BOT Viability Model for Large-Scale Infrastructure Projects

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Abstract: The key to a successful implementation of a build-operate-transfer (BOT) infrastructure project is in-depth analysis of all aspects related to economic, environmental, social, political, legal, and financial feasibility of the project. For these reasons, the analysis of the project feasibility decision needs a technique to include the qualitative decision factors that have a strong impact on the project. This paper aims to introduce a decomposed evaluation model developed to assess the most common significant decision factors that strongly affect the feasibility of BOT projects. The paper describes the viability decision factors that were identified and screened with the assistance of a group of industry experts. This analysis yielded 21 significant factors that would have a certain impact on the feasibility of any BOT project. These factors were classified into three relative categories forming the structure of the suggested project viability model. This model presents a new approach, based on the analytical hierarchy process technique, to evaluate the relationships between decision factors related to project feasibility determination. The new approach has been validated by information obtained from three case studies of BOT projects. The proposed approach to project feasibility evaluation aims to increase the decision maker's ability to determine the factors contributing the most to the viability to the BOT project at hand.

DOI: 10.1061/(ASCE)0733-9364(2007)133:1(50)

CE Database subject headings: Build/operate/transfer; Infrastructure; Decision support systems; Construction management.

Introduction

The process of procuring the public facility by private consortium is very complex, risky, sophisticated, and ultimately expensive. As infrastructure projects are crucial to the host country's economic development, their feasibility must be confirmed before further steps are commenced. Unfortunately, the increased popularity and the advantages of build-operate-transfer (BOT) contractual systems pushed many governments and private companies in the recent past to pursue BOT projects without studying, in depth, the feasibility of the proposed projects before obtaining financing, starting the planning, design, and construction. This, of course, may sometimes lead to the suspension or even demise of critically needed projects and bankruptcy for the contractors involved. To develop a successful BOT project, its promoters should ascertain that the project be politically, socially, legally, environmentally, economically, and financially viable (Shen, Lee, and Zhang 1996). Project viability may only be determined following a detailed and accurate feasibility study. Since the feasibility study of a large scale infrastructure project includes a large number of qualitative (subjective in nature) and quantitative decision factors, the study is usually expensive, needs extensive efforts, and a relatively long time to be properly completed.

In the past BOT practice, governments depended upon project feasibility studies prepared by private consultants. Usually, decision makers responsible for determining the feasibility of the project before proceeding with its implementation concentrated mainly on the quantitative decision factors, and used sometimes misinformed subjective evaluation of the project's qualitative decision factors. This often led to the elimination or neglect of potentially viable project opportunities (UNIDO 1996). Previous studies have indicated that many BOT projects failed to be completed or were suspended, and their a priori feasibility study was insufficient to conclude the viability of the entire undertaking. For example, during the last two decades, in Egypt only 9 of the 25 announced BOT projects have been awarded and the rest have been impeded (CRANA Corp. 2001). The challenge for decision makers is to answer questions such as "to what extent is the project viable?" and "what are the conditions needed and steps to be taken to improve project's viability?" In the subsequent sections, this paper introduces a decision support model able to identify these decision factors that will strongly influence project viability, and to assess quantitatively the overall viability of a BOT project.

Background

Ozdoganm and Birgonul (2000) introduced a checklist approach to test the viability of the qualitative decision factors in a hydropower plant project in Turkey. Three criteria were used, project specific (PS), country specific (CS), and government actions (GAs). This subjective judgment could not determine the exact influence of the qualitative decision factors on the project feasi-

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Note. Discussion open until June 1, 2007. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on September 2, 2004; approved on May 23, 2006. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 133, No. 1, January 1, 2007. ©ASCE, ISSN 0733-9364/2007/1-50–63/$25.00.

bility. The checklist approach reported in that study could constrain or even neglect possible strategies to improve certain qualitative aspects of a project decision. Dias and Ioannou (1996) provided a desirability model to measure the company competitiveness and project attractiveness from the viewpoint of a private promoter of the project. A project attractiveness index was derived from the analysis of combined country and project decision factors. However, a practical application of this model may lead to an extension of time and an increase in the costs of a project feasibility study, and many project decision factors may be missed or misinterpreted. The attribute worth score in the desirability model was valid only if the attribute performance was between two extreme values *P*1 and *P*2, where *P*1 is the minimum plausible performance level for an attribute and reflects the highest point on the performance scale where an attribute is worth its minimum (i.e., 0 worth points). *P*2, the maximum plausible performance level for an attribute, reflects the lowest point on the performance scale where an attribute value is at its maximum (i.e., 100 worth points).

Research Methodology

The selection of project viability decision factors was based upon evaluation of a wide range of factors and their corresponding subfactors gathered from the literature (Tiong 1990, 1995a,b, 1996; Tiong et al. 1992; Dias 1996; Levy 1996; UNIDO 1996; Gupta and Narasimham 1998; Ranasinghe 1999; Ozdoganm and Birgonul 2000). The second stage was to identify those variables, remove the redundant variables, and to classify them. Then, grouping these factors under main categories was conducted by a group of BOT project experts from industry and government organizations. The third stage involved quantitative processing of the data obtained. The flow chart in Fig. 1 depicts the methodology used in this study. The final outcome of project decision viability analysis is the viability index $V(x)$ that assesses the viability of the project for the BOT method of project delivery. This nondimensional viability measure is given by Eq. (1) as follows:

$$V(x) = \sum_{i=1}^{n} w_i v_i(x_i) \tag{1}$$

This equation was chosen on the basis of the assumptions made and the functional form used in the desirability model presented by Dias and Ioannou (1996) where w_i is the attribute composite weight and $v_i(x_i)$ is the worth of the attribute.

BOT Feasibility Decision Factors

To guarantee the ultimate success of a BOT project, the local government of the host country should ensure an environment which is conducive to BOT project delivery method. This can be achieved by assessing BOT feasibility factors on both the country and the project levels, respectively. The appropriate method to accurately and economically evaluate the project feasibility in a specific country is to divide the feasibility study into two main sequential levels: the country level and the project level. The country level analysis should be conducted first before assessing the project feasibility. Fig. 2 displays the suggested flowchart of BOT project feasibility analysis at both levels.

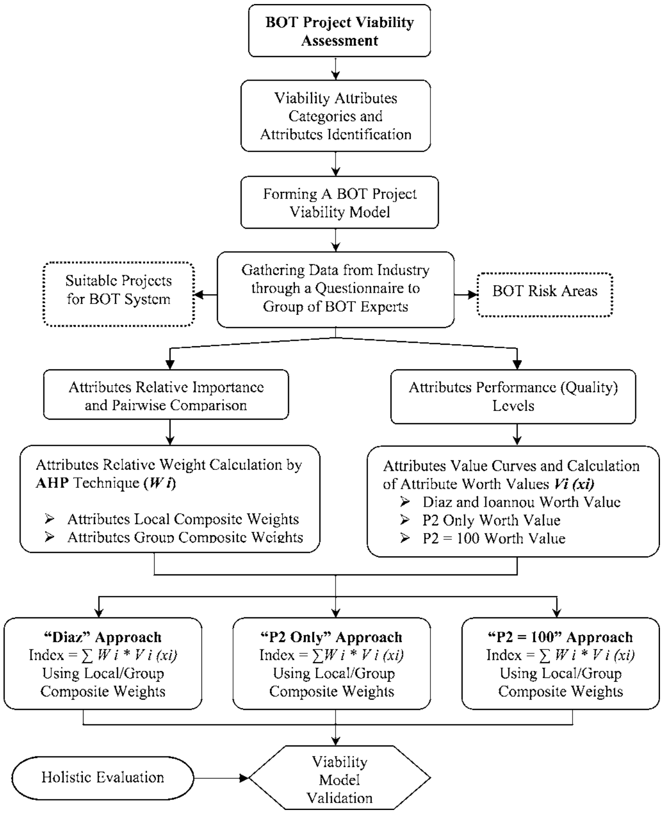

Fig. 1. Study methodology flow chart

Country Level

Government and investors must assess factors that make the host country attractive to foreign investors and lenders. Twenty three country-related decision factors were collected from several previous studies, grouped and classified according to relevance under four main categories (political and legal, financial and commercial, economic, and environmental). Most of these factors cannot be changed in a short period. If the national government or its regional agencies decided to adopt a BOT strategy for project delivery under consideration, it may decide to take steps to encourage private sector investment and reduce a negative impact of existing impediments in this realm. The evaluation procedures for determining BOT project feasibility on the host country level have been established by a number of international organizations (The World Bank, United Nations and its agencies, international commercial lenders, etc.). Readers are encouraged to consult these sources for detailed elaboration on country-level analysis. The country factors are represented here only to highlight the importance of assessing the host country first before proceeding to the project level and is not included in this research analysis.

