

# EVALUATION OF BUILD-OPERATE-TRANSFER (BOT) PROJECT OPPORTUNITIES IN DEVELOPING COUNTRIES

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*Paper:* Infrastructure projects procured via concession contracts are increasingly becoming the preferred option in developing countries. These projects are inherently high risk investments in which political and economic instability, social, technological and other non-financial factors can significantly affect the financial viability of the project over the long term of investment. Thus, any decision to invest in these projects must be based upon a combined assessment of the financial and non-financial factors surrounding the project. This paper provides a summary of Decision Support Systems (DSSs) currently available to investors, highlighting their inability to address the non-financial (risk) factors unique to developing countries. A basic numerical example is also presented to demonstrate the application of a prototype system developed for the effective, yet efficient evaluation and ranking of BOT investment options.

*KEYWORDS:* Build-Operate-Transfer (BOT) project, developing countries, decision support system (DSS), non-financial factors, evaluation

## INTRODUCTION

In many developing countries, rapid economic growth is outstripping infrastructure supply (Gupta and Sravat, 1998). Governments in these countries are unable to fund vital infrastructure development and rehabilitation, so they are increasingly turning to large international firms as a source of funding through concession contracts such as Build-Own-Transfer (BOT). These firms generally have a greater credit standing and capacity to finance the large scale projects. If procured properly, the BOT option presents a win-win-win solution for governments, private sector firms, and the community at large. From the government's perspective, private sector participation offers off balance-sheet funding whilst bringing an added advantage of cost and resource efficiency to the project. From the private sector's perspective, BOT projects present great opportunities to expand market share and earn higher returns. Finally, thanks to a user pays system, the community at large does not experience taxation increases.

However, although globalisation has created greater opportunities for construction companies to expand their market share abroad and earn higher returns, almost 15% of the top 225 global contractors have sustained losses on their international projects (Han and Diekmann, 2001) despite the fact that international projects are generally more profitable than domestic projects. Such losses can mainly be attributed to the difficulties experienced in assessing and evaluating the impact of non-financial (risk) factors on international projects (Dailami et al., 1999, Ho and Liu, 2002, Zhi, 1995), and more specifically on BOT projects in developing countries (Baloi and Price, 2002, Gupta and Sravat, 1998, Kumaraswamy and Morris, 2002, Ozdoganm and Birgonul, 2000).

BOT projects are by nature long-term investments involving complex organisational structures. Over the lifespan of these projects the legislative, political, social, market, and economic environment could all change significantly. This is especially the case in developing countries, where the social, political and economic conditions are unstable. Thus a high degree of risk and uncertainty surround BOT investment opportunities in these countries and it is critical that adequate identification, assessment, and evaluation of non-financial (risk) factors take place at the feasibility stage. This paper argues that a Decision Support System (DSS) would be beneficial to users, during this stage, in evaluating the impact of such factors, individually or in combination, on the investment opportunities at hand.

## **RISK IN BOT PROJECTS**

According to Wang *et al.* (2002) risks must be identified in a rational systematic manner, otherwise some risks may be overlooked, and it is these unidentified risks that tend to be most disastrous and catastrophic. Much research has been carried out in the area of risk identification with particular regards to BOT projects, in developing countries, resulting in different categorisations of risks (Gupta and Sravat, 1998, Kumaraswamy and Morris, 2002, Ozdoganm and Birgonul, 2000, Salzmann and Mohamed, 1999, Wang *et al.*, 2000). Typical methods adopted by the private sector to identify risks include experience, risk matrices, checklists, databases, site visits and intuition (Akintoye *et al.*, 2001). As project promoters and sponsors are becoming more experienced in the procurement of BOT projects, they are finding this process of identifying risks increasingly easier.

