultimate goal is to select the most appropriate ERP system considering uncertainty conditions and how selected strategy for making the decisions in uncertainty influence on the selection of ERP software.

3. DECISION MAKING UNDER UNCERTAINTY CONDITIONS

During the decision making process the DM or executive manager have to analyze a set of different alternatives with many different possible consequences. Furthermore, in some situations this process is related also with uncertainty conditions. Making the decision in uncertainty conditions suppose that DM understanding the goals to be achieved, but information for alternatives is incomplete. Generally, there is not enough data to evaluate the risk of each alternative. In such cases, the preferences of DM can be represented by so called utility function $f(a)$ over a set of alternatives $A = \{A_1, A_2, \ldots, A_m\}$ under different environment states $s = \{s_1, s_2, \ldots, s_n\}$. This allow the DM to assess the usefulness of given alternatives A_i, $(i = 1, 2,\ldots,m)$ by means of following optimization problem [Borissova & Mustakerov, 2013]:

(1) $$a_{opt} = \max f(a)$$

subject to

(2) $$a = \{a_1, a_2,\ldots,a_m\}$$

(3) $$s = \{s_1, s_2,\ldots,s_n\}$$

There exist some optimization criteria that could be used to deal with problem of uncertainty – Wald criterion, Savage minimax regret criterion, Laplace Criterion, and Hurwicz criterion [Vemic, 2017].

In the Wald criterion DM selects the strategy associated with the best possible worst outcome regardless of whether probabilities are available or not. For each alternative A_i $(i = 1, 2,\ldots, m)$ the worst output are to be determined as $\min E_{ij}$ $(j= 1, \ldots ,n)$. The best alternative is determined as a solution for which the $\min E_{ij}$ $(j=1,\ldots,n)$ has maximum magnitude [Harrell., 2015; Pawitan, 2013] as follows:

(4) $$A_{opt} \Rightarrow \max \min E_{ij} \; (i=1,2,\ldots,m), (j=1,2,\ldots,n)$$

The Savage minimax regret criterion, does take all payoffs into account is the minimax regret rule, which represents a pessimistic approach where DM looks at a small loss of efficiency due to missed opportunities using the following relation:

(5) $$R_{ij} = | E_{ij} - max\ E_{ij} |$$

The optimum value is the value of minimum losses R_{ij} among the alternatives:

(6) $$A_{opt} \Rightarrow min\ max\ R_{ij}\ (i=1,2,\ldots,m),\ (j=1,2,\ldots,n)$$

The Laplace criterion is probable the most intuitive criterion – if the value of the indicator is stochastic, it could be represented by its expected value and the optimal solution is determined as:

(7) $$A_{opt} \Rightarrow max_i\left(\sum_{j=1}^{n}\frac{E_{ij}}{n}\right)$$

Hurwicz criterion is also known as realistic criterion as the DM should subjectively set the weight for degree of optimism [Schniederjans, et. al., 2010]. The optimism coefficient α take values within the range of $0 < \alpha < 1$. When optimism coefficient is equal to zero ($\alpha = 0$), i.e. pessimistic, the Hurwicz solution is the same as the pure Wald solution. If $\alpha = 1$, i.e. DM is optimistic and consider maximum favourable environment. Selection of optimal alternative accordingly Hurwicz criterion requires to determine: 1) value for optimism coefficient α; 2) maximum and minimum payoff for given alternatives; 3) selection of optimal alternative as a result of the following expression:

(8) $$A_{opt} \Rightarrow max\ \{\alpha\ max\ E_{ij} + (1 - \alpha) min\ E_{ij}\}$$

where $(1 - \alpha)$ represent the coefficient of pessimism.

All of these criteria could be used to overcome the uncertainty in decision making process depending on the selected strategy.

3.1. Determination of utility function for evaluation of ERP system

There exist different elements that influence on total costs of ERP. Mainly, the costs of ERP system are associated with costs for purchasing that represent the paid amount for buy the system. Other elements contributing to the overall costs are related with 1) customization; 2) installation; 3) testing for technically and functionally after installation; 4) staff training; 5) change some working procedures; 6) conversion of files, uninstalling the old system, etc. [Zuyderduyn, 2011]. Implementation of ERP system certainly has considerable benefits. The benefits of proper ERP using influence on 1) reducing manual handling and respectively labor costs, 2) in-time delivery policy and reducing the need for keeping stock, 3) improving reliability by new policy for loyal clients, 4) using of more automated processes, etc. [Zuyderduyn, 2011].

In the current paper, the selection of ERP system is relying on cost-benefits evaluations for some suitable alternative software to choose from. The cost-benefit analysis is a relatively clear tool to determine if an investment decision is sound. As quantitative analytical tool the cost-benefit analysis can be used to assist the decision making [Boardmanet al., 2010]. For the goal, the utility function based on cost-benefit estimation should represent the ratio of cost and revenue if particular software is implemented in the company:

$$CBE = \frac{Cost}{Revenue} = \frac{C_{ac} + C_{cust} + C_{inst} + C_{test} + C_{staff} + C_{proc} + C_{file} + C_{un} + C_{np}}{R_{lcr} + R_{kis} + R_{lc} + R_{ap}} \quad (9)$$

The *Cost* express the total cost obtained by summing costs for acquisition (C_{ac}), customization (C_{cust}), installation (C_{inst}), testing for technically and functionally after installation (C_{test}), staff training (C_{staff}), change some working procedures (C_{proc}), conversion of files (C_{file}), uninstalling the old system (C_{un}), new policy for loyal clients (C_{np}). The *Revenue* is the expected incomes related with labor costs reducing (R_{lcr}), reducing the need for keeping stock (R_{kis}), improving reliability by new policy for loyal clients (R_{lc}), using of more automated processes (R_{ap}).