Project Level

The decision support model of assessing the viability of BOT project includes 21 significant decision factors selected from previous studies and filtered by a group of expert practitioners. The model includes three main levels; the first level is the objective of the study named BOT project viability, the second level consists of three major categories: legal and environmental, technical, and financial and commercial. The third level includes the relevant decision factors (attributes) with respect to each of the above

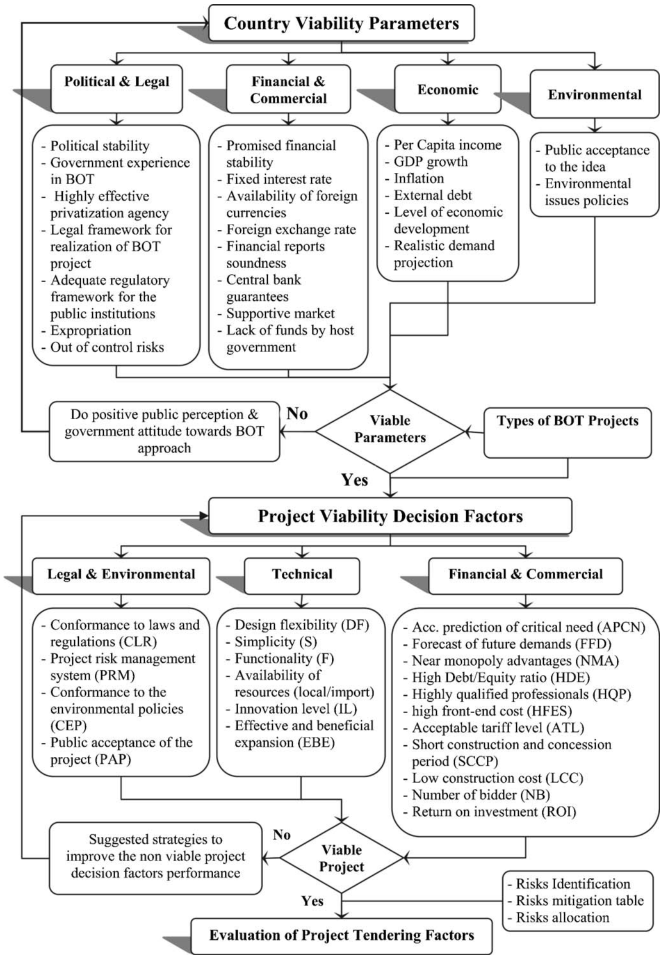

Fig. 2. Flow chart for country and project BOT feasibility analysis

three categories. The viability model structure and the decision factors identification and evaluation are described in the subsequent sections.

Questionnaire and Expert Criteria

The inter-relationships among project viability attributes include a combination of qualitative and quantitative critical success factors. These relationships require an assignment of weights, contribution for each attribute toward the project viability, and comparing their relative importance. This process requires gathering of the necessary information from experienced professionals in the industry who had participated in the development of BOT projects. In this research, the selection of the professional group (respondents) was based on several criteria as follows:

- The expert should have been directly involved in developing at least one major BOT project;
- The expert should have actively participated in the activities of the project management team; and
- Experts were selected from a variety of project participants (public or private agencies or financiers) to reflect likely differences in opinions of project participants about the feasibility of potential projects and the degree of importance of different project attributes.

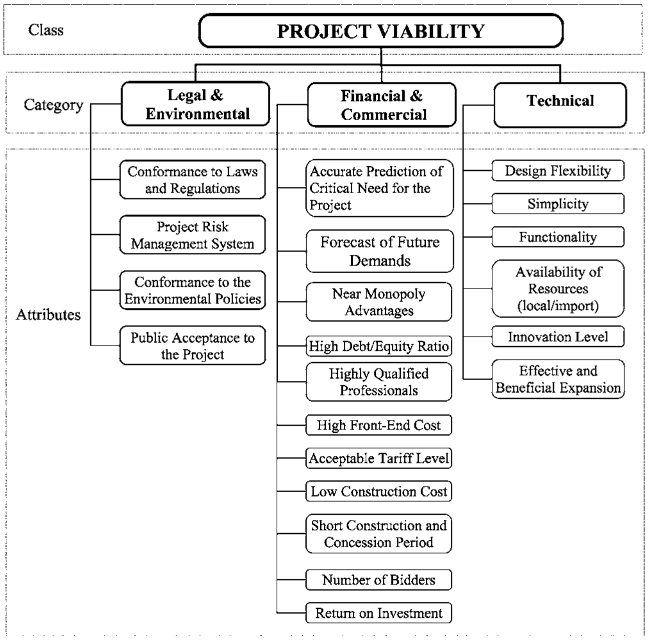

Fig. 3. Hierarchical structure of BOT project viability factors model

The BOT project viability model is a multiattribute evaluation model. It was developed with information gathered from two questionnaires. The first questionnaire was designed to rank critical success factors compiled from literature and affecting the feasibility of BOT projects. The first questionnaire included 85 factors extracted from previous studies, grouped together under the name of the corresponding critical success factors. The factors were ranked by the experts according to the significance level assigned to each factor. The experts were also asked to add additional attributes they judged necessary to enhance the quality of the model, but no additional attributes were actually identified in this manner. The information gathered from responses to the first questionnaire was refined, compiled, and screened according to relevant statistics. The significant common factors that have influence on the viability of BOT projects included 21 decision factors; these were used to form a hierarchical structure of the model shown in Fig. 3. The second questionnaire included the hierarchical structure of the model in order to check relevance of each factor with respect to its corresponding category, to assign weight and performance level to each decision factor, and to evaluate holistically the case study projects. The first questionnaire was sent to 188 international and local BOT experts representing different types of project participants (government agencies, project developers, and financial firms, legal, industrial, and academic consultants) according to the expert selection criteria mentioned above (see Table 1). The variety of the experts was intended for the identification and evaluation of the most common attributes that have the most significant impact on BOT project viability. Fifteen experts had completed the first questionnaire. Six of these were involved in more than one BOT project as engineering consultants, five were project company managers involved in only one BOT project, two were heads of project site offices, one academic expert was involved in several BOT projects as a construction management consultant, and one was involved in several projects as a financial consultant and member of the board of directors of a large construction firm. For the second questionnaire, 128 surveys were sent to international and local (Egyptian) experts (including the first questionnaire respondents). Only 12 respondents returned a fully completed survey and expressed readiness to provide more support to this study.

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Table 1. Mailed Survey and Response Status

	First questionnaire			Second questionnaire (pairwise comparison)		
Country	Sent	Excuses	Responses	Sent	Excuses	Responses
Egypt	25	—	3	25	—	6
U.S.	72	18	7	47	1	4
U.K.	30	3	2	20	—	—
France	10	2	—	5	—	—
Taiwan	15	1	1	5	—	1
Denmark	2	—	—	5	1	—
Malaysia	5	2	—	1	—	—
Australia	10	1	1	4	—	—
Canada	8	2	1	6	—	1
Hong Kong	3	1	—	2	—	—
Korea	2	1	—	2	1	—
South Africa	6	1	—	6	—	—
Total	188	32	15	128	3	12

The response rates for the first and the second questionnaires were 8 and 9.4%, respectively, based on the number of mailed surveys. Eight experts (three Egyptians and five international) participated in the two questionnaires. This low response rate could be attributed to the fact that the respondent criteria called for highly qualified experts in BOT systems that have the ability to deal with the complexity of qualitative decision factors and their relationships. Similarly, previous studies showed that the response rates to requests for qualitative factors assessment was considerably low. For example, in Dias and Ioannou (1996) only 12 and 8 respondents had accepted the invitation and completed the questionnaires. In fact, one can infer some statistical implications of this low rate of responses. Following the reasoning suggested by Saaty (1980), the Chebyshev's theorem statistical test (at least 75% of the data set must lie within the range of average ±2 standard deviations to accept the set of data) was applied to the data set from each respondent, and over 91% of the obtained data were within the above range which means the responses were accepted. The resulting inconsistency ratio of the pairwise comparison matrix was <0.1 for answers from each respondent. This represents an additional positive indication of reliability of the obtained responses.

Viability Model Decision Factors

The most important task in the development of multiattribute decision model was the identification of the relevant model attributes. Both host government and private sector should assess the decision factors that affect the feasibility of a BOT project. The common decision factors (attributes) on the project level are defined in detail in Appendix I. To generalize the idea, and because it is not possible to include all decision factors for all of the different types of BOT projects, the above factors were selected carefully from the previous studies as consensus-based decision factors typically included in the decision analysis of any BOT project. For any specific project, there are often additional unique factors which should be added to the analysis and their weights must be calculated. In cases when these unique factors are not related to the model based categories, their viability should be assessed separately.

Project Viability Attributes Relative Weights

The pairwise comparison matrices of the project viability attributes, obtained from responses, represent the relative importance between the attributes based on a numerical scale (1–9). Using the eigenvalue method (EM) as in the analytical hierarchy process (AHP) (Saaty 1980), the categories and attributes of local weights were calculated using Expert Choice 2000 software implementation of AHP. The input data included the formatted viability model categories and attributes as a hierarchical structure with relationships as presented in Fig. 3 and the pairwise comparison matrix values for each respondent. The output of the software included, for each respondent, inconsistency ratio of each comparison matrix, local importance weight for each decision factor (alternative) within the proper category (objective), and the composite weight of each factor with respect to its contribution to project viability (goal).