The success of a contracting firm looking to invest in BOT projects in developing countries depends upon its ability to select those investment options of most benefit, whether these benefits are purely financial or a combination of financial and non-financial gains (such as increased market share). Therefore, once risks and uncertainties have been identified, it is vital that their potential impact on the project's overall viability is assessed and evaluated so that all possible financial outcomes must be predicted and compared taking into account the impact of non-financial (risk) factors and uncertainty associated with the various investment parameters. To facilitate such a comparison, numerous attempts have been made to develop DSSs to assist in this process, the practical aspects of it still remain unstructured and lack strong foundations (Al-Jibouri *et al.*, 2002). Employing a DSS could deliver benefits including:

- A set of economic performance measures that would satisfy the needs of various stakeholders involved (financiers, government, developers)
- A streamlined project rating system, which takes into account the combined effect of finances, risk, and uncertainty on the overall project attractiveness
- Time and resource efficiencies due to the streamlined approach
- Increased confidence that predictions are realistic
- The facilitation of a Go/No-go decision through quantitative results
- The clear identification of project risk (non-financial) factors that may have otherwise been overlooked
- The identification of critical risk factors for input into the project's risk management plan via sensitivity analysis

- Analysis output values can be used in contractual negotiations between various project parties.

## **KEY REQUIREMENTS OF A DSS**

In order for a DSS to effectively (most suitably reflect the degree of certainty), yet efficiently (requiring less effort in defining factor distributions) model a real-life BOT investment in a developing country, it should cater for the following ten aspects of a BOT project:

- Various industries and evaluation methods;
- Multiple project phases/sub-phases;
- Cash flow characteristics;
- Time dependent project variables;
- Varied performance measures (eg. Benefit-cost ratio, NPV, IRR);
- Uncertainty;
- Comparison of several project alternatives/scenarios (including sensitivity analysis);
- Both detailed and generalised aspects of projects;
- Identification of individual important risk factors contributing to uncertainties (both positively and negatively impacting); and
- Interdependency of identified risk factors.

The first eight of these requirements were identified in recent work carried out by Abdel-Aziz (2000), while the last two became evident to the authors through extensive literature review. To illustrate, risk factors and their interdependencies which cause uncertainties, render the task of evaluation too complex for the human mind alone to evaluate. Thus, it is crucial to the effectiveness of the DSS that individual risk factors (financial and non-financial) as well as their interdependencies are accounted for in the investment model.

## **REVIEW OF CURRENT DSSs**

According to the decision making framework they are based upon, current available DSSs can be classified as follows:

1. Economic frameworks incorporating uncertainty (UNIDO's COMFAR III, CASPAR, NPV-At-Risk, @RISK, Value At Risk, the World Bank's INFRISK, and the Four Moment Framework);
2. Real options frameworks;
3. Multi-criteria decision making (MCDM) frameworks
  - 3.1 Frameworks not including factor interdependencies (Multi-Criteria Analysis, Weighted Sum Model (WSM), Weighted Product Model (WPM), and Multi-Attribute Utility Analysis);
  - 3.2 Frameworks including factor interdependencies (Neural Networks, Cross Impact Analysis (CIA), Analytical Hierarchy Process (AHP), ICRAM-1 model, and Analytical Network Process (ANP)).

These DSSs were then analysed in relation to their ability in meeting the key requirements of a DSS detailed above. The advantages and limitations of each are listed in Table 1.

The first category of DSSs is composed of fully developed computer software packages that perform both probability and sensitivity analysis on economic parameters in order to predict an expected envelope of values for selected economic performance measures of projects. Thus they facilitate a definite go/no-go decision through their quantitative results, yet are limited in one or more of the following ways: there is no allowance for interdependency of risk factors; individual non-financial (risk) factors are not formally identified; a high level input definition is required (probability distribution parameters); and/or the complexity of calculations renders certain systems prone to crashing when simulating realistic investment situations.

The second category of DSSs includes those based upon the Real Options approach. The distinct limitations of this category are the high level input definition required, the assumption that firms have an option to defer the investment (project), and one particular system developed by Ho (2001) rules out risks caused by non-financial factors such as legal, economic, political environment, and host country credit rating.

The third category of DSSs, has been divided into two groups: 1) MCDMs not including factor interdependencies, and 2) MCDMs including factor interdependencies. In real life BOT project situations, factor interdependencies can significantly affect the overall feasibility of an investment. Also, from review of the latter group of DSSs it was found that:

- The Neural Network would be difficult to implement, due to the absence of large amount of data, needed to develop the DSS;
- The CIA requires the analyst to estimate the bounds of the final project cost distribution incorporating the effects of the variables prior to defining the variables and their interactions, and also adopts an unstructured brainstorm structure;
- The AHP and ICRAM-1 (a variation of the AHP) both limit the way in which factors can be interdependent to some degree.
- Finally, the ANP, which simply extends the AHP from a hierarchical to a network structure, would be capable of meeting all ten key requirements of a DSS. However, no evidence has been found of this framework being applied to the modelling of BOT investment options to date.

