A SOFTWARE TOOL FOR IT PROJECT SELECTION (PROSEL)

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SUMMARY

With the increasing expenditure into IT projects, a systematic evaluation of investment options is needed. This paper proposes a user-friendly software tool (PROSEL) capable of modelling the effects of both monetary (tangible) and non-monetary (intangible) aspects of an IT investment option, using interval mathematics and possibility theory to handle the inherent uncertainty associated with such aspects. A case study with a large development and construction company is used to demonstrate its application in the assessment and ranking of available IT investment options.

INTRODUCTION

In recent years, there has been growing interest in developing decision-making tools to aid the IT project selection process. These decision-making tools include scoring (Lucas, 1976), ranking (Buss, 1983), goal programming (Badri et al., 2001), option pricing theory (Ho and Liu, 2000), probability theory (Marsh and Flanagan, 2000), possibility theory (Coffin and Taylor, 1996) and the analytical hierarchy process (Tam and Tummala, 2001). These tools are based on the premise of selecting the project(s) that will best meet the organisation's objectives. In doing so, organisations are expected to be able to critically evaluate each project based on estimated total benefit and costs. In view of the uncertainties of IT project proposals, selection tools that are based on scoring or ranking methods ignore the limitation of real world resource constraints (Lee and Kim, 2001). A shortcoming of goal programming is the lack of a systematic approach to set priorities and trade-offs among objectives and criteria (Reza et al., 1988). The major limitation of the option pricing theory is its single criteria approach which handles the uncertainty of financial decisions but ignores intangible criteria (Mohamed and Stewart, 2001). While probability theory can be a powerful tool in approximate circumstances, many times the type of uncertainty encountered in IT projects does not fit the axiomatic basis of probability theory (Mohamed and McCowan, 2001). The possibility theory model developed by Coffin and Taylor (1996) enables the selection of IT projects under financial and resource uncertainty but fails to encompass the intangible value and risk factors associated with these projects.

This paper attempts to address the above shortcomings by introducing an IT project selection process which builds upon the strengths of each one of the following three methods; possibility theory, Analytical Hierarchy Process (AHP), and Information Economics (IE). The possibility theory is an appropriate vehicle for handling uncertainty as it is based on the concept that all values within a certain range are possible, with the exact value being unknown. A range of values, or an interval, is assigned subjectively, but the individual values in the interval are not assigned a relative belief value. An expert may feel that a given parameter is within a certain range and may even have an intuitive 'feel' for the 'best' value within that range. Possibility theory has been used successfully in a wide range of engineering and scientific fields including: project scheduling and network analysis (Lorterapong and Moselhi, 1996), contract selection and decision-making (Wang et al., 1996).

The IE criteria developed by Parker et al. (1988) have been adapted for this model to encompass the intangible value and risk factors derived from an IT investment. These include a number of human and management factors that organisations typically overlook, or simply ignore. The AHP is used as the tool to weight the IE criteria and their associated sub-criteria. AHP is an effective tool in structuring and modeling multi-criteria problems and has been successfully used in a variety of construction management applications (Mohamed and Stewart, 2001). AHP enables the decision-maker to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under multiple, and perhaps conflicting criteria.

The above mentioned investment appraisal techniques are the essential architecture for the windows-based IT project selection model PROSEL presented herein. This process is illustrated through a five-step methodology to analyse and rank a number of proposed IT projects (see Figure 1). The proposed PROSEL model is demonstrated in a case study with one of Australia's leading companies in the project management and construction services industry.