Category Weights

Project viability attributes were classified under three main categories as in Fig. 3, and the individual results provided by participants for the comparison of relative importance of the categories as well as the calculated local weights for each category are presented in Table 2. About 75% of the responses indicate that the financial and commercial category is the most important (superior) category in the project viability decision, 16.7% indicate that financial and commercial shares the same importance with the legal and environmental category. The second important decision category was the legal and environmental category, while the technical category came as the least important. The average weights for the three categories also indicate that the financial and

Table 2. Category Pairwise Comparison Matrix and Relative Weight

	$R1$	$R2$	$R3$	$R4$	$R5$	$R6$	$R7$	$R8$	$R9$	$R10$	$R11$	$R12$
Category relative importance												
LE versus T	3	4	1/4	3	6	5	4	6	6	3	1	3
LE versus FC	1/4	1/6	1/5	1	1	1/4	1/4	1/3	1/4	1	1	1/5
T versus FC	1/6	1/9	1	1/7	1/3	1/8	1/8	1/7	1/9	1/3	1	1/7
Weights												
LE	0.218	0.176	0.100	0.388	0.499	0.237	0.223	0.293	0.243	0.429	0.333	0.188
T	0.091	0.061	0.433	0.097	0.105	0.064	0.070	0.067	0.056	0.143	0.333	0.081
FC	0.691	0.763	0.467	0.515	0.396	0.699	0.707	0.641	0.701	0.429	0.333	0.731

Note: LE=legal and environmental; T=technical; and FC=financial and commercial.

Table 3. Category Group Pairwise Comparison and Group Relative Weights

	Relative importance (Geo-M)
Category comparison	
Legal and environmental versus technical	2.89
Legal and environmental versus financial and commercial	0.40
Technical versus financial and commercial	0.22
Group weights	
Legal and environmental	0.282
Technical	0.114
Financial and commercial	0.603

commercial category represents 59% of the total project viability score, legal and environmental—28%, and technical—13%. Thus, the financial and commercial category is about twice as important as the legal and environmental category, and about five times as important as the technical category. According to these results, the decision maker must give the financial and commercial factors the highest priority when assessing project viability.

The overall weight of individual responses (group weight) for each category is necessary to calculate the weight of the contribution of each category to the project viability score. Geometric mean was used to group the individual judgments for each category rather than an arithmetic mean because the method used to consolidate individual judgments should preserve the reciprocal nature of the comparison matrix (Saaty and Aczel 1983). The group weights of categories are almost the same as the average of local weight. As shown in Table 3, the financial and commercial category has the highest weight of (60.3%) followed by legal and environmental (28.2%), and the technical category (11.4%).

Attribute Weights

The 21 viability model attributes were classified according to their relation to the four attributes under the legal and environmental category, the six attributes under the technical category, and the eleven attributes under the financial and commercial category. The relative local attribute weights assigned by the respondents are presented in Table 4. The local weights of attributes within their categories indicate that project conformance to laws and regulations in the legal and environmental category, availability of project resources in the technical category, and return on investment in the financial and commercial category are the most significant decision factors that have the maximum impact on project viability. Thus, decision makers should give them the highest priority in project feasibility studies.

The group weights for the attributes were calculated in a similar process as in the category group weights. The results shown in Table 5 indicate that the conformance to laws and regulations in the legal and environmental category, the availability of resources in the technical category, and a reasonable return on investment in the financial and commercial category have the highest weights of 0.395, 0.448, and 0.262, respectively, within their categories. Note that the weights of attributes in each category sum to a unity.

In order to simplify the process of comparison, the project viability attributes were classified under three main categories and the local attributes weights were calculated within their categories. In order to check the similarities and differences between individual weights, and to calculate the individual attribute contributions to the project viability, it was necessary to determine the individual relative weight of each attribute toward the total project viability (composite weight W_i). The composite weight of an attribute is equal to the local weight of that attribute "W_l" multiplied by its local category weight "W_c"

$$W_i = W_l \times W_c \tag{2}$$

The summation of attributes composite weights must equal to unity then

$$\sum W_i = 1 \tag{3}$$

The composite weights of the 21 attributes calculated from Eq. (2) for each participant are displayed in Table 6. The average composite weight of each attribute and its boundaries of ± one standard deviation are presented in Fig. 4, which indicates that return on investment, acceptable level of tariffs, conformance to laws and regulations have received the highest weights of 0.1606, 0.1276, and 0.1111, with the standard deviations of 0.0714, 0.0601, and 0.0612, respectively, while design flexibility, simplicity, innovation level, and near monopoly advantages attributes received the minimum weights of 0.0078, 0.0078, and 0.0081, with standard deviations of 0.0051, 0.0095, and 0.0085, respectively. This result leads to the conclusion that BOT project participants are first interested whether the project is financially and legally sound before they become concerned with the project's design characteristics and its conformance with relevant technical standards.

The group composite weight of an attribute represents its relative importance to the total project viability. These weights are obtained by multiplication of the group attribute weights (Table 5) by the corresponding group category weights (Table 3). For instance, the group composite weight of the attribute *availability of resources* is determined by multiplying the group weight of this attribute by the group weight of the *technical* category. Therefore, the group composite weight of this attribute is $0.448 \times 0.114 = 0.051072$. Table 7 displays the group composite weights of attributes toward the project viability. Fig. 5 displays the individual range of each attribute's weights. For each attribute, the bottom part of the column represents the minimum importance weights assigned by respondents, and the top of the column indicates the maximum importance weights. The shaded row in the middle represents the group composite weight of the attribute, the dark regions above and below the row of the group composite weight indicate the standard deviation of the individual attribute weights (one half of the standard deviation is placed above while the other half is placed below). An examination of Fig. 5 shows that seven attributes have a considerably wide range between their maximum and minimum importance weights. The return on investment attribute has the maximum range of weight difference which reflects a wide range of attitudes by respondents based on their primary concern in the project performance (the minimum weight was given by $R11$, a "government consultant" while the maximum weight was given by $R3$, a "private financial consultant"). Six attributes have a considerably small range (difference in weights), and the design flexibility attribute has the smallest range as the respondents had similar opinions about the importance of flexibility of project design.

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Table 4. Feasibility Decision Factors: Local Attributes Weights

	$R1$	$R2$	$R3$	$R4$	$R5$	$R6$	$R7$	$R8$	$R9$	$R10$	$R11$	$R12$
Legal and environmental category												
CLR	0.478	0.314	0.26	0.446	0.46	0.499	0.741	0.458	0.432	0.415	0.096	0.385
PRM	0.199	0.078	0.365	0.167	0.166	0.137	0.188	0.173	0.088	0.346	0.096	0.087
CEP	0.272	0.544	0.237	0.329	0.315	0.299	0.267	0.289	0.416	0.093	0.675	0.364
PAP	0.052	0.064	0.139	0.058	0.058	0.066	0.074	0.079	0.065	0.146	0.132	0.164
Technical category												
DF	0.161	0.054	0.035	0.036	0.042	0.069	0.082	0.079	0.069	0.077	0.049	0.090
S	0.079	0.031	0.081	0.081	0.058	0.039	0.034	0.039	0.036	0.046	0.049	0.033
F	0.308	0.162	0.255	0.293	0.289	0.177	0.214	0.179	0.231	0.198	0.248	0.164
AOR	0.376	0.334	0.280	0.469	0.474	0.429	0.452	0.470	0.394	0.448	0.529	0.484
IL	0.024	0.073	0.070	0.048	0.073	0.065	0.058	0.073	0.069	0.033	0.062	0.064
EBE	0.052	0.346	0.280	0.072	0.063	0.222	0.161	0.160	0.201	0.199	0.063	0.166
Financial and commercial category												
APCN	0.088	0.022	0.072	0.041	0.043	0.040	0.063	0.053	0.062	0.047	0.032	0.034
FFD	0.025	0.015	0.073	0.149	0.135	0.018	0.020	0.021	0.020	0.066	0.013	0.019
NMA	0.017	0.015	0.035	0.028	0.025	0.023	0.031	0.021	0.023	0.021	0.017	0.013
HDE	0.105	0.086	0.039	0.096	0.117	0.107	0.107	0.110	0.097	0.090	0.241	0.096
HQP	0.022	0.015	0.051	0.031	0.028	0.021	0.020	0.022	0.021	0.020	0.103	0.032
HFEC	0.110	0.069	0.045	0.031	0.030	0.058	0.094	0.072	0.054	0.058	0.047	0.077
ALT	0.247	0.236	0.076	0.239	0.231	0.221	0.226	0.237	0.288	0.048	0.201	0.239
SCCP	0.085	0.081	0.139	0.149	0.125	0.066	0.040	0.062	0.090	0.189	0.132	0.109
LCC	0.026	0.084	0.148	0.035	0.042	0.077	0.053	0.084	0.061	0.114	0.109	0.083
NB	0.028	0.015	0.056	0.016	0.023	0.025	0.035	0.039	0.032	0.013	0.030	0.028
ROI	0.247	0.362	0.267	0.185	0.201	0.345	0.310	0.279	0.253	0.335	0.075	0.270

Note: CLR=project risk management system; CEP=conformance to the environmental policies; DF=design flexibility; **S**=simplicity; **F**=functionality; APCN=accurate prediction of critical needs; FFD=forecast of future demand; HQP=high qualified professionals; HFEC=high front-end cost; ALT =acceptable tariff level; SCCP=short construction and concession period; PRM=project risk management system; PAP=public acceptance of the project; AOR=availability of resources (local/imported); IL=innovation level; EBE=effective and beneficial expansion; NMA=near monopoly advantages; HDE=high debt/equity ratio; LCC=low construction cost; NB=number of bidders; and ROI=return on investment.

