Implementing AHP Approach to Select an Appropriate Financing Method for PPP Highway Projects in Iran

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Abstract—The wide dimensions and nature of activities related to procurement, execution, maintenance and operation of highway projects in Iran and the effects of executing such projects as well as considerable usage of financial resources, call for a better coordination between these issues and other affairs of the country. This objective will not be achieved unless highway projects are financed by the most effective method. This research aims to evaluate different methods of financing such projects, identify the important criteria to select these methods, and finally select the most effective financing method. Identification of the criteria to choose the optimum financing method is significant in highway projects. If these criteria are carefully selected and applied, they will not only contribute to more efficient completion of highway projects, as one of the most significant infrastructures of a country, but also generate considerable revenues for the economy. In this paper, at first the most important criteria to select an optimum financing method for a highway project are identified by a questionnaire survey. In the next step, by using Cronbach Alpha calculated by SPSS, the questionnaire’s reliability is obtained and relative importance of each criterion is determined from perspective of project execution experts. Subsequently, AHP method and Expert Choice software are employed in order to choose the best financing method in highway projects. Finally, the most suitable financing method for highway projects in Iran is determined under the condition that all the identified and important criteria be applied.

Index Terms—PPP contracts, highway project, AHP approach, decision making

I. INTRODUCTION

Nowadays, there is a pressing need for infrastructures in many countries, due to the daily increasing population growth and economic development during the recent years. Nevertheless, government budgets are usually limited and inadequate for development of the required infrastructures of a country [1]. One of the proposed solutions is to implement the project using joint venture contracts of public-private sectors. According to the statistical reports of World Bank in 2008, some 137 countries in the world have well appreciated using this kind of contracts [2]. Based on fifth 5-year development plan of Iran, the government is allowed to deliver the construction projects with the participation of public-private sector in order to promote their efficiency and efficacy. A joint venture of the public-private sector is a long term contract between private and public sectors. Thereby, resources and risks are shared between the both parties, while its aim is still to establish facilities for the public [3].

In Iran, many discussions have been made on key role of the government about construction and development of the infrastructural transportation projects. Everyone knows that the role of government is significantly important in this case because: (1) such projects need a considerable amount of budget, long time for leadership and adequate tolerance for risk; (2) these projects incorporate a high social-economic cost which cannot be compensated by the money received from the user; (3) strategic role of the control. That is why the governments tend to adopt methods of financing the project from outside the government. So they could not only compensate for their budget deficit, but also can develop the needed important infrastructures such as construction and development of railway system. For this purpose, the use of private partnership for financing is an appropriate alternative. However, it is necessary to choose the correct PPP contract.

Although the PPP contracts have lots of advantage versus the traditional contract, the results and statistics show that a high percentage of them are cancelled. These statistics also show these cancellations increase until 70% in those countries which don't have enough experience in use of such contracts. The real reason of these contracts failure is the basic differences in problems of the PPP
contracts with identified problems of the traditional contracts [4].

In Iran, one of the main problems of highway projects is lack of quantity evaluation in optimal selection of finance method by PPP contracts. Available shortages and weaknesses in this subject cause unsuitable choosing of the opponent of contract, confusing the executives in understanding and correct using of the selected contract method for projects finance and sometimes wrong interpretations and results [5]. So survey and optimal choice of PPP method is very important because of the current challenges in finance method in Iran and the importance of proper selection in success of highway projects; And if there is sufficient attention and using of it in highway projects, which they constitute one of the basic foundation of development, extraordinary progress is achieved, and make remarkable advantages for Iran economy.

II. SPECIES OF PPP CONTRACTS FOR TRANSPORTATION PROJECT FINANCE

PPP advantages such as reducing public sector administration expenses, solving public sector budget problem restraint, providing high quality public products and services, and saving delivering time of the projects, make it a popular procurement method in recent years [6].

In PPP contracts, the responsibility of investment would be shared between both parties or entirely borne by the private sector again. In this case, the government is transformed from a base of planning, execution and operation in the previous processes to a command center for coordination, control and organization. Meanwhile, before applying PPP, the governments must identify and evaluate all advantages and limitations taking into account the project conditions, and choose the correct PPP technique [7].