## **PROPOSED DSS FRAMEWORK**

In order for a DSS to meet all ten of the key requirements identified above, its design must be based upon a combination of the optimal decision making framework and most suitable mathematical modelling techniques available (McCowan and Mohamed, 2002).

The mathematical modelling technique selected to facilitate the definition of input data into the DSS should most suitably reflect the degree of certainty surrounding a construction project (effectiveness), while requiring less effort in defining their

distributions (efficiency). Deterministic (single) values, probability distributions, or possibility distributions, are all mathematical techniques that could be used for this purpose. It would not be correct to define the majority of input values for a BOT investment model as deterministic values due to the risk and uncertainty that characterise these projects in developing countries. Also, while probability theory (including Monte Carlo simulation) has become the most widely accepted technique for incorporating risk and uncertainty in analyses, in the construction industry (Pender, 2001, Raz and Michael, 2001), the superiority of the possibility theory as a mathematical modelling technique for the evaluation of construction project investments is well documented (Andersson, 1998, Mohamed and McCowan, 2001).

The possibility theory, also known as fuzzy logic, is based on the concept that all values within a certain range are possible, with the exact value being unknown. A range of possible values, or an interval, is assigned subjectively, but the individual values in the interval are not assigned a relative belief value. Using this technique, the project factors can be represented as crisp (single) values, intervals, triangular, trapezoidal, or even more rounded S, Z, or bell-shaped distributions. The possibility theory has already been applied successfully to a wide range of construction engineering fields.

A pilot project was undertaken to investigate the implementation of possibility theory to modelling the combined effects of financial and non-financial factors on a BOT investment opportunity and hence evaluate and rank several options. A prototype DSS was developed using a simple Weighted Sum Method (WSM) MCDM framework and followed the process shown in Figure 1. This prototype was validated by comparing results with those gained from a probability based utility method, and successfully applied to the ranking of two BOT projects (Mohamed and McCowan, 2001). It was found that the possibility theory offers a less calculative intensive method whilst still providing accurate and transparent results.

However, the WSM method falls into the category of "MCDM – Including No Factor Interdependencies". This means that while it does allow for the specific identification of non-financial (risk) factors, and considers both financial & non-financial aspects according to relative importance, it does not allow for the interdependency of factors or assist in the development of factor importance weightings. As mentioned earlier factor interdependencies can significantly affect analysis results. From the above review of various available DSSs based upon economic, real options, or MCDM frameworks, it would appear that the ANP is the optimal DSS framework structure for the modelling and comparison of BOT investment options. The ANP framework looks more like a network than a hierarchy, making it ideal for modelling the complexity of a real-life BOT investment situation.