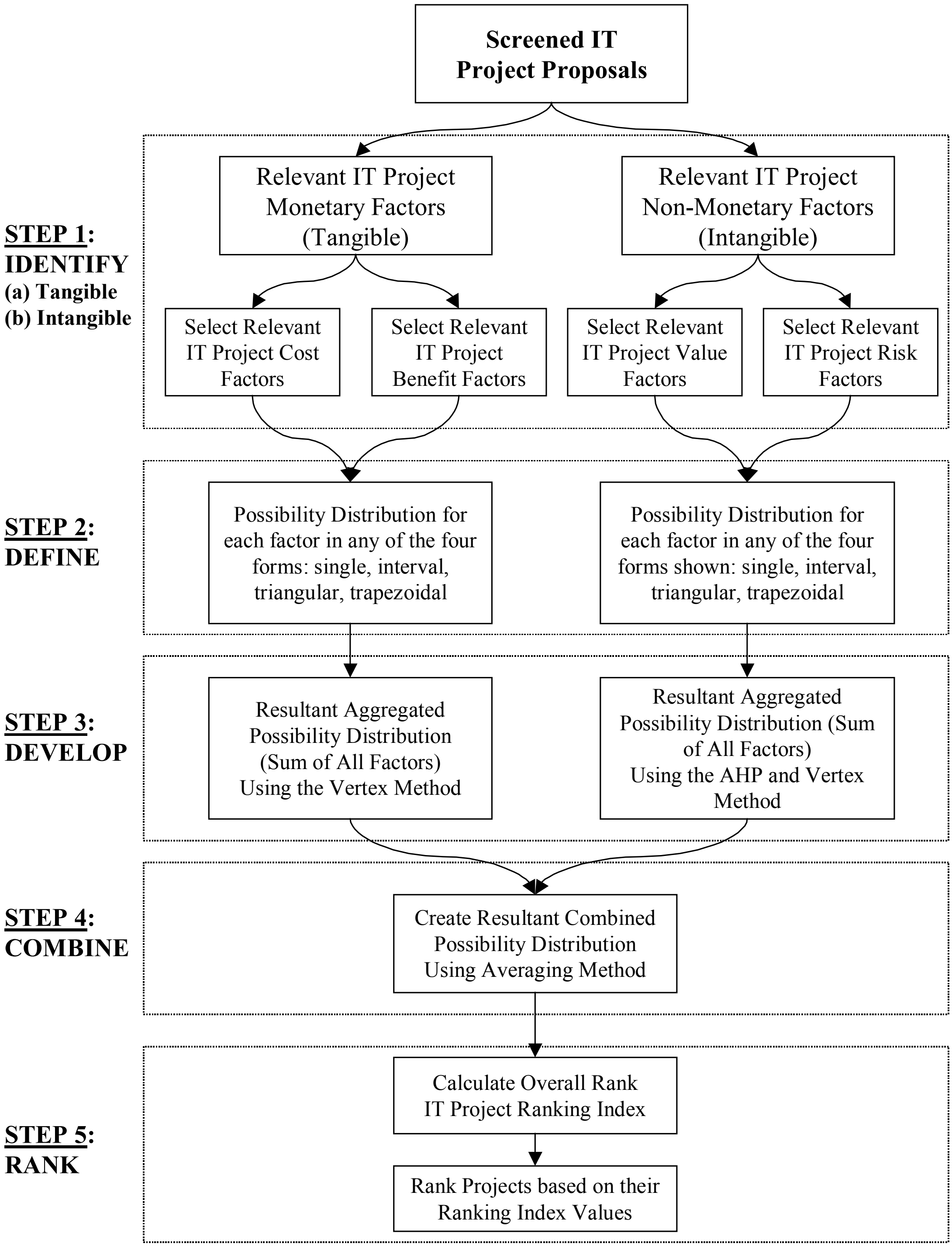

Figure 1 IT project selection flow chart

IT PROJECT SELECTION PROCESS

The IT project selection process consists of five defined steps to analyse and rank IT project proposals being considered by an organisation (Figure 1). It should be noted that the size constraints of this paper limit the degree of explanation provided for each step.

Step 1: Identify monetary and non-monetary factors

In recent years, expenditures on IT have been significant. However, organisations fail to fully acknowledge the total costs of their IT projects. The total ownership costs of IT investments include both the direct and indirect costs. Typically, organisations encompass the direct costs as those attributed to the implementation and operation of the proposed IT project. Indirect costs comprise human and organisational factors. A significant amount of resource will also be used to investigate the potential of the IT project, and in experimenting with new information flows and modified reporting structures (Love et al., 1997). Wheatley (1997) suggests that a further indirect human cost, which is often overlooked, is that of system support and trouble-shooting. According to Wheatley (1997), lifetime support costs are at least 400% of the original purchase price. Total ownership costs include all direct and indirect costs that can be attributed with the initiation, design, development, operation and maintenance of the IT investment. Therefore, all costs for the proposed IT project, over its entire lifecycle, must be included in the costing process.

