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A SIMULATION BASED OPTIMIZATION METHODOLOGY for INFORMATION SYSTEM PROJECT SELECTION PROBLEM

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ABSTRACT
Information system (IS) project selection is a strategic decision problem discussed by many researchers for more than 40 years. Prior IS project selection approaches are considered this problem as a very complex decision making process since it is affected many selection criteria, limited resources, and one or more corporate objectives. In addition, there is a high level of risk for the uncertainty when determining the different input data such as weights of evaluation criteria and performance values of candidate projects. However, little attention has been paid so far to take into account these uncertainties in the IS project selection process. In this paper, considering possible uncertainties in the input data of IS project selection problem, a methodology that incorporates simulation optimization linked to a multi-criteria approach into the selection process for the best IS project alternative is presented. An illustrative example is provided in order to demonstrate the application of the proposed methodology.
Keywords: IS project selection, simulation based optimization, multi-criteria decision making, uncertainty.

1. INTRODUCTION
In the project selection problem, a decision maker has to allocate limited resources to a set of alternative projects by considering multiple, conflicting, incommensurate criteria and one or more corporate goals or objectives [1,2]. Due to the complexity of the problem, project portfolio selection has been the topic discussed by many researchers for a long period of time [3]. Selecting the right information system (IS) project from a pool of potential ones is a significant resource allocation decision that can enhance operational competitive advantage of a business [4]. By reason of the strategic importance of IS project selection for enterprises, the research on the project selection has also been applied to this area for more than 40 years.
According to Chen and Cheng [4], IS project selection problem is difficult, because there are lots of quantitative and qualitative factors to be considered in the candidate projects such as business goals, benefits, project risks and available resources. Hence, in the literature, numerous integrated methodologies that use various methods such as goal programming, analytic hierarchy process (AHP), analytic network process (ANP), quality function deployment (QFD), data envelopment analysis (DEA), balanced score card (BSC) have been developed to address this problem, see [5] for a recent literature review on methods and tools supporting IS project selection.
IS project selection takes place in an incomplete, intangible and uncertain information environment. In addition, it is very common to require multiple decision makers before making a IS project selection decision. There is a high level of risk for the uncertainty or incompleteness of the problem when

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determining the different input data such as weights of evaluation criteria and performance values of candidate projects. On the one hand, some factors like user based criteria are subjective. Linear mathematical models that are commonly used in the IS project selection is insufficient to overcome the subjectivity of judgments, since the human subjective evaluation does not always hold linearity [6]. On the other hand, some factors such as project risk based criteria, organizational requirements based criteria etc. are difficult to measure quantitatively. Hence, there is a need to make IS project selection decision based on qualitative processes [7].
However, detailed review of the previous researches shows that identifying the best set of IS projects with uncertain input data has received less attention in the IS project selection literature. According to Shakhsi-Niaei et al. [1], this lack of attention occurs also in the project selection literature. Hence, in this paper we tried to fill this gap by presenting an easy to understand methodology that considers possible uncertainties in the input data and deals with real-world constraints of IS project selection problem. The proposed methodology uses the advantages and capabilities of Analytic Hierarchy Process (AHP), Monte Carlo simulation and linear optimization. In the following section, we provide the details of the proposed methodology.

2. PROPOSED INFORMATION SYSTEM PROJECT SELECTION METHODOLOGY

The proposed simulation optimization based methodology consists of three phases, namely problem formulation, performing AHP analyses, and simulation based optimization. Figure 1 represents the first two phases, while Figure 2 represents the third phase of the proposed methodology with detailed steps and the outputs of each phase.