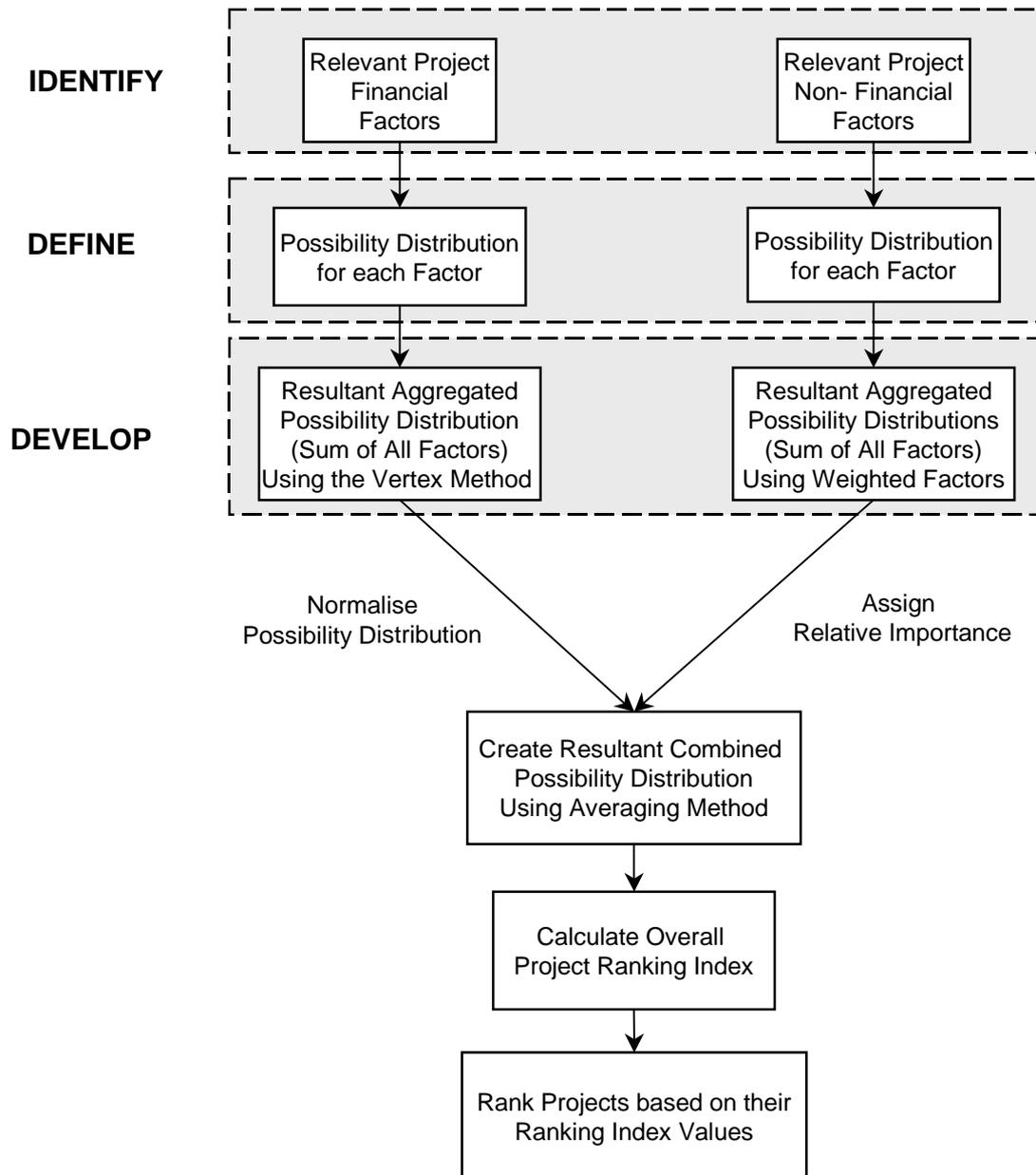


Figure 1: The prototype DSS process flowchart (Mohamed & McCowan, 2001)

## NUMERICAL EXAMPLE

The following basic numerical example adapted from Mohamed and McCowan (2001) shows the difference in results (non-financial only) when analysis is based on; case 1) the independence of non-financial factors (using the WSM method), and case 2) the interdependence of factors as shown in Figure 2 (using ANP, based upon project description and findings of Hastak and Shaked (2000)).

Table 1 presents the input weightings and impact values (possibility distribution) of the non-financial (risk) factors for BOT Project A, as defined in Mohamed and McCowan (2001). Table 2 compares the results of analysis cases one and two. As can be seen from these results, the inclusion of interdependencies between factors has noticeably altered the resultant value of non-financial factors for the project.