Tangible benefits derived from IT project proposals, over their entire lifecycle, are identified similarly to costs. Identifying these benefits will usually require an understanding of the work processes of the organisation. IT-induced benefits are primarily strategic or tactical in nature and their financial rewards are difficult to predict (Ordoobadi and Mulvaney, 2001). These types of benefits can be handled by the non-monetary (intangible) element of the proposed model. However, many operational benefits are tangible and are more likely to display direct financial relationships. For example, monetary savings resulting from a web-based document management system could include reduced overhead costs.

To date, many researchers have focused on developing a “single” generic appraisal approach, which can deal with all types of IT projects, in all circumstances (Sharif and Irani, 1999). This has resulted in the development and use of “traditional” appraisal techniques (Irani et al., 1997). However, these appraisal techniques fail to accommodate the intangible benefits and risks associated with technology investments. According to Farbey et al. (1992), the Information Economics (IE) approach is one of the recommended investment appraisal techniques for strategic IT investments. The major advantage to adopting an IE approach is that it goes beyond traditional ‘business value’ techniques and introduces the concepts of value and risks (Stewart and Mohamed, 2000). To enable effective assessment of proposed IT projects, the adapted IE criteria and associated sub-criteria need to be grouped into a structured hierarchy. This structured hierarchy will enable weighting of criteria and sub-criteria and evaluation of proposed IT projects against sub-criteria. The framework hierarchy is composed of four levels and detailed later in the paper.

Step 2: Define possibility distributions

The first step to using possibility theory as a modeling tool is to define each IT project cost and benefit as a possibility distribution. The form of possibility distribution is determined by its membership function, $\mu(x)$. When the factor’s value is possible, it has a membership value of 1, and when its value is impossible, it has a membership value of zero. The factor can also have a possibility distribution between these units. For the purpose of the IT project selection model, it is assumed that the distributions will be one of the following types

(a) **A single value**: This form of input includes no uncertainty in the value and thus is called ‘crisp’. It is the form commonly used in traditional modeling.
(b) **An interval number**: This form is used to represent a value that is equally possible between a given range, *a* to *b*, but impossible to be outside that range. It can be represented by what is called a crisp set because its membership value, $\mu(x)$, jumps abruptly from a value of one at its lower and upper bounds, *a* and *b*, to a value of zero just beyond these bounds.
(c) **A triangular distribution**: Triangular distributions are used to define values that are uncertain and typically described by language such as “about 50%”. As its name suggests, it is defined by three points, the most likely, and an upper and lower least likely value.

(d) **A trapezoidal distribution**: This final form of distribution is used to represent data that can be defined by a most-likely range and a least likely range.

For each stage of the IT project lifecycle, the organisation needs to estimate direct and indirect IT project costs. The organisation should set up a series of activity cost matrices for each stage of the IT project lifecycle. This step allows the organisation to define the appropriate possibility distribution for each cost element in dollar values. These defined cost distributions for each activity need to be related to a particular year of the IT project lifecycle to enable them to be discounted to present day. Completing this exercise for each activity over each year of the IT project lifecycle will enable the creation of an annual cost matrix for proposed IT projects. IT project benefit possibility distributions are defined in a similar manner to IT project costs. Once the monetary (tangible) benefit factors of the IT project have been identified, the extent of benefit created by the proposed IT project can be estimated using the four possibility distribution forms detailed previously.