Species of PPP contracts include:

A. Build, Operate and Transfer (BOT) Contracts

In this method after completion of the contract period, the ownership of the project will be transferred to the government by the investors. Also, private party undertakes all or part of the financing and thus the contract period should be long enough to ensure a return on investment and benefit from a private party [6]. These contracts are used in different countries and known as BOT contracts. These contracts from the design process until the end of operation may last twenty years or even more. It is clear that a large part of traditional state control over projects in these Contracts is assigned to private sector

B. Concessions Contracts (DBFO)

In Design- Build- Finance- Operate contracts, the private sector directly finances public sector projects and undertakes all responsibilities from the design to operation related to the project. Instead, the income of the project will be owned by the Executive private sector until agreed time with the public sector. These contracts may be used for the construction of new facilities, the renovation (modernizing) and the updating or the expansion existing facilities. Concession contracts usually last between 25 to 30 years. In BOT after construction, ownership is transferred to the government, but in DBFO, basically owned by the government at first and private party profits from exclusive right of exploiting from the project and taking income from this way (Private party cannot benefit from the acquisition and sale of facilities). In fact BOT, BTO and DBFO patterns in the developing countries make this possible to the government that provides the required funds for the construction project without a waiver of the right to exercise control over the project [7].

C. Private Divestiture Contracts (BOO)

In these contracts in order to implementation of privatization plans, public assets will be sold to the private sector. Public sector ownership transfer in a specific project can include all or part of government's share of the project assets.

D. Traditional Private Outsourcing Contracts

In these contracts ownership of the assets and project is dedicated to the public sector and the lowest share of the responsibility is transferred from the public sector to the private sector. Also usually in this case, the transferred responsibilities and duties are quite isolated from other parts of the project which are classified into three categories as follows [8]:

1) Service Contracts: Usually, these contracts for the implementation or completion of a specific task in a project will be used between the government and the private sector, such as providing machinery, work with them or repair and maintenance; For example, in highway toll collection.

2) Operation and Management Contracts: In these contracts the responsibility for the operation and management are transferred from public sector to the private sector. Due to the complexity of the correlate public projects when it is used to attract private sector cooperation that the level of technology used in the project is very high and also effectiveness is strongly influenced by its complexity. These contracts typically are longer than Service Contracts.

3) Leasing Contracts: These agreements provide an opportunity for private sector units to create revenue flows for themselves by paying a fixed rent and also with the commitment that public sector assets are managed carefully and the related operations are done correctly. In this attitude, the interest rate of the private sector (tenant) depends on this sector ability to lower operational costs. In other words, project commercial risk is transferred to the private sector. However, the unit that contract with the public sector is committed to meet intended Standards of the government in providing services.

The concept of investment is considered from two perspectives. A useful operational definition of investment is transfer of property rights. To understand the concept, it must be considered what rights there are in association with the ownership. The ownership includes two groups of rights, including: the rights related to
residual profit which means profit in general meaning and management control which covers a range of short-term operations and long-term development [7].

Public-private partnership is a long-term contract between representatives of the private sector and the public sector that whereby resources and risks are shared between the parties and the purpose of this contract is facilities for the general public. In Iran’s law, there are two potential sources for infrastructure projects finance through partnership, including internal private investment and international private investment [7].

III. RESEARCH BACKGROUND

In 1936, one of the most influential economists John Maynard Keynes published his famous theory called Keynesian economics. He offered a combination of economic based on public private partnership by survey on various economical methods. He imagined in his theory the following tasks for governments: Effects of government intervention to the macroeconomic, Government policy in economic issues, Government monitoring the economy, Government supports from private sector activities.

After a long time and in the 1980s, Foundations of Keynes economics has been considered at the macroeconomic level. For the first time in the world, Halil Turgut Özal, Prime Minister of Turkey in the 1980s, used a series of BOT contracts to develop energy infrastructure, especially in power industry [9]. In recent years a lot of efforts have been made in order to determine the risks of PPP projects [10]-[12]. Iyer and Sagheer specifically reviewed the risks of PPP contracts in highway projects [13]. Researchers considered discussion of identifying success criteria and evaluating the final performance of PPP contracts in recent years. For example, the researches of Jefferies [14] and Ozorhon [15] can be noted. In 2012, Yuan offered a structured model for evaluating the performance of PPP projects [16]. Kashtiban and Sobhie surveyed on application of Management approach of PPP in a series of BOT contracts in power plant projects [17]. Also, noorzai and Vahedi examined the optimal choice method of public private partnership projects in road and urban ministry in Iran [5].