Attributes Worth Scores and Model Validation Approaches

Dias and Ioannou (1996) stated that the use of external criteria to objectively assess the validity of evaluation models is a difficult issue as multiattribute decision models are essentially subjective in nature. Therefore, in the past, researchers have relied mostly on indirect approaches, such as convergent validation, predictive validation, and axiomatic validation. Convergent validation consists of comparing the results obtained by a multiattribute decision model with a holistic evaluations made by the decision maker. In using this approach, several alternatives (e.g., projects) are defined and then, evaluations based on the model and on the decision maker's judgments are compared as to how they rate and/or rank these alternatives. To verify if the model is capturing the decision maker's holistic evaluation, high correlation between the decomposed model and the holistic evaluations is expected to occur. A convergent validation approach was used in our research to validate the viability multiattribute decision model. The reasons for this selection are similar to those described in Dias and Ioannou (1996). Three existing BOT projects: Sidi Karir Power Plant, Marsa Allam Airport in Egypt, and Channel Tunnel Project in the UK were defined (see Appendix II) and presented to the respondents who were asked to evaluate the performance of the model attributes in the three project profiles on the performance scale (1–9) and to rate them holistically on a 0–10 scale. Two respondents to the first questionnaire were involved in the Sidi Karir Power Plant project, and six in Marsa Allam Airport project in Egypt. The channel tunnel was selected because of its prominence among the world's BOT projects. In contrast to the Dias and Ioannou (1996) approach, the performance value of $p1$ will be kept at zero in the other two alternative ($P2$ only, $p2=100$) approaches. This assumption was based on the fact that all of the selected decision factors were considered significant by experts and have a measurable impact on the outcome of the project viability. Also in the $p2=100$ approach the performance point $p2$ will be kept at 100 points to widen the range of performance satisfaction. The three alternative decomposed evaluation approaches (Dias and Ioannou, $P2$ only, $p2=100$) were used to calculate the worth of each project profile and they were based on the following assumptions:

Dias and Ioannou (1996) Approach

The worth score $V_i(x_i)$ for each model attribute was calculated from the value curves that consider the points $P1$ and $P2$ as the performance extremes, whereas if the attribute's performance $P \leq P1$, this will result in a zero score for the attribute's worth, and finally if $P > P2$, it will result in a 100 score. The value curve used to calculate attributes' worth in this approach is based on the Dias and Ioannou modified value curve. To see this curve, the reader may wish to be referred to (Dias and Ioannou 1996).

$P2=100$ Approach

The $P1$ value is always equal to zero based on a logical assumption that any of the model decision factors (attributes) are important and have a certain impact on the project viability, and their

Table 5. Group Weights for the Comparison of Attributes within Their Categories

Attribute	Group weight
Legal and environmental	
Conformance to laws and regulations	0.395
Project risk management system	0.181
Conformance to the environmental policies	0.338
Public acceptance of the project	0.086
Technical	
Design flexibility	0.065
Simplicity	0.048
Functionality	0.236
Availability of resources (Local/Imported)	0.448
Innovation level	0.06
Effective and beneficial expansion	0.143
Financial and commercial	
Accurate prediction of critical need for the project	0.055
Forecast of future demands to the project	0.039
Near monopoly advantages	0.025
Reasonable High Debt/Equity ratio	0.112
Highly qualified professionals	0.03
High front-end cost	0.056
Acceptable level of tariff	0.202
Short construction and concession period	0.105
Low construction cost	0.079
Number of bidders	0.035
Reasonable return on investment	0.262

performance level P should be considered in the evaluation (even for very small performance values where $P \leq P1$). The $P2$ value is always equal to 9 (the *extremely desirable* point on the performance scale). Thus the value curve will begin from the origin to the extreme point of "extremely desirable" (see Fig. 6).

P2 Only Approach

It uses the same logical assumption used in the $P2=100$ Approach for the $P1$ value, while $P2$ value is still considered at 100 points even if $P > P2$ as in the Dias and Ioannou (1996) approach (see Fig. 7).

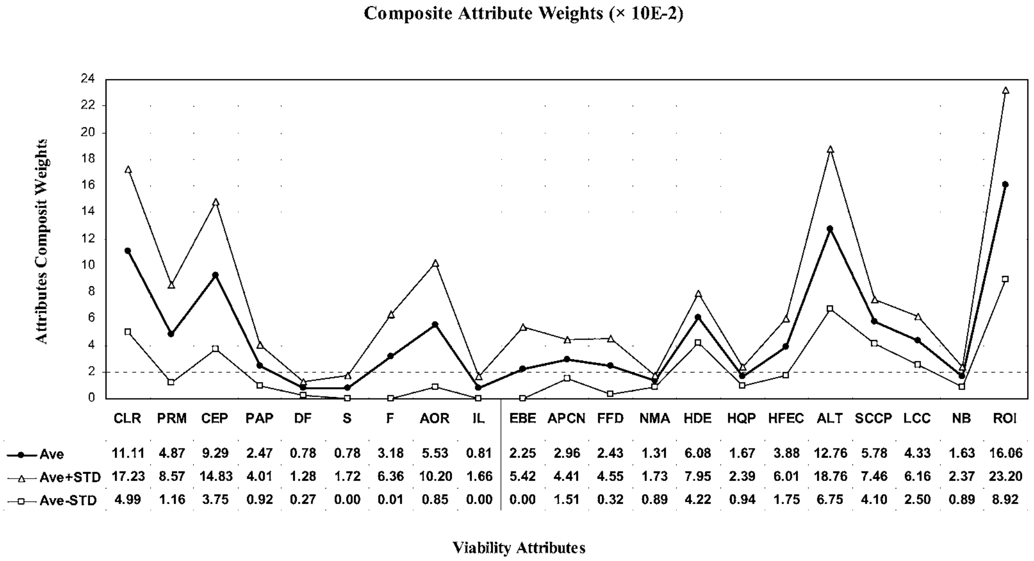
For each of the alternative approaches, 21 value curves (corresponding to the number of attributes) were plotted using the performance level points $P1$ and $P2$ and the individual worth score of each attribute $V_i(x_i)$ in each project profile was obtained from projecting the performance level points P on the corresponding value curves. The values of $P1$, $P2$, and P were given by respondents in the second questionnaire. To see these values in details, the reader may wish to be referred to Salman (2003).

Results from Evaluation of Decision Factors in Project Viability Model

The contribution of an attribute to project viability can now be determined for each approach by multiplying their worth scores by their composite weights. The total project value (index) will be the outcome of the decomposed evaluations as in Eq. (1). The individual holistic evaluations and the decomposed evaluation by EM of the three approaches [Dias and Ioannou (1996) $P2$ Only, $P2=100$] for each project profile are presented in Table 8. Average results of the decomposed evaluations of project profiles by

Table 6. Local Composite Weights of the Attribute toward Project Viability (× 10E-2)

	$R1$	$R2$	$R3$	$R4$	$R5$	$R6$	$R7$	$R8$	$R9$	$R10$	$R11$	$R12$
Legal and environmental												
Conformance to laws and regulations	10.40	5.50	2.60	17.30	23.00	11.80	10.50	13.40	10.50	17.80	3.20	7.30
Project risk management system	4.30	1.40	3.70	6.50	8.30	3.20	4.20	5.10	2.10	14.80	3.20	1.60
Conformance to environmental policies	5.90	9.60	2.40	12.80	15.70	7.10	6.00	8.50	10.10	4.00	22.50	6.90
Public acceptance of the project	1.10	1.10	1.40	2.20	2.90	1.60	1.60	2.30	1.60	6.30	4.40	3.10
Technical												
Design flexibility	1.50	0.30	1.50	0.30	0.40	0.40	0.60	0.50	0.40	1.10	1.60	0.70
Simplicity	0.70	0.20	3.50	0.80	0.60	0.20	0.20	0.30	0.20	0.70	1.60	0.30
Functionality	2.80	1.00	11.00	2.90	3.00	1.10	1.50	1.20	1.30	2.80	8.30	1.30
Availability of resources	3.40	2.00	12.10	4.60	5.00	2.80	3.20	3.10	2.20	6.40	17.60	3.90
Innovation level	0.20	0.40	3.00	0.50	0.80	0.40	0.40	0.50	0.40	0.50	2.10	0.50
Effective and beneficial expansion	0.50	2.10	12.10	0.70	0.70	1.40	1.10	1.10	1.10	2.80	2.10	1.30
Financial and commercial												
Accurate prediction of critical need	6.10	1.60	3.40	2.10	1.70	2.80	4.50	3.40	4.30	2.00	1.10	2.50
Forecast of future demands	1.70	1.20	3.40	7.70	5.30	1.20	1.40	1.30	1.40	2.80	0.40	1.40
Near monopoly advantages	1.20	1.20	1.60	1.50	1.00	1.60	2.20	1.30	1.60	0.90	0.60	1.00
Reasonable high debt/equity ratio	7.30	6.50	1.80	4.90	4.70	7.50	7.50	7.10	6.80	3.90	8.00	7.00
Highly qualified professionals	1.50	1.10	2.40	1.60	1.10	1.50	1.40	1.40	1.40	0.80	3.40	2.40
High front-end cost	7.60	5.30	2.10	1.60	1.20	4.00	6.70	4.60	3.80	2.50	1.60	5.60
Acceptable level of tariff	17.10	18.00	3.50	12.30	9.10	15.50	16.00	15.20	20.20	2.10	6.70	17.40
Short construction and concession period	5.90	6.20	6.50	7.70	4.90	4.60	2.80	4.00	6.30	8.10	4.40	8.00
Low construction cost	1.80	6.40	6.90	1.80	1.70	5.40	3.80	5.40	4.30	4.90	3.60	6.00
Number of bidders	1.90	1.10	2.60	0.80	0.90	1.70	2.40	2.50	2.20	0.50	1.00	2.00
Return on investment	17.00	27.60	12.40	9.50	8.00	24.10	21.90	17.90	17.70	14.30	2.50	19.80