After identifying the relevant non-monetary criteria and sub-criteria for each IT project proposal the organisation can begin to define their possibility distributions using a predetermined scale (i.e. 0-10). Value is defined as the predicted value added to the sub-criteria (factor) due to the implementation of the IT project. Risk is defined as the product of probability of the event and the associated severity (loss) e.g. high, medium and low severity. The determination of value and risk is based on available information on the proposed IT project. Since the model relies on subjective assessment of value and risk factors, it is important that scores are based on reliable sources and judgement. Using an appropriate 'value' and 'risk' assessment scale, the possibility distributions for each value and risk factor can be established.

Step 3: Develop resultant aggregated possibility distribution

Applying the conventional time-cost-of-money principle, the Net Present Value (NPV) for all monetary factors can be calculated. The NPV approach is used to enable a direct comparison between tangible costs and benefits of proposed IT projects. To facilitate the arithmetic manipulation (addition and multiplication) of the possibility distributions, the vertex method (Dong et al., 1987) can be utilised. Also, the following three assumptions are made:

- Monetary factors (prior to IT project implementation) take place in Year (0);
- Monetary factors (during operation of the IT project) are converted to Year (0) i.e. –'ve cost outflow and +'ve benefits in-flow; and
- Cash flow discount can be represented by any of the above four forms of possibility distribution.

Costs and benefits must be grouped separately and signified by a negative and positive monetary value. Converting each cost back to a NPV will establish the aggregated cost possibility distribution for the proposed IT project. The aggregated benefits possibility distribution is obtained in the same manner. These calculations will be demonstrated in the case study.

There are three major steps to establish the aggregated non-monetary possibility distribution. The first of these steps is to weight the value and risk factors using the AHP method. The organisation must determine how value and risk contribute to the final goal to obtain the project(s) with the highest net benefit. At all levels of the hierarchy, expert judgement is required by the organisation to compare the relative importance of each objective of the framework. The second step is to combine the weighted possibility distributions of value and risk factors using the Averaging Method. Then, the same method is used to combine the aggregated value and risk possibility distributions. The calculations involved in these steps are handled by PROSEL.

Step 4: Combine resultant aggregated possibility distribution

This step is required to combine the resultant monetary and non-monetary possibility distributions for each proposal. Before this process can be undertaken, the resultant monetary possibility distributions for each IT project proposal must first be modified so that they have the same range and units. Thus, they are converted into their 'normalised' form. Non-monetary values are already on a scale from 0-10 and do not need to be normalised. However, monetary values have a $ unit and a magnitude range that varies from IT project to project. Once the resultant monetary possibility distributions have been normalised, they can be combined with the resultant non-monetary possibility distribution to form a unified distribution. The Averaging Method is used to combine the monetary and non-monetary possibility distributions. The organisation must weight the monetary and non-monetary possibility distributions to enable their combination. A construction organisation with a strategic outlook may assign the non-monetary (intangible) possibility distribution with high weighting. However, an organisation, which is focused on achieving tangible benefits from their IT investments, may assign the monetary (tangible) possibility distribution high weighting. PROSEL handles these calculative processes.

Step 5: Rank IT project proposals

The IT project proposals are ranked using the Ranking Index Method. Once the projects are ranked according to their index value, the organisation can select which project(s) will be implemented. Naturally, the number of projects selected will depend on the “earmarked” budget. An organisation that has scarce capital may select only the highest ranked IT project for implementation.

WINDOWS-BASED TOOL (PROSEL)

Obviously, the above-mentioned analysis process would be time consuming and require in-depth knowledge of possibility theory and interval mathematics. To ensure that the IT project selection procedure is user-friendly and could be used by practitioners, a user-friendly windows-based model has been developed by the authors. The PROSEL computer model enables practitioners to follow a step-by-step procedure to input the required information and the program utilises the above-mentioned mathematical techniques and procedures to rank proposals based on both monetary and non-monetary factors. The PROSEL computer model was developed using a Visual Basic (6.0) interface that is linked to a Microsoft Access Database. The application of the PROSEL model is demonstrated in the following case study.

CASE STUDY – PROSEL IMPLEMENTATION

This section illustrates the workings of the of PROSEL model in a practical environment. For the purpose of this exercise the case study IT project detailed herein is compared against a hypothetical IT project proposal.