IV. RESEARCH METHOD

A. Identification of Selection Criteria

In this stage, it was tried to determine the most effective factors on PPP method selection through interviews with experts and by using analytical hierarchy process multi-criteria decision making method, optimal PPP method for highway projects was chosen.

TABLE I. PREFERENCES (ORAL JUDGMENT)

<table>
<thead>
<tr>
<th>Importance</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme importance</td>
<td>9</td>
</tr>
<tr>
<td>Very strong and demonstrated importance</td>
<td>7</td>
</tr>
<tr>
<td>Strong importance</td>
<td>5</td>
</tr>
<tr>
<td>Moderate importance of one another</td>
<td>3</td>
</tr>
<tr>
<td>Equal importance</td>
<td>1</td>
</tr>
<tr>
<td>Intermediate values between adjacent scale values</td>
<td>2, 4, 6, 8</td>
</tr>
</tbody>
</table>

Generally, two original questionnaires were used in this study. The first questionnaire determines the factors affecting highway projects and second one examines effected factors on PPP method, then the results were analyzed using AHP process.

Based on Table I, categorizing in the context of affecting challenges on PPP method in highway projects was done in the research area and the quantities importance of them were determined according to the following numerical scale table:

**Estimation of Sample Size**

In this study in order to estimate the number of Interviewees or expert, or in other words to estimate main population, hire Levy and Lemeshow sampling model [18]. It is worth noting that estimating main population through other sampling method does not differ much with this formula. Main population was 166 and by using Levy and Lemeshow sampling method sample size were estimated 30. The following formula (1) shows that how sample size have been estimated:

$$n \geq \frac{Z^2 NV^2}{(N-1)e^2 + Z^2 V^2}$$

In this formula variation of criteria is calculated as follow (2):

$$V_x = \frac{S_x}{\bar{X}}$$

n= sample size, Z= confidence level, N=population size, $V_x$= coefficient of variation, $\bar{X}$= Average, $e$ = coefficient of error (in this study equals 0.08)

$$S_x = 0.66, \bar{X} = 2.77, V_x = 0.24, Z = 1.96, N = 166$$

Hence the sample size has determined: $n \geq 28.69$

With regard to confidence interval for collecting questionnaires, 42 samples were considered as the sample size according to the following composition, as it can be seen in Table II.

**TABLE II. QUESTIONNAIRE’S RESPONDENTS COMPOSITION**

<table>
<thead>
<tr>
<th>Considered sections</th>
<th>Number of considered experts</th>
<th>Percent</th>
<th>Number of Respondent experts</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>14</td>
<td>33.33%</td>
<td>9</td>
<td>30%</td>
</tr>
<tr>
<td>Contractor</td>
<td>14</td>
<td>33.33%</td>
<td>11</td>
<td>36.67%</td>
</tr>
<tr>
<td>Designer</td>
<td>13</td>
<td>30.95%</td>
<td>9</td>
<td>30%</td>
</tr>
<tr>
<td>Academic expert</td>
<td>1</td>
<td>2.38%</td>
<td>1</td>
<td>3.33%</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>100%</td>
<td>30</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Research Tool Reliability Measurement Using SPSS**

In this study, reliability of questionnaire was calculated by SPSS through Alpha Cronbach method. The result shows 0.83 that means the questionnaire is reliable.

The results of the first questionnaire (i.e. expert views for identified criteria) were surveyed and 15 important criteria in highway projects are listed below.

The most important indicators identified by the experts in highway projects are:

1. Reduction of changes in laws
2. Paying the bills from the government
3. Increase of the applicability of government guarantees
4. Ease of receiving loans
5. Decrease of inflation effect on operating costs
6. Being clear in the ownership of project
7. Supply of quality and standards
8. Selection of appropriate private sector
9. Environmental preservation
10. Ease of maintenance and repair
11. Decrease of operating costs
12. Commitment of the parties to their obligations

13. Proper distribution of authorities and responsibilities between the parties
14. Benefit from adequate legal and political commitments
15. Increase of project profitability

B. Formulation of Mean Utility Values

In the second questionnaire, the expert respondents choose a number of 1-9 for the effects of each criterion on each PPP method with regard to the paired comparison. After normalization of different weights corresponding matrix, Table III was gained that shows the values of the weight of each PPP method in any criterion.