	CLR	PRM	CEP	PAP	DF	S	F	AOR	IL	EBE	APCN	FFD	NMA	HDE	HQP	HFEC	ALT	SCCP	LCC	NB	ROI
—●— Ave	11.11	4.87	9.29	2.47	0.78	0.78	3.18	5.53	0.81	2.25	2.96	2.43	1.31	6.08	1.67	3.88	12.76	5.78	4.33	1.63	16.06
—△— Ave+STD	17.23	8.57	14.83	4.01	1.28	1.72	6.36	10.20	1.66	5.42	4.41	4.55	1.73	7.95	2.39	6.01	18.76	7.46	6.16	2.37	23.20
—□— Ave-STD	4.99	1.16	3.75	0.92	0.27	0.00	0.01	0.85	0.00	0.00	1.51	0.32	0.89	4.22	0.94	1.75	6.75	4.10	2.50	0.89	8.92

Fig. 4. Average EM composite attribute weights with its boundaries of ± standard deviation

each respondent were calculated for the three approaches and plotted against average holistic evaluations. The resulting Fig. 8 shows that in $P2$ Only and $P2=100$ approaches, all individual decomposed evaluations produced higher scores than those produced in evaluations based on the Dias and Ioannou (1996) approach. This is because of the assumption that the performance level point $P1$ was kept at zero in the two approaches, so that any attribute performance less than $P1$ and larger than zero had a worth score and is included in the determination of the calculation of project viability [Eq. (1)]. In the Dias and Ioannou (1996) approach, the attribute performance level point $P1$ was considered in the evaluations so that all the attribute performance levels located behind $P1$ had their worth score equal to zero and are excluded from the Eq. (1). Fig. 8 also shows that the $P2$ Only approach resulted in larger project viability scores than the $P2=100$ approach. In the $P2$ Only approach, performance level points $P2$ provided by respondents were considered as the extreme points of desirable performance and assigned the value of 100 points even if they were not at the extreme end of the performance scale and all attribute performance levels located after this point would have the same worth. While in the $P2=100$ approach the attribute performance point $P2$ was always kept at the end of the performance scale so that for the attribute performance point P higher than the $P2$ point provided by the respondents, its worth would be under 100. This resulted in attribute worth values smaller than those in the $P2$ Only approach. The holistic evaluation curve is also included in Fig. 8 to compare the results of the three approaches and their holistic evaluations. From observations, the $P2=100$ approach curve is the closest to the holistic curve which indicates that it appears to be most suitable to capture the holistic approach. The group results of the holistic and decomposed evaluations for each project profile were calculated by taking the averages of individual evaluations for the three approaches. The results are shown in Table 9. The holistic and the decomposed evaluation were compared by the Pearson's product-moment correlation coefficient. Three correlation processes were used to verify the validity of the model and to determine which approach was the closest to capture the holistic approach.

Table 7. Attributes Group Composite Weights of Attribute ($\times$10E-2)

Attribute	Group composite weight
Legal and environmental	
Conformance to laws and regulations	11.139
Project risk management system	5.1042
Conformance to the environmental policies	9.5316
Public acceptance of the project	2.4252
Technical	
Design flexibility	0.741
Simplicity	0.5472
Functionality	2.6904
Availability of resources (local/imported)	5.1072
Innovation level	0.684
Effective and beneficial expansion	1.6302
Financial and commercial	
Accurate prediction of critical need for the project	3.3165
Forecast of future demands to the project	2.3517
Near monopoly advantages	1.5075
Reasonable high debt/equity ratio	6.7536
Highly qualified professionals	1.809
High front-end cost	3.3768
Acceptable level of tariff	12.1806
Short construction and concession period	6.3315
Low construction cost	4.7637
Number of bidders	2.1105
Reasonable return on investment	15.7986

The first correlation process was to compare individual holistic evaluations and decomposed evaluations obtained from each approach. The results indicate that the three approaches have a reasonably high correlation coefficient with the holistic approach (correlations range between 0.750 and 0.999). The averages of Pearson's correlation coefficients in the three approaches indicated that the $P2=100$ approach best captures the holistic approach (average correlations for $P2=100$, $P2$ Only, and Dias and Ioannou (1996) approaches were 0.9573, 0.94223, and 0.935955, respectively). The above results were plotted in Fig. 9 and provide

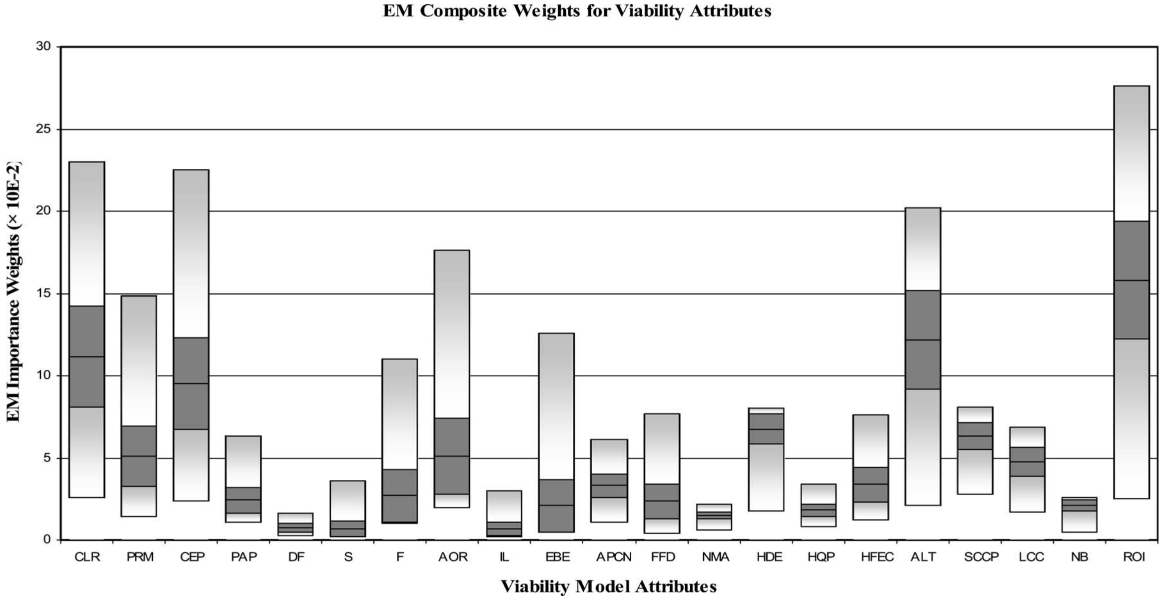


Fig. 5. Group weights and range of individual weights

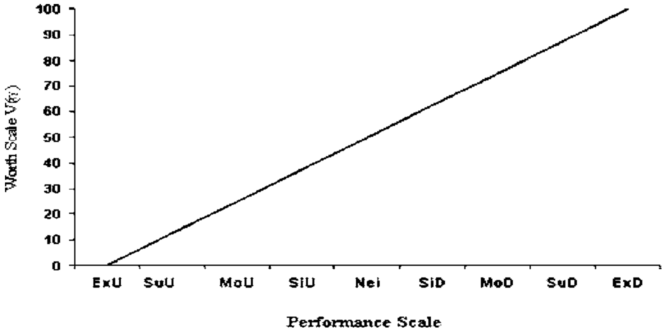


Fig. 6. Modified generic form of value curves in $P2=100$ approach

that, by observation, the confined area between the $P2=100$ approach curve and the holistic line is smaller than the confined areas between holistic and each of the $P2$ Only and Dias and Ioannou (1996) approaches. This means that the $P2=100$ approach has the highest correlation with the holistic evaluations and therefore appears to be the best approach to capture the holistic evaluation. The Dias and Ioannou (1996) approach has the largest area which indicates that it is far from capturing the holistic approach. The second correlation was determined by calculating the Pearson correlation coefficients between the holistic