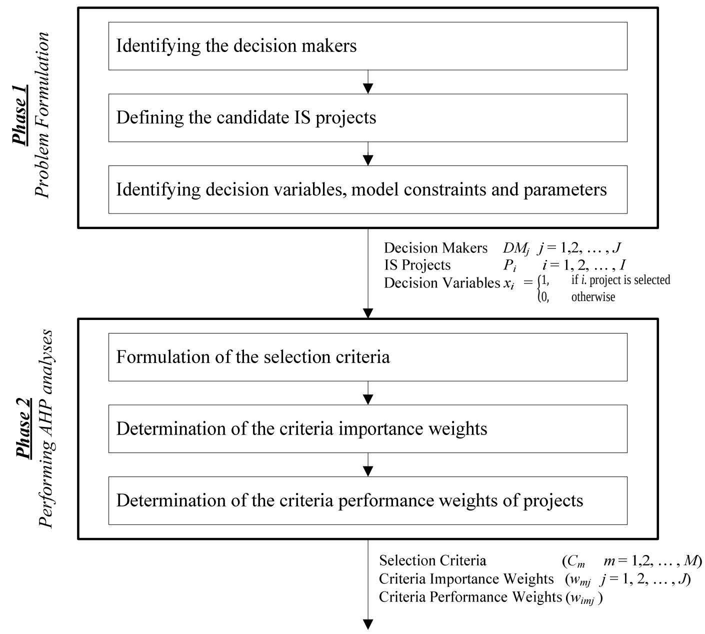

Figure 1. The first two phases of the proposed methodology

3. ILLUSTRATIVE EXAMPLE

A leading company in Turkey's clothing industry has to select an appropriate IS project among a pool of potential ones. A cross-functional team of 15 decision makers (DM_j, j=1, 2,…,15) has been formed to conduct the selection process. After preliminary investigations, three candidate projects, P_1, P_2, and P_3, remain for further analyses. x_i is determined as a 0-1 variable, where i = 1,2,3 possible projects to be select from and where x_i = 1, then select the ith IS project or when x_i = 0, then do not select ith IS project. Thereafter, team members reach consensus on the model constraints that must be considered in the selection from the available pool of three IS projects: (1) maximum of 180 days of analyses time, (2) maximum of 40 days of programming time, (3) maximum license cost of $200000, (4) maximum hardware cost of $150000, (5) maximum training cost of $50000, (6) maximum maintenance cost of $20000 is available to complete the selected IS project. The cost and time usage information for each of 3 projects are also obtained to set the constraint parameters. After an extensive literature review on IS project selection criteria in the previous researches, the team develops a set which includes 6 main criteria namely, financial (C_1), organizational (C_2), technical (C_3), environmental (C_4), risk (C_5), and user factors (C_6). By using pairwise comparison matrices of AHP, 15 decision makers compare these criteria to set importance weights, w_{mj} s (m=1,2,…,6; j=1,2,…15). Again, they compare the project alternatives with respect to each criterion in order to obtain criteria performance weights w_{imj} s (i=1,2,3).

