Iranian Journal of Management Studies (IJMS)
Vol. 7, No. 2, July 2014
pp: 437-456

Determination of Concession Period in Build-Operate-Transfer Projects Using Fuzzy Logic

Farnad Nasirzadeh[1*], Mostafa Khanzadi[2], Majid Alipour[3]
1. *Assistant Professor, Dept. of Civil Eng., Faculty of Engineering, Payame Noor University, Tehran, Iran*
2. *Assistant Professor, Dept. of Civil Eng., Iran University of Science and Technology, Tehran, Iran*
3. *M.Sc. Student, Dept. of Civil Eng., Iran University of Science and Technology, Tehran, Iran*
(Received: 15 April 2013 - Revised: 23 January 2014 - Accepted: 18 February 2014)

Abstract

The build-operate-transfer (BOT) projects are a popular method of privatization of public infrastructure development. There are several risks which might affect a BOT project negatively. Concession period is one of the most important decision variables in arranging a BOT-type contract which should be determined considering the existing risks and uncertainties. A longer concession period is more beneficial to the private investor, whereas a prolonged concession period may result in loss for government investments. On the other hand, if the concession period were too short, the investor would either reject the contract offer or would be forced to increase the operation fees in order to recover the investment costs and to make a certain level of profit. In this paper, the concession period is determined using a new fuzzy logic based methodology. The proposed approach accounts for the existing risks and uncertainties. In the proposed methodology, the interests of both parties would be ensured and a win-win solution would be achieved. To evaluate the performance of the proposed methodology, the methodology was implemented in a highway project.

Keywords:

BOT, Concession period, Fuzzy logic, Risk management.

* Corrsponding Author Tel: +98-912-3305032 Email: f.nasirzadeh@gmail.com

Introduction

Build-operate-transfer (BOT)[1] projects are attracting increasing interest with the growing thrust towards privatizing infrastructure projects in both developing and developed countries (Kumaraswam & Zhang, 2001). BOT schemes in many large infrastructure projects such as roads, expressways, railways, bridges, dams, ports, and power plants are constructed and operated by private firms under a procurement system (Liou & Huang, 2008). This type of contract has also led to cost-effectiveness, timelier delivery, and a better performance and quality of the project. This is also due to the fact that the project management is more efficient in private businesses in comparison with the governmental ones. Many different types of public-private partnerships schemes are used. The most important ones include build-operate-transfer (BOT), build, operate and own (BOO)[2], build, operate, own, and transfer (BOOT)[3], build, transfer, and operate (BTO)[4], build and transfer (BT)[5], reconstruction, operate, and transfer (ROT)[6], and operate and transfer (OT)[7]. These types of contracts are subject to concession agreement (Liou & Huang, 2008; Khanzadi *et al*,. 2010; Khanzadi *et al*, 2012; Kumaraswamy & Morris, 2002). The BOT method has been used for a long time. The first important BOT contract project was the Suez Canal project that was constructed in 1854. In this contract, the private company obtained a 99-year concession from the Egyptian government for the construction and operation of the canal connecting the Mediterranean and Red Seas (Levy, 1996; Shen & Wu, 2005). In BOT contracts, the public projects will be financed, designed, and constructed by the project company, set up by private investors. After the construction time, in the concession period, the corporation operates the projects to repay loans, recover the investment and receive profit.

1. Build-Operate-Transfer
2. Build-Own-Operate
3. Build-Own-Operate-Transfer
4. Build -Transfer-Operate
5. Build -Transfer
6. Reconstruct-Operate-Transfer
7. Operate-Transfer

Concession period is one of the most important decision variables in arranging a BOT-type contract, and there are few methodologies available to help determine the value of this variable (Shen *et al*, 2007). The terms of concession agreement, including tariff and concession period of the project, are often discussed intensively during negotiations (Liou & Huang, 2008). A longer concession period is more beneficial to the private investor, whereas a prolonged concession period may result in loss for government investments. On the other hand, if the concession period is too short, the investor would either reject the contract offer or would be forced to increase the operation fees in order to recover the investment costs and to make a certain level of profit. Consequently, the risk burden, caused by short concession period, would be shifted to those who use the facilities (Shen *et al*, 2002). Generally, the investor's revenue cannot be more than the total revenue of the project in the economic life and also it should not be less than the minimum expected investment return of the investor.