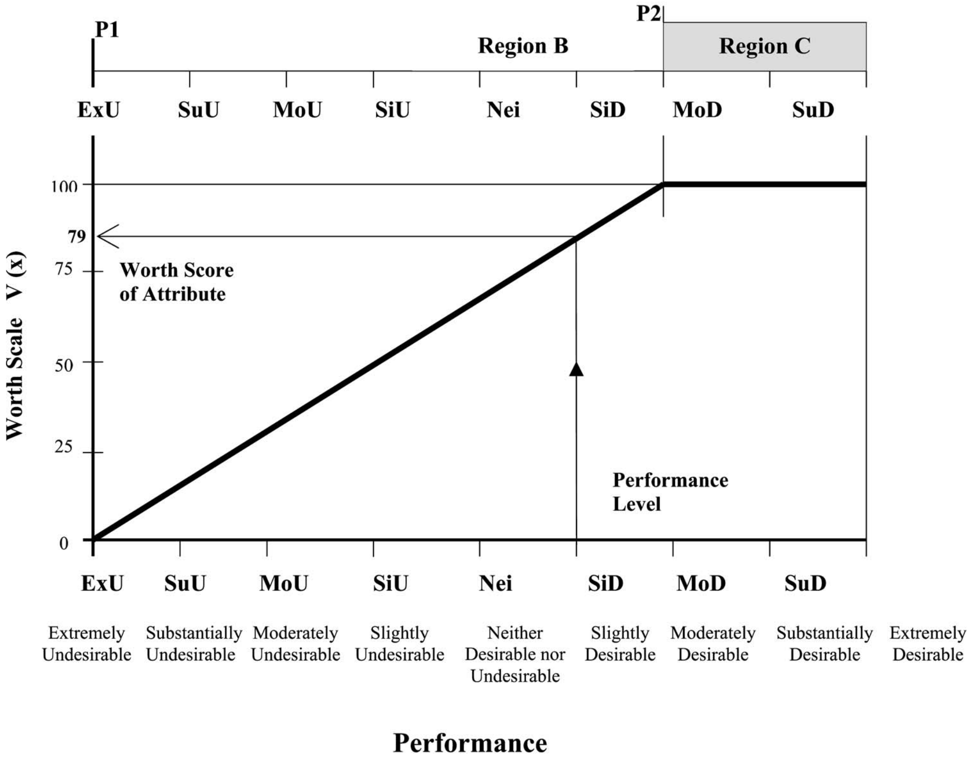


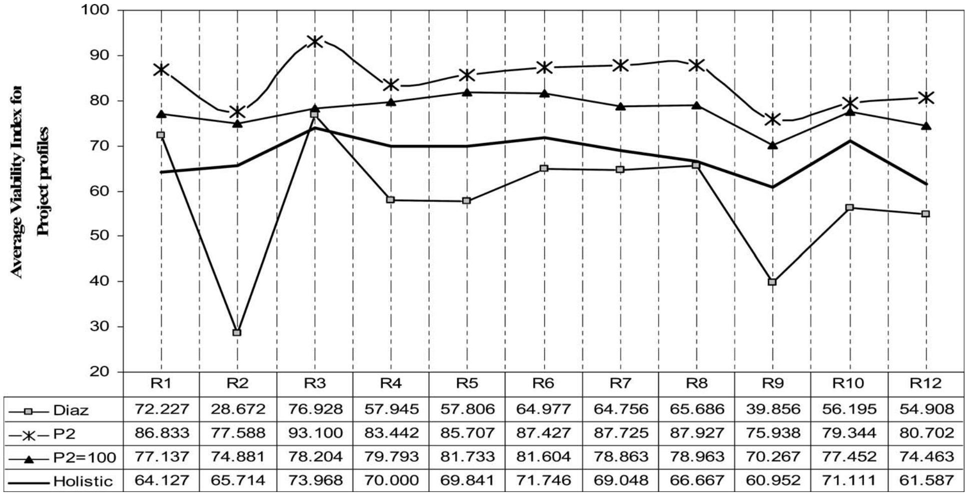
Fig. 7. Modified generic form of value curves in $P2$ only approach

Table 8. Holistic and Decomposed Evaluations Performed by Individuals on Project Profiles

Method	*R*1	*R*2	*R*3	*R*4	*R*5	*R*6	*R*7	*R*8	*R*9	*R*10	*R*12
Sidi Karir power plant project											
Holistic	61.90	79.05	77.14	68.10	66.19	59.52	62.38	63.81	56.19	78.10	59.05
Diaz	69.48	44.37	77.65	51.31	45.79	35.04	56.82	63.11	30.45	67.50	51.15
*P*2 Only	86.10	88.04	93.54	81.20	82.31	76.23	83.51	87.13	73.50	73.02	81.07
*P*2=100	72.01	84.77	78.52	77.42	78.41	70.62	74.43	76.42	67.37	82.50	73.04
Channel tunnel											
Holistic	77.14	65.24	69.52	72.86	72.38	80.00	73.81	71.43	68.10	65.71	68.10
Diaz	99.66	22.45	73.20	72.54	73.38	98.62	76.10	70.68	53.40	43.53	65.38
*P*2 Only	99.75	76.23	92.38	88.44	91.05	99.37	92.53	89.37	79.71	82.05	82.55
*P*2=100	95.07	73.27	77.78	86.54	86.76	94.64	83.48	84.00	75.02	72.44	78.90
Marsa Allam Airport											
Holistic	53.33	52.86	75.24	69.05	70.95	75.71	70.95	64.76	58.57	69.52	65.00
Diaz	47.54	19.20	79.93	49.98	54.25	61.27	61.35	63.28	35.72	57.55	48.20
*P*2 Only	74.65	68.50	93.38	80.69	83.76	86.68	87.13	87.28	74.61	82.96	78.49
*P*2=100	64.33	66.61	78.31	75.41	80.03	79.54	78.68	76.47	68.41	77.41	71.44

approach and the three decomposed approaches for each project profile and the results are presented in Fig. 10. It is interesting to see that the *P*2=100 approach has the highest correlation coefficients for the three project profiles with the holistic evaluations. Also, the Channel Tunnel project seemed to be the closest project to its holistic evaluation in the three alternative approaches; it was followed by the Marasa Allam Airport project while Sidi Karir Power Plant project was the least correlated. This order might be related to the degree of availability of information related to each project in the media.

The third correlation was made between holistic and decomposed evaluations of attributes with respect to the three approaches and the results shown in Fig. 11 indicate that 17 attributes have a considerably strong correlation with the holistic while three attributes: simplicity; effective and beneficial expansion; and accurate prediction of critical need for the project have a considerable moderate correlation with their holistic value. One attribute, acceptable tariff level, is considered slightly correlated. The average values for correlation coefficients and the confined areas between holistic and each of the three designed approaches in Fig. 11 show that the *P*2=100 approach is the closest to capturing the holistic approach. Fig. 12 displays the viability index provided by the respondents for each project profile. In Fig. 12 each project is associated with four columns. Each of the first three (left to right) columns represents one of the alternative evaluation approaches, and the fourth column represents the corresponding holistic approach. Each column indicates the average and the range of individual's indexes with their standard deviation [for ease of comparisons, the column format was adapted from Dias and Ioannou (1996)]. The bottom of each column indicates the minimum value of the viability index for the group of respondents and the top of the column indicates the maximum value of the viability index. The line in the middle of the darker region reflects the grouped results (i.e., average of the individual indexes) and the darker region represents one half of the standard deviation above and below the corresponding average. From Fig. 12, it can be seen that the *P*2=100 approach (i.e., the third column in each project) has the minimum range between the maximum and minimum indexes for the group of respondents with minimal values of standard deviation (darker areas above and below the average index). Also, in the three project profiles, the average values and the range of individual's indexes for the *P*2=100 approach are the closest to the holistic approach values (i.e., the fourth column in Fig. 12).

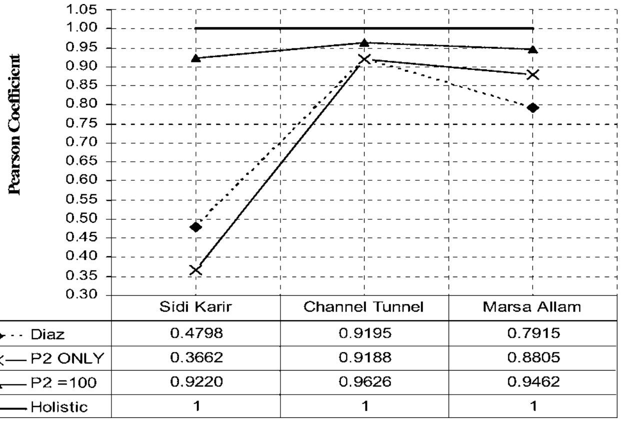


	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R12
Diaz	72.227	28.672	76.928	57.945	57.806	64.977	64.756	65.686	39.856	56.195	54.908
P2	86.833	77.588	93.100	83.442	85.707	87.427	87.725	87.927	75.938	79.344	80.702
P2=100	77.137	74.881	78.204	79.793	81.733	81.604	78.863	78.963	70.267	77.452	74.463
Holistic	64.127	65.714	73.968	70.000	69.841	71.746	69.048	66.667	60.952	71.111	61.587

Fig. 8. Comparison between average holistic and decomposed evaluations approaches

Table 9. Viability Indices for Average Project Profiles (Group Results)

Project	Holistic approach	Diaz approach	*P*2 only approach	*P*2=100 approach
Sidi Karir Power Plant	66.494	53.879	82.332	75.957
Channel Tunnel	71.299	68.084	88.494	82.536
Marsa Allam Airport	65.325	52.570	81.647	74.241