Using of cost-benefit analysis make it is possible to estimate the value of costs and benefits that are expected as a result from particular activity.

4. NUMERICAL TESTING

To illustrate the proposed approach for selection of ERP system under uncertainty conditions a set of 3 alternatives of ERP system are investigates toward 3 possible situations. These situations could be described as follows: 1) in case of increase in requests; 2) in case of decrease in requests; and 3) in case of no changes. The total cost is the sum of costs for acquisition, customization, installation, testing for technically and functionally after installation, staff training, change some working procedures, conversion of files, uninstalling the old system. The policy for loyal clients requires corresponding discounts that is another element of costs. The *Revenue* parameter estimated as incomes from labor costs reducing, decreasing of cost for keeping the items in stock, improving income by policy for loyal clients, expected income from more automated processes using.

The evaluations of three alternatives ERP software by using the proposed utility function (9) toward three expected scenarios are shown in Table 1.

Table 1. Payoff matrix

Alternatives	S-1 increase in requests	S-2 decrease in requests	S-3 without changes
A-1	0.82	0.63	0.75
A-2	0.80	0.66	0.72
A-3	0.84	0.64	0.71

When pessimistic criterion is used (Wald criterion), the minimum value for each alternative is chosen and then the maximum of these values is selected:

$$A_{opt} = \max(0.63; 0.66; 0.64) = 0.66$$

Using of Wald criterion to take into account uncertainty, the optimal decision should be alternative A-2.

The minimax regrets accordingly the Savage's criterion is calculated as follows:

$$r_{i1} = \max(0.82; 0.80; 0.84) - E_{i1}$$
$$r_{i2} = \max(0.63; 0.66; 0.64) - E_{i2}$$
$$r_{i3} = \max(0.75; 0.72; 0.71) - E_{i3}$$

The calculated regrets in case of Savage's criterion using are shown in Table 2.

Table 2. Savage's Minimax Regrets

Alternatives	Regrets			Minimax
A-1	0.02	0.03	0	0.03
A-2	0.04	0	0.03	0.04
A-3	0	0.02	0.04	0.04

The optimal decision when Savage's criterion is used indicates that alternative A-1 has the lowest regret and should be the best choice:

$$A_{opt} = \min (0.03; 0.04; 0.04) = 0.03$$

Applying of Laplace criterion results in following calculation to determine the optimal alternative:

$$A_{opt} = \max\{(0.82+0.63+0.75)/3, (0.80+0.66+0.72)/3, (0.84+0.64+0.71)/3\} =$$
$$= \{0.7333; 0.727; 0.730\} = 0.733$$

The optimal decision in case of Laplace criterion using shows that alternative A-1 are to be selected.

To perform the Hurwicz criterion, a value for optimism coefficient α is to be set. It is assumed that optimism coefficient is equal to 0.3. The optimal alternative is calculated as follows:

$$A_{opt} = \max\{(0.3*0.82 + 0.7*0.63), (0.3*0.80 + 0.7*0.66), (0.3*0.84 + 0.7*0.64)\} = \\ = \max\{0.687, 0.702, 0.7\} = 0.702$$

In case of Hurwicz criterion using, the optimal decision is to select the alternative A-2.

5. RESULT ANALYSIS AND DISCUSSION

The results of numerical testing for selection of ERP system under uncertainty condition demonstrate the applicability of using optimization criteria of Wald, Savage, Laplace, and Hurwicz. These optimization criteria together with the proposed relation for costs-benefit ratio (9) contribute to determine optimal alternative considering uncertainty conditions. These optimization criteria together with the proposed relation for costs-benefit ratio (9) contribute to determine optimal alternative considering uncertainty conditions expressed via three possible states. Applying the Wald criterion, the decisions are ranked in accordance to their worst-case outcomes and the optimal decision is alternative *A-2* with the least worst outcome. The optimal decision when looking for a small loss of efficiency due to missed opportunities (according to Savage's criterion) determine alternative *A-1* as the best choice. The optimal decision in case of equal probability for all possible states when no other information is available (Laplace criterion) determine alternative *A-1* as optimal decision. Hurwicz criterion incorporates a measure of optimist and pessimist criteria by a certain weight for optimism $\alpha = 0.3$ and for pessimism $(1 - 0.3)$, which determine the optimal decision is to be alternative *A-2*. The results of Hurwicz criterion application depend on defined value for the optimism coefficient α. All of these four criteria lead to different optimal decisions (alternative A-1 and alternative A-2) depending on the selected strategy to tackle with uncertainty conditions. That is why carefully should be selected the most appropriate strategy for decision making to overcome the conditions of uncertainty.

The proposed approach could be coded and implemented in the environment of spreadsheet as a tool to assist the decision making. This would make it easier for managers in decision-making when uncertainty conditions are available to make reasoned decisions.

6. CONCLUSION

The paper describes an approach for selection of ERP system under uncertainty conditions as the fact of business reality. A key factor for success in today's competitive environment of any organization is the use of suitable ERP system. The current paper is focused on cost-benefit utility function for estimation of

ERP system taking into account some future company states (business perspectives). The applicability of the proposed approach is illustrated in selection of ERP system with three possible company perspectives: 1) increase in requests; 2) decrease in requests; and 3) without changes. As a result of this approach numerically proved optimal alternative is determined using of proposed utility function and some well known optimization criteria to overcome the uncertainty. It should be noted that selected strategy to deal with uncertainty influences on the optimal decision and it choice should be carefully considered. In the future it is interesting to consider other utility function to evaluate the ERP system and to compare the optimal decisions under same strategies used to tackle with uncertainty conditions.

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