C. Choosing Optimal PPP Method for Implementing Highway Projects with AHP Approach (Assignment of Selection Criteria Weightings)

In this stage after collecting the second questionnaire, the score of each PPP method has determined and were arranged descending based on the top score.

Analytic Hierarchy Process (AHP)

Invented by Thomas L. Saaty in 70s, AHP method is one of the most famous multi-criteria decision making techniques. This method is hired when decision action is faced with more than one option and criteria. AHP enables to combine qualitative criteria and quantitative criteria simultaneously. AHP method is based on paired comparison of options and criteria of decision making. For such a comparison we need to collect information from decision makers. This makes possible for decision maker to focus only on comparing two criteria regardless of any external influence or interference. Moreover, one by one comparison provides valuable information to investigate the problems and makes rational decision making process because the respondent compares only two factors and has no attention to the other one.

After surveying questionnaires information accuracy of the information should be checked through incompatibility rate (IR) that should be less than 0.1, is calculated by software and obtained by the following stages [19]:

1. A series of matrix manipulations of the pairwise inputs give lmax (the closer lmax is to “n”, the more consistent is the result). The mathematical treatment and proof can be found in the work of Saaty [20].

2. Calculate inconsistency index (II)—II = (lmax - n)/(n - 1), where n is the number of elements in the matrix, which is the number of selected criteria in the present application (i.e., n = 8).

3. Calculate IR—IR = II/RI (IR of 0.10 or less is considered acceptable.

It can be said that analytic hierarchy is one of the most comprehensive systems for multi-criteria decision making and has an Ability to formulate problems in terms of qualitative and quantitative criteria that is based on paired comparison which provides the possibility for sensitivity analysis on criteria and sub-criteria. This process demonstrates the compatibility or incompatibility rate of the decision which is one the most important features of this technique that is based on axiom principles.

<table>
<thead>
<tr>
<th>PPP options</th>
<th>Number of Selection Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOO</td>
<td>179 0.188 0.809 0.037 0.195 0.167 0.315 0.102 0.145 0.412 0.368 0.070 0.339 0.180 0.378</td>
</tr>
<tr>
<td>BOT</td>
<td>154 0.167 0.107 0.419 0.415 0.167 0.414 0.209 0.145 0.412 0.421 0.085 0.286 0.410 0.422</td>
</tr>
<tr>
<td>DBFO</td>
<td>0.154 0.188 0.093 0.419 0.195 0.167 0.261 0.209 0.145 0.412 0.368 0.070 0.339 0.180 0.378</td>
</tr>
<tr>
<td>Traditional</td>
<td>0.410 0.417 0.413 0.145 0.073 0.417 0.144 0.417 0.421 0.118 0.158 0.408 0.411 0.164 0.178</td>
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</table>

Table IV: A Sample of Completed Questionnaire

<table>
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</table>
Data Survey

42 questionnaires had been sent to the respondents and 40 questionnaires returned. An example of a completed questionnaire can be seen in Table IV that is related to comparison among 15 criteria for optimal PPP method selection in highway construction projects. “The non-payment of bills for Reasons attributable to government” criteria, for instance, is more important than “Changing the rules” hence number 1/3 had been entered into the table; this is how the table should be filled.

After ideal synthesizing for every item we reach table 5 which is showing the weight of each criterion totally and the weight of each item. Table numbers have been achieved by multiplying the weight of each criterion and gain weight of each method which is related to the each criterion. Weights of “BOO contract” and first criterion that is “Changing the rules”, for example, resulting from above tables are 0.039 and 0.179 which by multiplying equals to 0.007. Ultimately the IR for questionnaire is 0.04 that is less than 0.1. Thus questionnaire information is reliable.

V. Conclusion

At first the research was paid to the topic literature. In the next step the different groups of contracts were studied. subsequently The effective criteria for choosing of public private partnership method in highway projects using library resources and collected expert opinions was identified. Finally, in an overall conclusion the effect of each criterion on four PPP methods including Build-Operate-Transfer (BOT), Concessions Contracts (DBFO), Private Divestiture Contracts (BOO) and Traditional Private Outsourcing Contracts in highway project was checked. In this paper, many required effective resources in addition of extensive field researches are used. The results of the AHP method and Expert Choice software include:

A. Determination of Optimal PPP Contract in Highway Projects in Iran

In Fig. 1, it can be seen ideal synthesizing results that its numbers show rank of PPP contracts in highway projects. It is clear that Traditional Private Outsourcing contract has received a higher score.