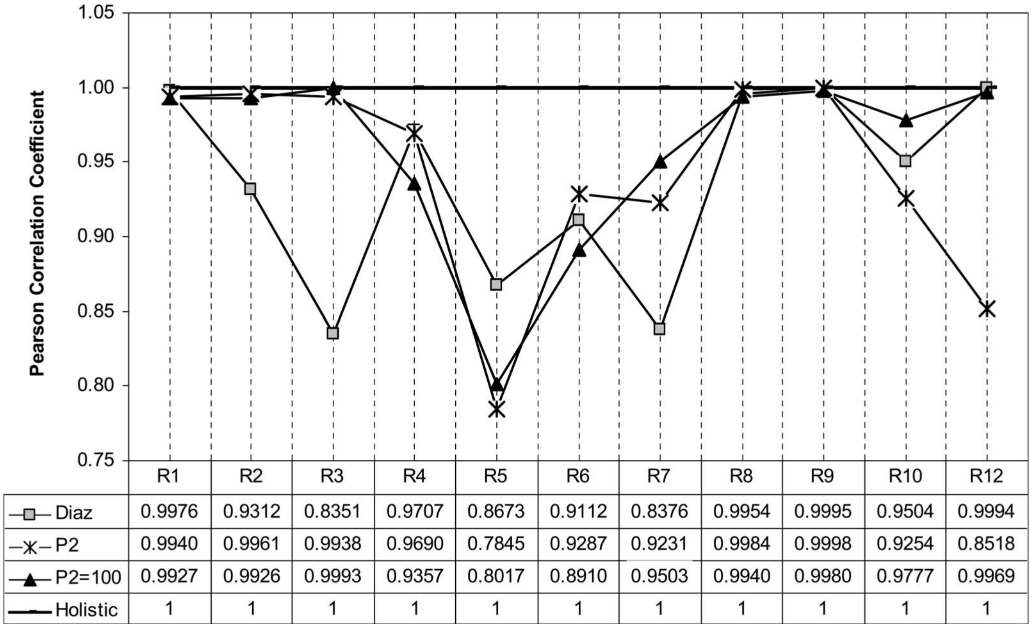
	Sidi Karir	Channel Tunnel	Marsa Allam
◆ Diaz	0.4798	0.9195	0.7915
× P2 ONLY	0.3662	0.9188	0.8805
▲ P2 =100	0.9220	0.9626	0.9462
Holistic	1	1	1

Fig. 10. Correlation between individual's holistic and decomposed evaluations approaches for each project profile

Conclusions

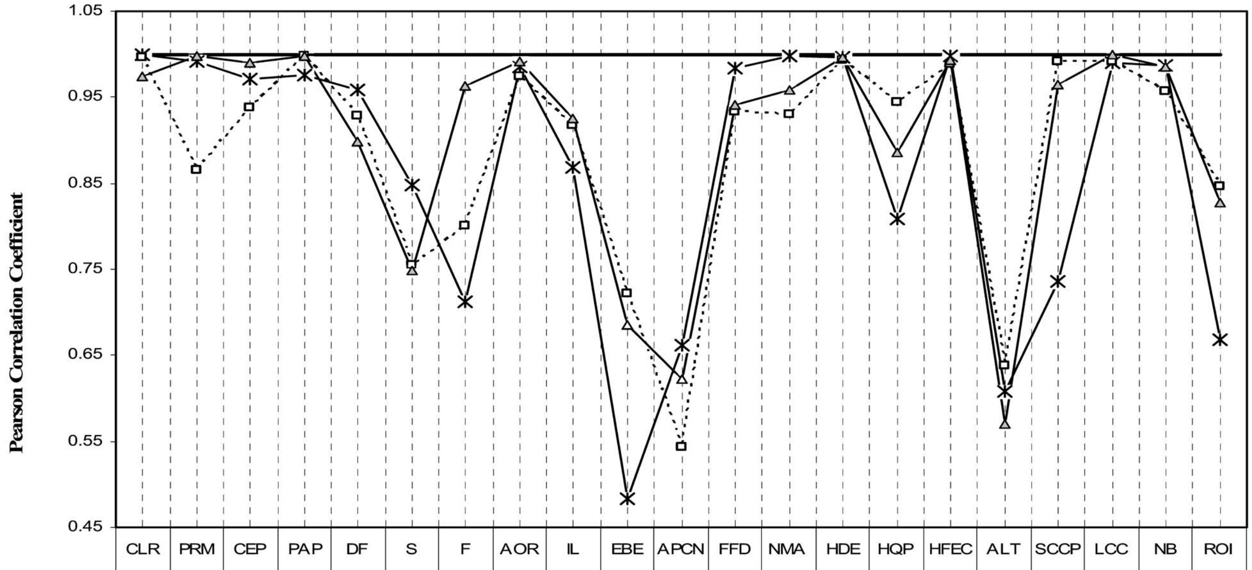
To develop a successful BOT project, the project promoters should ascertain that the project must be politically, socially, legally, environmentally, economically, and financially viable. Since project feasibility study is essential for both government and private promoters to develop the project, both parties should share the efforts and costs needed to complete it.

In this research, a new combination of 21 decision factors relevant in BOT infrastructure projects have been identified and classified (legal and environmental, financial and commercial, technical) to determine their inter-relationships and their effect on the total project viability. The importance weights for these factors were calculated with Expert Choice 2000 software based on the analytical hierarchy process (AHP) technique developed by Saaty (1980). Expert respondents to questionnaires used in this research indicate the financial and commercial category of project viability factors as the most important (60.3%), with the legal and environmental category somewhat less important (28.2%) and technical categories of factors being relatively least important (11.4%). To determine the contributions of the decision factors to the project viability index, the attributes worth scores were calculated based on the respondents' measure of the performance level for each attribute and the use of three alternative approaches To validate the model, the three alternative approaches have been applied to three case study projects. The outcomes of these alternatives were correlated in several ways to the direct holistic evaluations of the three project profiles and indicate the outcomes of the $P2=100$ approach presented in the paper as being the most relevant in capturing the holistic evaluations. In the study presented above, the decision factors used in the project viability model have some limitations that a decision maker needs to be aware of: (1) the viability decision factors were selected from different types of completed infrastructure projects and generalized, but for a specific project in a given country there will be unique project related decision factors that decision maker should add to the above generalized decision factors; and (2) the use of an expert's opinion in the viability model methodology limited the maximum number of factors being considered to 11. Categorizing the related factors under three main categories was the suggested solution for the second constraint. Merging more than 11 factors under each category would complicate pairwise comparisons and produce incorrect results of the evaluation. The sug-



	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R12
▢ Diaz	0.9976	0.9312	0.8351	0.9707	0.8673	0.9112	0.8376	0.9954	0.9995	0.9504	0.9994
✳ P2	0.9940	0.9961	0.9938	0.9690	0.7845	0.9287	0.9231	0.9984	0.9998	0.9254	0.8518
▲ P2=100	0.9927	0.9926	0.9993	0.9357	0.8017	0.8910	0.9503	0.9940	0.9980	0.9777	0.9969
Holistic	1	1	1	1	1	1	1	1	1	1	1

Fig. 9. Correlation between individual's holistic and decomposed evaluations approaches



	CLR	PRM	CEP	PAP	DF	S	F	AOR	IL	EBE	APCN	FFD	NMA	HDE	HQP	HFEC	ALT	SCCP	LCC	NB	ROI
—✱— Diaz	0.999	0.992	0.971	0.976	0.958	0.847	0.712	0.986	0.868	0.483	0.661	0.984	0.997	0.997	0.808	0.999	0.608	0.736	0.990	0.987	0.667
- - -□- - - P2Only	0.996	0.866	0.938	0.998	0.928	0.754	0.801	0.974	0.917	0.722	0.544	0.933	0.929	0.993	0.944	0.989	0.638	0.992	0.991	0.956	0.847
—△— P2=100	0.973	0.999	0.991	0.998	0.898	0.749	0.964	0.992	0.926	0.685	0.621	0.941	0.959	0.996	0.885	0.993	0.570	0.965	1.000	0.985	0.827
—— Holistic	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Viability Attributes

Fig. 11. Correlation between viability attributes holistic and decomposed evaluations approaches for project profiles

gested solution is to add other related categories and reclassify the factors due to their relevancy under each category.