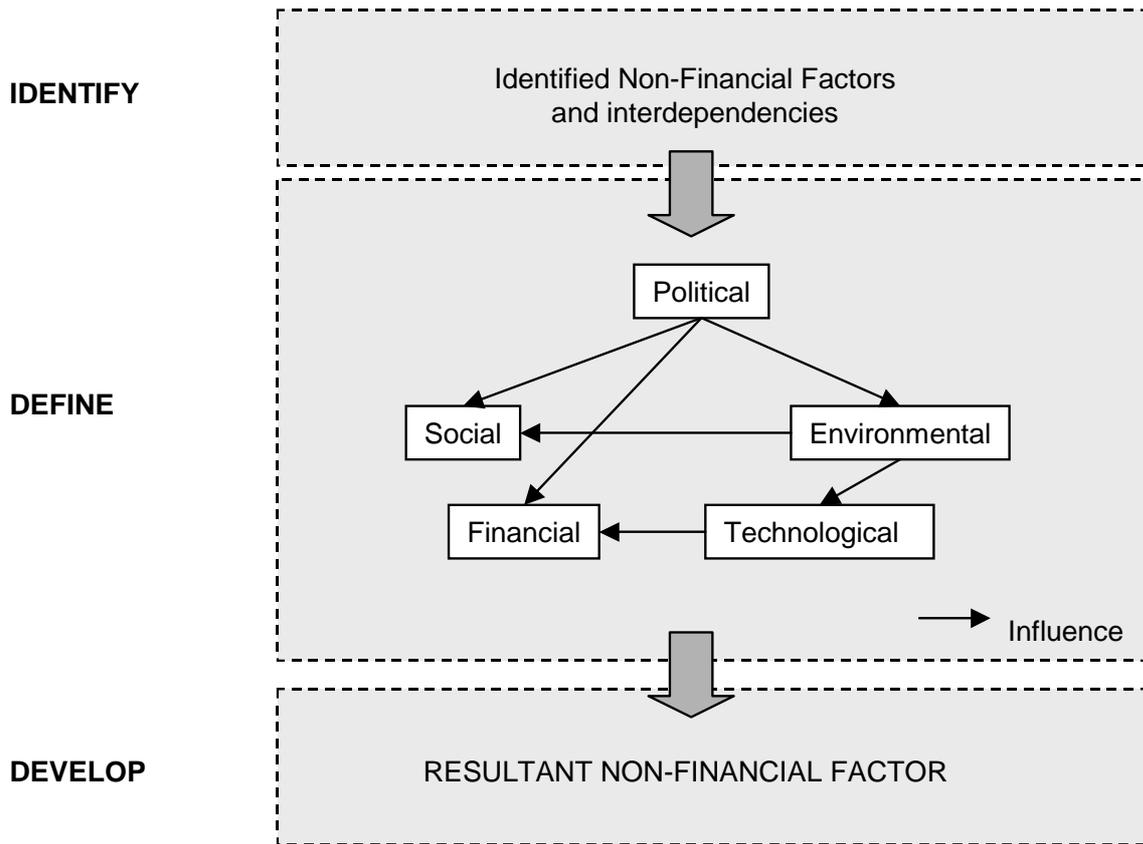


Figure 2 –Non-Financial Factor Interdependence for Analysis Case Two

Table 1 - Non-Financial Factors Input Weightings and Impact Values - BOT Project A

Non-Financial Factor	Weighting	Impact values (possibility distribution)			
		a	b	c	d
Political	0.40	0.90	0.95	0.95	1.00
Environmental	0.75	0.50	0.60	0.70	0.75
Social (Tourism)	0.85	0.80	0.80	0.95	0.95
Technological (Innov.)	0.80	0.25	0.50	0.50	0.70
Financial	0.50	0.40	0.40	0.60	0.60

Table 2 – Comparison of Analysis One and Two Results

Analysis	Resultant Non-Financial Distribution			
	a	b	c	d
1 – Factor Independence	0.55	0.64	0.73	0.80
2 – Factor Interdependence	0.64	0.73	0.79	0.86

## THE ANP ADVANTAGE

According to Saaty (2001), the discovery of new elements or the clarification of the decision problem often results from using the ANP. Also, the amount of user input and complexity of mathematical calculations could be greatly reduced by allowing users to define interdependencies between factors only where required.

The ANP Project Rating Method is presented as Figure 3 (Saaty, 2001). This method overcomes difficulties encountered when combining financial and non-financial values into one aggregated project rating in the following ways:

- The ratio of Benefit to Cost, and Opportunity to Risk, eliminates the need for a common unit (\$\$ vs. no units) or scale of comparison (\$1billion vs. \$10billion).
- A series of linguistic pairwise comparisons overcomes the difficulty of subjectively assigning importance weightings to the non-financial factors.
- This technique facilitates the inclusion of both positively (Opportunities) and negatively (Risks) impacting non-financial factors in a logical and well-structured manner.
- Results will be similar to a Benefit/ Cost Ratio already used by most public sector departments to evaluate project feasibility and could therefore be presented as part of a bid proposal.