Overview

The development and construction organisation (ABC) is one of Australia’s top listed company’s and operates in six continents with approximately 10,000 employees. ABC recommended that the Internet and the World Wide Web (WWW) is well suited for the global distribution of information using widely available commercial and industry standards. In order to facilitate the management of project information and address project communication requirements, ABC proposed to implement a Project Web Information Management Extranet (PWIME) and associated communication tools (video conferencing, web cameras etc.) on their construction projects. This IT project proposal was aimed at maximising benefits and reducing costs for the entire project team. It was envisaged by the Investment Review Committee (IRC) of ABC that the proposed PWIME can be used to instantly share, visualise and communicate project information between any project participants including staff, clients, consultants, subcontractors, suppliers and authorities. In addition, the PWIME should enhance the document management processes and procedures of the organisation.

PROSEL Application

Utilising the above-mentioned five-step procedure and PROSEL model, the two IT project proposals were analysed and ranked. Once the weighting of the various monetary and non-monetary factors were entered into the system the IT proposal number and description was entered. The framework detailed in Figure 2 consists of four defined levels of framework hierarchy. Referring to the hierarchy of non-monetary factors, Level 4 is concerned with the criteria of the framework i.e. strategic match, technical risk etc. Level 3 looks at assessing the contribution of value and risk as separate hierarchical trees. At level 2, the organisation is concerned with the aggregated value and risk possibility distributions for each proposed project. Finally, Level 1 is concerned with the combination of the resultant monetary possibility distribution with the resultant non-monetary distribution, in order to rank the IT project proposals.

As detailed in Step 2 of the procedure, each monetary and non-monetary factor needs to be assigned a possibility distribution representing the envisaged range of possible values obtainable from a particular IT project proposal. The PROSEL model allows users to enter four possible distribution types as described previously: single value; interval number; triangular; and trapezoidal. For example, in order to develop the resultant non-monetary distribution the user needs to enter the distribution for each sub-criterion of the framework. Figure 3 details the screen for entering the possibility distribution for sub-criteria under the *Return on Investment* criteria. As can be seen by this figure, there are three sub-criteria in total that need to be evaluated for this 'value' criterion. These include: (1) profitability and growth; (2) shareholder value; and (3) business value of IT project. These three sub-criteria need to be rated based on the ten-point scale mentioned previously. For the Profitability and Growth (PG) sub-criterion a triangular distribution was chosen and a distribution of [1,3,5] was chosen. This process is repeated for all remaining 'value' and 'risk' sub-criteria. The program can then combine all these factors and form the resultant non-monetary distribution using interval mathematics and the weighting of factors established through AHP.

A similar process is utilised for combining the monetary possibility distributions. For entry of a particular monetary factor the user needs to specify the cost in dollars of the project as a negative (-) outflow of money and the tangible benefit as a positive (+) inflow of money. At this stage the program only allows the resultant monetary cost and benefit distributions to be entered. However, future developments of the program will allow the user to input specific cost and benefit categories and sub-categories.