In conclusion, this paper presents the following contributions to the state-of-the-art in feasibility analysis of BOT infrastructure projects:

- Provides new combinations of the most important feasibility decision factors that were carefully identified, selected, and screened by a group of experts;
- Introduces the newly designed $P2=100$ approach which provides in-depth analysis of the qualitative (linguistic) decision factors that were commonly evaluated arbitrarily. This could shed new light on the concerns of BOT project decision makers in government and private sector organizations who have historically focused primarily on the quantitative (numerical) decision factors; and

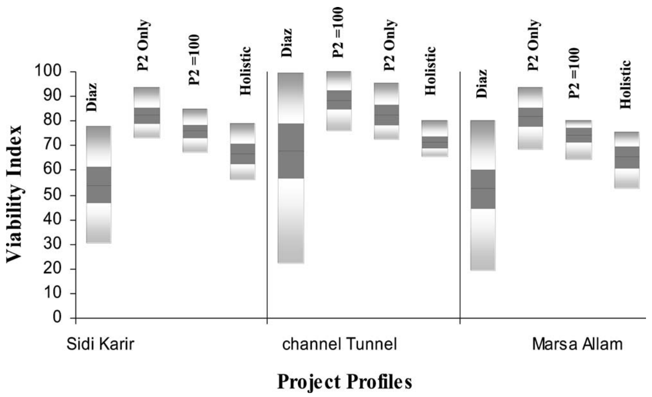


Fig. 12. Project group averages and range of individual's viability indexes

- Helps the decision maker to determine appropriately the viable and nonviable decision factors and to determine what factors would contribute most to improve the viability of future BOT projects

Appendix I. Build-Operate-Transfer Project Viability Decision Support Factors

Legal and Environmental Factors

This category includes four sub-factors:

- ***Conformance to laws and regulations for specific project category***—The laws and regulations that will apply to sponsors and lenders such as foreign investment, corporate law, security legislations, taxation, intellectual property rights, etc., is widely recognized as essential for a successful BOT project. The differences between the legal nature of a BOT project and the legal nature of the country must be assessed carefully and should be amended as "project agreements, concession agreements" in the project documents.
- ***Conformance to environmental policies***—The environmental impact of the proposed BOT project on the surrounding environment during the project identification should be evaluated correctly. This measure determines the project conformance to the environmental norms.
- ***Project risk management system***—The actual risks inherent in BOT projects which are significant will vary from project to project. In order to reduce the potentially disastrous consequences of risks, project participants before undertaking the project seek to understand them and deal with them appropriately.
- ***Project acceptance to the project***—BOT infrastructure

projects tend to have a high public profile because of the fact that the public is normally the end users of the project. Major BOT projects such as tunnels, bridges can therefore attract much opposition from different groups of people in the host country, each having its own motive and interest. Such groups can range from the political opposition that aspires to be regarded as a champion of public interest, environmentalist's opposition to the changes in environmental conditions of the project area, to contractors, who wish not to be excluded from these reputable projects. BOT projects need support and understanding from the community directly affected by the project, who should be able to tolerate the inconveniences caused during the construction phase. Examining the public acceptance to the project before undertaking it is essential to guarantee its success.

Technical Factors

This category includes six subfactors:

- ***Design flexibility***—Built-in flexibility for future growth and changes: The design concept of large-scale BOT infrastructure projects are invariably human-activity centered and, as such, dynamic and capable of continual growth. The design guidelines should be laid down so as to achieve both flexibility and adaptability to change and the ability to expand to accommodate future growth.
- ***Simplicity***—The technical design of the project must provide a simple solution to the need of the project. This will save a considerable amount of time and construction cost and will make the technical proposal highly attractive to the host government.
- ***Functionality***—The design functionality of the BOT projects must at least meet the project requirements, deliver a project that most closely conforms to the user's expectations, and satisfy the government. Functionally of design should be tested accurately before proceeding in bidding.
- ***Availability of local/imported resources***—the availability of project resources such as construction materials, equipments, skilled laborers operating equipment, and fuel supply (power plant projects), etc., in the host country should be examined and assessed, and the other resources that need to be imported should be determined before proceeding with the bidding process.
- ***Innovation level***—Imaginative technical design should accommodate the local project environment. In some circumstances, a high innovation level in an undeveloped country may decrease the possibility of winning the bid, while for developed countries it is very important to a provide a higher level of innovation in design to make the technical proposal more attractive.
- ***Effective and beneficial expansion***—In the majority of large scale infrastructure projects, once the project has been operated and found effective and beneficial, the further expansion becomes substantial to accommodate the future growth. Due to this, the project design elements must be effective and beneficially expandable. Those features will make the technical proposal more attractive to the host government.

Financial and Commercial Factors

This category includes eleven subfactors:

- ***Accurate prediction for critical need for project***—The need of a particular project must be estimated and identified before advertising the project for bidding.
- ***Forecast of future demands***—In the feasibility study of the BOT infrastructure project, it is essential to estimate in depth the future demands because of the long useful project life.
- ***Near monopoly advantages***—Project promoters are willing to achieve near monopoly advantages that there will not be other existed/planned competitive facilities in the area of their project which will badly affect their return on investment during the concession period.
- ***Reasonable high debt/equity ratio***—Debt-equity ratio is a way of measuring the amount of leverage used to fund a project. Financiers prefer to lend to projects which have substantial equity invested in them. The equity investment gives the sponsor and investors an incentive to make the project work by placing the equity at risk. The governments also have the same fears of financiers and need the sponsor to be totally committed to the project. A reasonable debt/equity ratio will satisfy all the parties involved in the project.
- ***Highly qualified professionals***—BOT infrastructure project participants should include highly qualified BOT professionals. The government agency which offers the project to bidding must have enough experience in the BOT system to set the project documents and to evaluate the project bids. The highly qualified bidders will only be included in the short list that will only bid on the project.
- ***High front-end cost***—Due to the nature of the large scale of BOT projects and the tremendous amount of elements need to be settled before proceeding with the project, the procurement process (project feasibility study, bidding, negotiations, project contracts, and agreements) is very expensive and its costs may be multimillions of dollars (the front end cost of the project), usually the promoters bear most of the project high front end cost. Without winning the bid the promoters may face the risk of bankruptcy; the government should find a way to compensate them.
- ***Acceptable tariff level***—Tariff level is the master key in bidding evaluation process, it must commensurate the economic conditions of the end users of the project. The main objective for the promoters is to adjust the tariff to repay their debts, equity, and maximize their profits during the concession period, while the main objective of the government is to minimize the level of tariffs to maximize their economic, political, and social gains from the project. These conflicted objectives make the negotiations on tariffs very complicated and usually consuming long period of time.
- ***Short construction and concession period***—This factor is extremely critical for the success of the BOT project, particularly for projects in developing countries where the rates of inflation and interest are very high and the need for the project is crucial.
- ***Low construction cost***—Represents a main objective for the government and the promoters because it will make the project economically sound for the government and spare considerable sums of money for the promoters in the early stage of the project. All the possible design alternatives should be assessed in depth basically to reduce the cost and time of construction; the optimal construction cost should be the goal of the project designers with the other complementary factors.
- ***Low number of bidders***—Unlike traditional tendering processes, the BOT tendering process does not necessary aim to maximize the number of competitors: To ensure the quality of a limited number of competitors is a more important objective.

Bidding for BOT usually is very expensive. A long list of bidders will complicate the negotiation process with bidders.

- ***Reasonable return on investment***—The return on investment is defined as the internal rate of return for the unleveraged projected cash flows to be generated by the project. The investor's viewpoint is "the project is usually deemed feasible and therefore fundable, if return on investment is sufficiently high."

Appendix II. Case Study Projects—Summary of Information Sent to Respondents for Holistic Evaluation

Sidi Karir Power Plant BOOT Project

Host country agency: Egyptian Electricity Holding Company (EEHC)

Private owner (sponsor): Sidi Karir Generating Company (SKGC)

Project profile: Steam turbine power plant (two unit fired steam) 325 MW

Location: 30 km west of Alexandria adjacent to Sidi Karir

Number of bidders: Nine bidders

Bid submittal: October 1997 **Bid awarded:** February 1998

Construction period: 3 years, starting July 1999, ending January 2002

Concession period: 20 years

Equity: $ 139.2 Million (Intergen 61%, Edison 39%)

Debt: $342.5 million (local banks $212.5 million, international banks $130.0 million)

Total cost: $481.7 million

Tariff level: $0.02540/kWh

Project resources: 35% local resources 65% imported

Channel Tunnel (UK-France) BOT Project

Host country: France and England, each country is responsible for bidding part of the project located on its own land according to their geographic terminals

Private owner (sponsor): Contracting organization, Transmanche Link (TML), made up of five French contractors and five British contractors won the contract and Eurotunnel was declared the owner of the 55-year concession for the link in 1986

Location: Tunnel link between France and England under Manche channel. The tunnel two terminals are The French terminal at Frethun referred to as the Coquelles facility, and the British terminal at Cheriton (Folkestone).

Number of bidders: 3 **Bid submittal:** December 1985

Bid awarded: 1986 **Construction period:** 10 years, starting July 1986, ending 1993

Concession period: 55 years

Equity: $2.3 Billion (TML $71.58 million, 40 Banks $313.74 million, French Bank $663 million, another investors $1.252 billion)

Debt: $12.6 Billion

Total cost: $ 14.9 billion **Tariff level:** From $325 to $465/vehicle

Marsa Allam Airport (Egypt) BOT Project

Host country agency: Egyptian Aviation Holding Company (EAHC)

Private owner (sponsor): El-Khorafi Group (EMAC)

Marsa Allam Aviation Service Company will be owned in 50-50 between EMAC and Egyptian Aviation

Service Company: Egyptian Aviation Service Company (EASC)

Project profile: Marsa Allam airport is the first BOT airport in Egypt, constructed to serve the southern red sea region

Project location: On the Red Sea coast south of Hurghada

Number of bidders: 25, short list 3 **Bid submittal:** 1997, **awarded:** 1998

Construction period: 3 years (July 1998–January 2001)

Operating: November 2001 **Concession period:** 40 years

Total cost: $40 million **Tariff:** average US$12/passenger

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