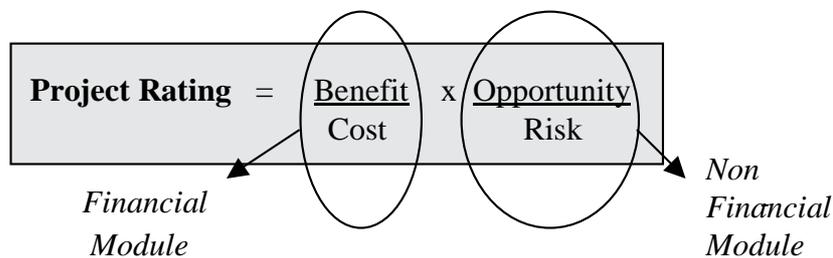


Figure 3: Saaty's (2001) ANP Project Rating Method

The proposed design of the optimal DSS will consist of a Financial Module which will provide Benefit and Cost results, and a Non-Financial Module which will provide Opportunity and Risk results, to the Rating module of the DSS. The Non-Financial Module will implement the ANP to derive the various factor importance weightings (taking into account interdependencies) via two networks of Opportunities and Risks. Although the DSS generalised framework structure has not yet been developed (existence and degree of impact of interdependencies between non-financial factors in BOT projects to be established via survey), Figure 4 gives an illustrative example of how these two networks could potentially be structured. In this figure, an arrow represents a direction of influence.

The ANP can also be applied to the Group Decision Making Module. The decision to invest in a concession project will typically be made by a group of decision makers. The importance of each group member's evaluation of the project will vary depending on the level of experience of the member and his/her position in the company. Pairwise comparisons of the group members importance weightings can be used to determine the group's overall rating of the project (Yang *et al.*, 2001).

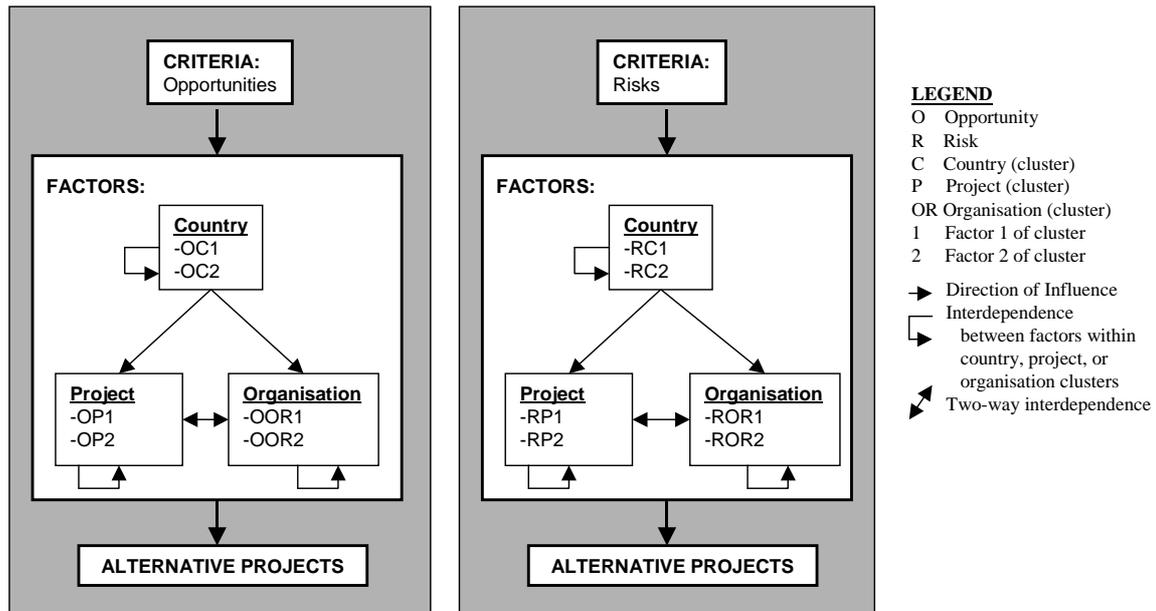


Figure 4: Illustrative Diagram of Potential Opportunity and Risk Networks of the Non-Financial Module