1. Traditional Private Outsourcing Contracts
2. Build-Operate-Transfer (BOT)
3. Concessions Contracts (DBFO)
4. Private Divestiture Contracts (BOO)

<table>
<thead>
<tr>
<th>Synthesis with respect to:</th>
<th>Goal: Selecting an Appropriate Financing Method for PPP Highway Projects in Iran</th>
<th>Overall Inconsistency</th>
<th>0.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Private Outsourcing</td>
<td>0.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOT</td>
<td>0.29</td>
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<tr>
<td>DBFO</td>
<td>0.27</td>
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</tr>
<tr>
<td>BOO</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. The results of the ideal synthesis (summery) - Prioritization of PPP contracts

B. The Most Effective Criteria for Choosing PPP Contracts in Highway Projects

The most effective criteria for choosing PPP contracts in highway projects based on Fig. 2 in order of importance are as follows:

1. Selection of appropriate private sector
2. Supply of quality and standards
3. Paying the bills from the government
4. Environmental preservation
5. Increase of the applicability of government guarantees

6. Commitment of the parties to their obligations
7. Ease of receiving loans
8. Benefit from adequate legal and political commitments
9. Proper distribution of authorities and responsibilities between the parties
10. Increase of project profitability
11. Decrease of inflation effect on operating costs
12. Reduction of changes in laws
13. Decrease of operating costs
14. Being clear in the ownership of project
15. Ease of maintenance and repair

Figure 2. The importance of criteria based on gained weight from Expert Choice software

TABLE V. WEIGHT TABLE OF EACH CRITERION TOTALY AND GAIN WEIGHT OF EACH ITEM

<table>
<thead>
<tr>
<th>PPP options</th>
<th>Number of Selection Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
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Traditional PRI | 0.016 | 0.04 | 0.031 | 0.009 | 0.003 | 0.003 | 0.01 | 0.016 | 0.078 | 0.032  | 0.002  | 0.006  | 0.029  | 0.023  | 0.01  | 0.008  | 0.313 |

REFERENCES


Esmatullah Noorzai (Afghanistan, 1980) has graduated with a bachelor’s degree in civil engineering from Sistan and Baluchestan University, Zahedan, Iran (2007), and a master’s degree in project and construction management from the University of Tehran, Tehran, Iran (2010), being a PhD student at the University of Tehran in construction and project management.

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implementation of construction projects of road, railway and freeway: 2011-2012, value engineering workshop for road construction project in Pataveh – Dehdasht (63 km): 2012-2013). She currently works on a project in the Faculty of Engineering in the University of Tehran to optimize construction method of mass housing in Kayson Company. Also she works as a project financial manager in Hadish Civil &Trade Company. In addition, she assisted with compiling two books titled Projects Delivery Methods and Building Information Modeling, a Process for Integrated Design in Tehran University Press and now is working on a book titled Value Engineering in Infrastructure Projects. She has published several papers in national and international conferences and journals. Ms. Gharouni is a key member of Project Management Institute of University of Tehran, participating in many workshops and research projects.

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Babak Vahedi (Iran, 1979) has graduated with a bachelor’s degree in civil engineering from Amirkabir University of Technology, Tehran, Iran (2005), and a master’s degree in construction management from Amirkabir University of Technology, Tehran, Iran (2007). He has over eight years of experience in project planning & control in scheduling, cost and risk management, extensive site experience in heavy international EPC projects in oil & gas and subway construction, skilled in producing critical path schedules, budget/cost reports and project analysis reports, highly experienced in cost control based on earned value (EVMS) analysis and related KPI’s, good knowledge of offshore drilling and refinery units establishment utility, process, LNG & condensate tanks, gas export and reception facilities), solid knowledge of metro construction methods (TBM, NATM, Russian Method, Open Trench, Cut & Cover), familiar with metro fixed equipment (Rectifier, LPS, Control Panel, Signaling systems and etc.), skilled in analyzing change requests and claims time and cost impacts, experienced in conducting risk management plan preparation, risk identification, qualitative and quantitative risk analysis, and finally solid knowledge of different types of international contracts (EPC, PPP, lump sum, DB, DBB). Recently he has worked in OIEC group as a Project Planner/Risk Analyst (Onshore and Drilling Parts) since 2011. Mr. Vahedi has PMP and RMP Certificate, being a member of OIEC group.