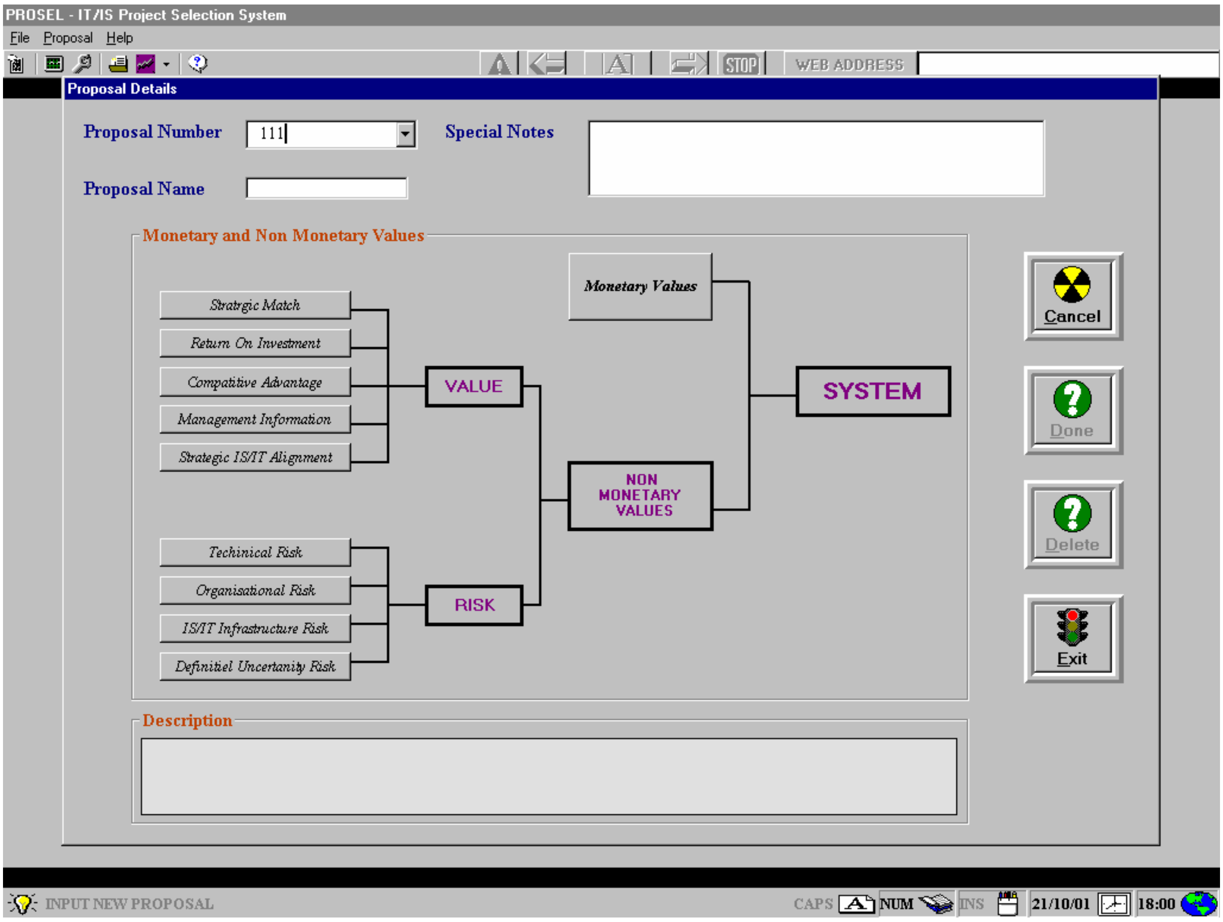

Figure 2 PROSEL – proposal development and framework weighting

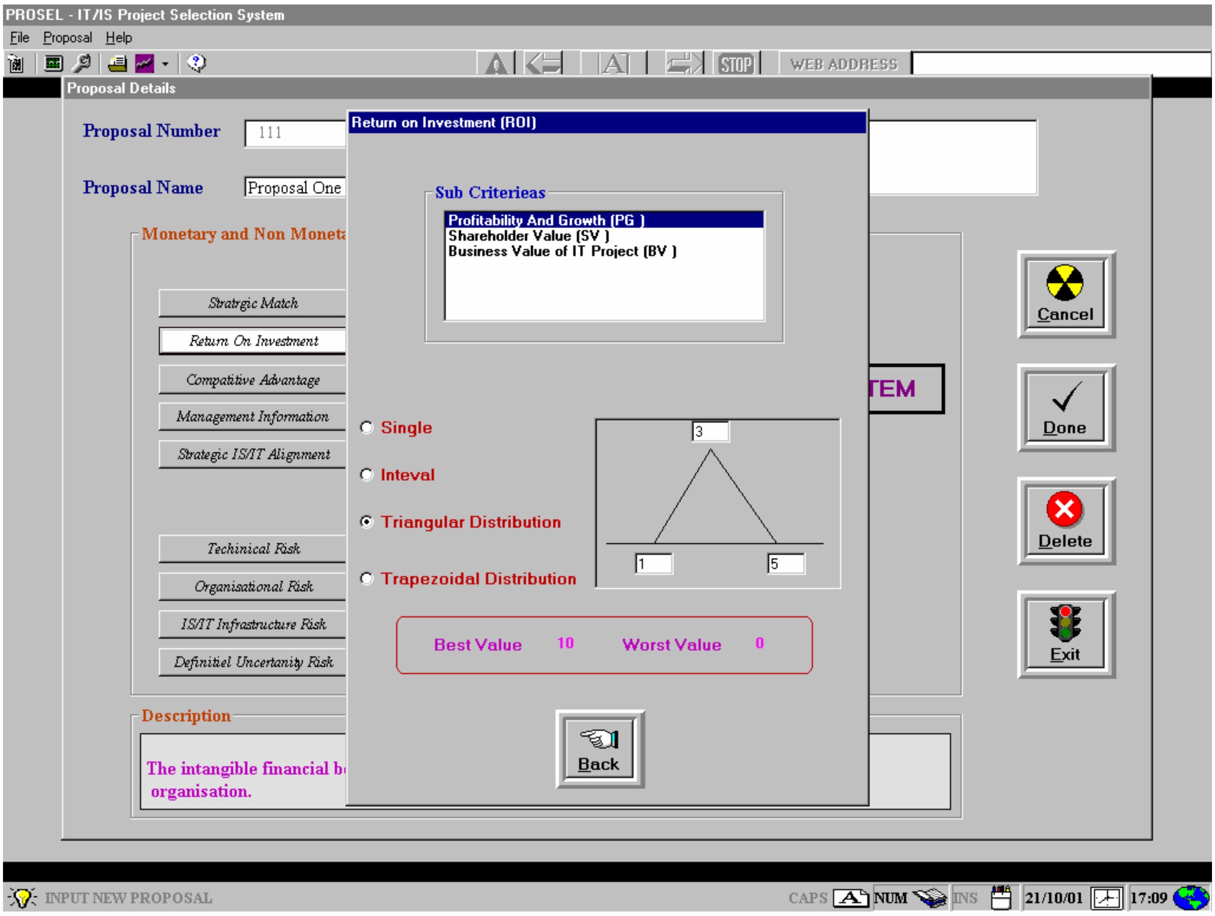

Figure 3 PROSEL – possibility distribution assessment and entry

Once the data for each proposal has been entered into PROSEL, the analysis process can be performed. The program uses interval mathematics, previously briefly explained in Steps 3 and 4 above, to combine the weighted possibility distributions and the Ranking Index Method to obtain the rank of each IT project proposal based on their resultant combined possibility distribution. For this case study, the ranking index value of the PWIME was 0.466 while the hypothetical Human Resource Management Information System (HRMIS) proposal this was compared to, received a value of 0.423. In addition to the summary output, the user can examine the 'advanced details', which detail the possibility distributions of each monetary and non-monetary criteria and the resultant possibility distribution at each level of the framework hierarchy. This option is essential for users to examine various decision-making elements of the model on a case-by-case basis.

CONCLUSIONS

Many organisations are seeking to invest in viable IT projects to automate or re-engineer their existing processes. In many cases, the viability of a project cannot be determined unless detailed feasibility studies are conducted. A considerable amount of financial and human resources have to be allocated for the development of such feasibility studies. In order to optimise the use of these resources, organisations should adopt a specific methodology to select the most advantageous IT projects.

This paper has sought to emphasise the importance of a structured IT project selection process. The developed IT project selection model and five-step methodology goes beyond traditional selection approaches that only focus on tangible costs and benefits by accommodating the wider intangible value and risk factors. Possibility theory was used to handle the inherent uncertainty associated with these tangible costs and benefits and intangible value and risk factors. A structured hierarchy of IE criteria and associated sub-criteria was used to evaluate the intangible value and risk factors. The

AHP technique was used to assess the relative weighting of these intangible criteria and sub-criteria. This framework architecture was utilised for developing the windows-based PROSEL model. The case study detailed the application of the PROSEL model and methodology in an attempt to select the most beneficial IT project proposal for the organisation (ABC).

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