## SUMMARY

Over the past two decades, concession contracts such as the BOT scheme, are being used more and more by governments of developing countries in the provision of vital infrastructure projects that otherwise would not have gone ahead. If procured correctly, the BOT option can present a win-win-win solution for government, private sector, and the community at large. However, while these investments offer higher returns to private sector participants, they also represent higher risk due to the high risk nature of BOT projects themselves coupled with the unstable investment environment (for example, political, economic, and social) encountered when investing in developing countries. Various studies and surveys have identified a predominantly risk averse attitude amongst the private sector, largely due to their inability to identify, assess, and evaluate the impact of the inherent non-financial (risk) factors and uncertainty surrounding these investments at the feasibility stage. Thus, it is evident that there is a definite need for a DSS or decision making tool capable of effectively and efficiently evaluating the combined effect of financial and non-financial (risk) factors for various project investment options.

This paper has presented findings of a review of currently available DSSs according to the ten key requirements identified for these systems, highlighting their limitations. It proposes a combination of the ANP and the possibility theory as the most efficient and effective decision making framework and mathematical modelling technique to form a basis for the optimal DSS design. It then presents a numerical example which demonstrates the application of an optimal proposed DSS framework to the non-financial (risk) evaluation of a BOT project. Future work will focus on establishing the existence and degree of impact of interdependencies between non-financial (risk) factors via a survey of both public and private sector BOT project participants.

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TABLE 1 – A Summary of Currently Available DSS Advantages and Limitations

DSS Classification	Economic Frameworks Incl. Uncertainty	Real Options Frameworks	MCDMs – No Factor Inter-dependency	Neural Networks	CIA	AHP & ICRAM-1	ANP
<b>Advantages</b>	<ul style="list-style-type: none"> <li>✓ Accurate financial model of PFI projects,</li> <li>✓ Quantitative results facilitating a Go/No-go decision.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Considers both financial &amp; non-financial aspects.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Specific identification of non-financial (risk) factors,</li> <li>✓ Considers both financial &amp; non-financial aspects according to relative importance.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Simulated approach.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Specific identification of non-financial (risk) factors,</li> <li>✓ Considers financial &amp; non-financial aspects,</li> <li>✓ Simulated approach (Monte Carlo),</li> <li>✓ Allows inter-dependencies between ANY factors.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Easy to determine factor weights via pairwise comparisons,</li> <li>✓ Simplistic, hierarchical structure.</li> </ul>	<ul style="list-style-type: none"> <li>✓ Same as AHP, plus</li> <li>✓ Ability to reflect real-life complexities,</li> <li>✓ Allows inter-dependencies between ANY factors.</li> </ul>
<b>Limitations</b>	<ul style="list-style-type: none"> <li>✗ No allowance for interdependency of factors,</li> <li>✗ Individual non-financial risk factors causing uncertainty distributions in forecasts are not formally identified,</li> <li>✗ A high level input definition is required (probability distributions),</li> <li>✗ Some systems prone to crashing realistic investment situations.</li> </ul>	<ul style="list-style-type: none"> <li>✗ A high level input definition is required (probability distributions),</li> <li>✗ Value of non-financial factors must be converted into dollar values,</li> <li>✗ No allowance for the inter-dependency of factors,</li> <li>✗ Bid must be placed by set date – no option to delay in real-life.</li> </ul>	<ul style="list-style-type: none"> <li>✗ No allowance for the inter-dependency of factors,</li> <li>✗ Some have not yet been used to model the holistic investment decision (ie. financial &amp; non-financial),</li> <li>✗ Difficulty in assigning factor weights.</li> </ul>	<ul style="list-style-type: none"> <li>✗ A high level input definition is required,</li> <li>✗ Large quantities of historical data required,</li> <li>✗ Inter-dependencies determined by training of network using historical data.</li> </ul>	<ul style="list-style-type: none"> <li>✗ Confusing brainstorm structure,</li> <li>✗ Input of final project cost distribution required,</li> <li>✗ Relative frequency distributions must be defined for factors;</li> <li>✗ Limited scale (-3 to +3) for inter-dependencies.</li> </ul>	<ul style="list-style-type: none"> <li>✗ No inter-dependencies between factors.</li> </ul>	<ul style="list-style-type: none"> <li>✗ Not yet applied to the modelling of a CPI decision.</li> </ul>