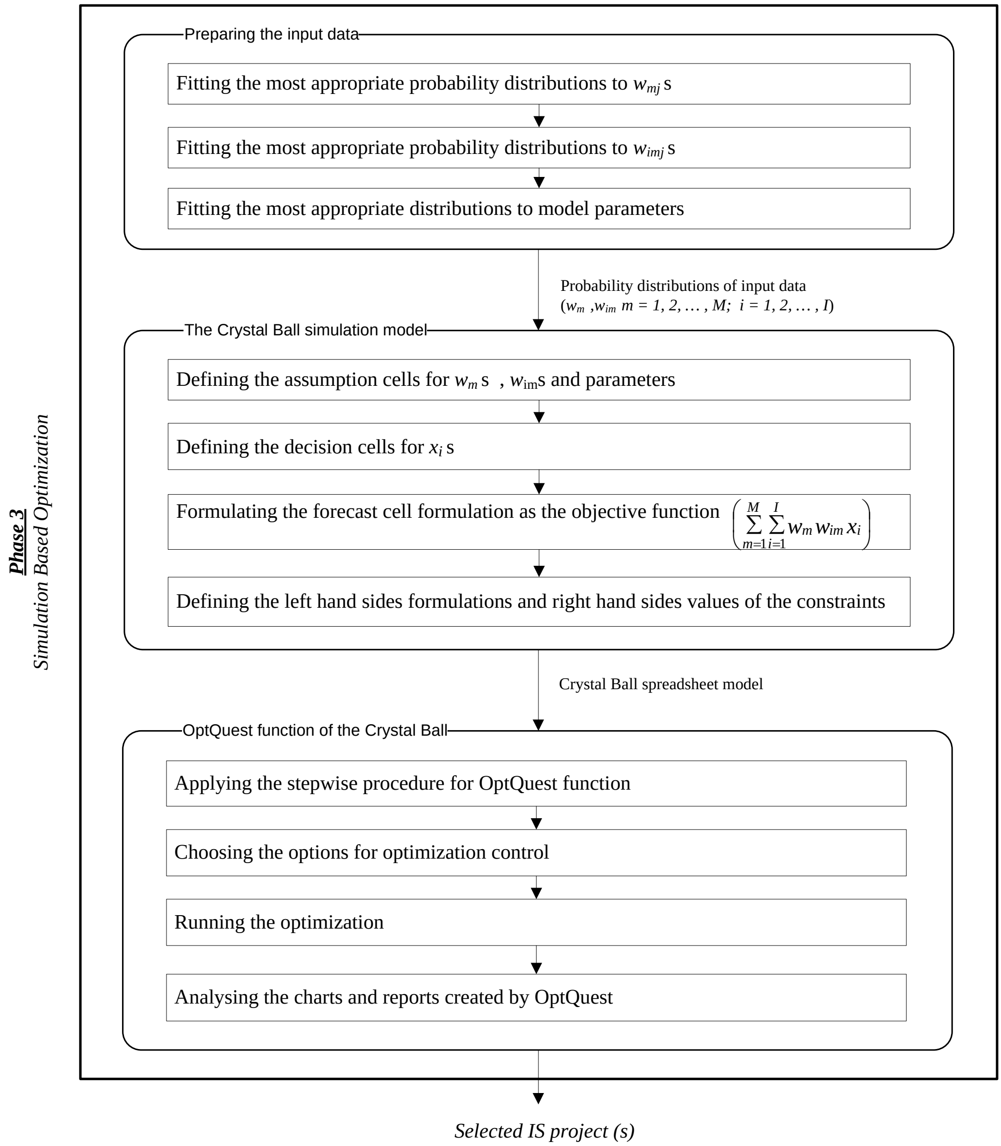

Figure 2. The third phase of the proposed methodology

All steps of the phase 3 in our proposed methodology are performed by using the Crystal Ball simulation model, an application of Monte Carlo simulation. Crystal Ball enhances the spreadsheet by creating assumptions cells for entering distributions and forecast cells for key outputs described by formulas [8]. In the "preparing the input data" step, the probability distributions of w_{mj} s and w_{imj} s derived from AHP analyses are fitted using "Fit" option in the "Define assumption" element of the Crystal Ball to generate probabilistic variables w_ms and w_{im}s. In this way, the probability distributions of the w_{mj} s are respectively fitted to lognormal, lognormal, normal, weibull, triangular, and normal. Criteria performance values of the projects, w_{imj} s, and cost and time parameters of three projects are determined as uniform distributions with min and max probable values. In the spreadsheet, all assumptions and decision cells are defined, then forecast cell is formulated as total performance value formulated as $\sum_{m=1}^{6}\sum_{i=1}^{3} w_m w_{im} x_i$. Since the left hand sides of the model constraints (total license cost, total hardware cost, total analyses time etc.) are formulated by multiplying each project parameter in the assumption form by the related decision variable and summing over all projects, they are treated as forecasts in the Crystal Ball model and defined as requirements in the OptQuest element. Right hand side values are defined by placing an upper bound on the requirements. Finally, the Crystal Ball's OptQuest optimizer feature is ready to explore the combinations of the decision variables that would maximize the final performance value. Before running OptQuest function, maximum number of simulation is set to 100, maximum number of trials in each simulation is set to 1000, confidence level is specified at 95% and sampling method is set to Latin hypercube. The simulation shows that Project 1 is selected (x_1=1, x_2=0 and x_3=0) with the maximized final performance value, while preserving feasibility in terms of all requirements of the model.

4. CONCLUSIONS

A simulation optimization based methodology for IS project selection problem is proposed in this paper. By using simulation optimization in the problem, all possible uncertainties in the input factors can be handled and much more scenarios than the traditional optimization methods can be produced. A multi-criteria decision making method, AHP, is embedded into the methodology in order to obtain priority scores of the project alternatives. The Crystal Ball OptQuest simulation software is used in the proposed methodology, since it offers all the required features to conduct simulation optimization. As a conclusion, the proposed methodology is able to effectively incorporate the real-world constraints and deal with possible uncertainties which have the most effect on the IS project selection decision. For a future study, we can conduct a comparative analysis between the results of the model with the existing models in the literature.

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