Shen *et al*. proposed an alternative model to determine a proper concession period that could safely protect the interests of both the government and the private investors. The investor's considerations in a BOT contract usually include return of the investment (ROI) or net present value (NPV). Consequently, the concession period should bring a certain level of ROI or NPV to the investor (Shen *et al*, 2002). However, there is a major limitation in using the model, i.e., it gives no consideration to the impacts of risks on the estimation of various economic variables in the model (Shen *et al*, 2005). The undertaking by the concessionaire of all the risks associated with the project during the concession period is a major issue of concern for all parties involved, i.e., the contractors, the sponsors, and the government. The success of a BOT project lies in the appropriate initial risk assessment by the potential concessionaire, which provides the reasoning for a "go or no go" decision (Yiannis & Demos, 2005).

The risk impacts on the performance of a BOT-type contract and the concession period have been discussed by various researchers.

Shen *et al*. developed a risk concession model to provide an approach for formulating the concession period considering the impacts of risks as well as the basic interests of both the investor and the government (Shen *et al*, 2002). In this research, the Monte Carlo simulation and the Crystal Ball software package were used to determine the NPV value for each year in the life cycle of a project. A simulation model was developed by Thomas *et al*. to assist the public partner to determine an optimal concession period. In this model, the impact of risk can be taken into account in establishing a proper concession period (Thomas *et al*, 2007).

Thomas *et al*. proposed a fuzzy multi-objective decision model to evaluate and establish the most satisfactory concession option for BOT projects. The complex impact of risks is considered and an appropriate concession period can be deduced by a fuzzy multi-objective decision model to trade-off the associated three concession items (max IRR, min concession period and min tariff regime) (Thomas *et al*, 2007). Shen *et al*. (2007) developed a model to enable the identification of a specific concession period, which takes into account the bargaining behavior of the two parties concerned in engaging a BOT contract namely, the investor and the government (Shen *et al*, 2005).

Several researches have been conducted to determine the concession period; however, all of them face some major defects. In the previous studies, the risks affecting a BOT project were not usually considered. In the few researches in which the risks are taken in to account, the probability theory has been implemented to model uncertainties. The probability theory, however, may not be a suitable choice for considering the effects of risks since the historical data are not normally available in construction projects. Moreover, the construction projects are unique and they are not normally iterative processes (PMBOK, 2004). In fact, the various features of a construction project cannot be identical between two different projects and BOT construction projects present additional features that render each project different from the other ones (Yiannis & Demos, 2005).

In summary, the reasons for why a fuzzy approach would be the most appropriate to assess the risks in a BOT project could be found in fundamental concepts of fuzzy set theory:

- Fuzzy set theory can treat inconsistent data including scarce, imprecise, or vague data.
- Fuzzy set theory address subjective judgment. Therefore, it is very appropriate to address subjective parameters in risk assessment, as different perception of risks exists among stakeholders in BOT projects.
- Fuzzy set theory allows easier modeling of complex systems. It provides the platform to understand and model complex system behavior (Yiannis & Demos, 2005).

In the previous studies, Monte Carlo simulation was used for calculating the NPV. Some of the disadvantages of Mont Carlo simulation are computational burden, sensitivity to uncertainty about input distribution shapes, and the need to assume correlations among all inputs (Shaheen *et al*, 2007).

Most of the factors affecting a BOT project have an uncertain nature, and it is impossible to assign precise crisp numerical values as their magnitude. In this research the possibility theory (Fuzzy Logic) is employed to consider the effects of risks and uncertainties. The values of different input factors affecting the concession period are determined by fuzzy numbers based on the opinions of different experts involved in the project. The extension principle is used to calculate the NPV value in order to determine the concession period. Since the model inputs are Fuzzy numbers, the NPV value as well as the concession period is also determined as Fuzzy numbers. Finally, a crisp number is derived from the achieved fuzzy number of concession period through difuzzification. The proposed fuzzy logic based methodology is computationally simple. The model is not very sensitive to moderate changes in the shape of input distributions and does not require the analyst to assume particular correlation between input parameters. The proposed methodology is employed in a real highway project in order to evaluate its applicability and performance.

Analytical approach, measures and sample and procedure

There are three types of advanced research designs called qualitative, quantitative, and mixed methods. In this study, the quantitative method has been used for designing the research. Quantitative research is a means for testing objective theories by examining the relationship among variables. Survey research, which provides a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population, has also been used in this research. Survey research includes cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection.

In this research, the variables that were measured include total capital investment, construction duration, toll price, operation and maintenance cost and annual traffic volume. By measuring these variables, data can be analyzed using statistical procedures (John. W. Creswell, 2009). These parameters will be illustrated in the next sections and their values will be determined for a case study project.

In the present study, since the number of BOT projects in the country in which this research was carried out is very limited, a non-random sampling method based on convenience sampling was used. In this research, north ring of Mashhad highway was selected as a sample project. The project documents were used for gathering the required data and information.

Finally, the main research question is how long the concession period should be in order to repay loans, recover the investment, and receive profit by the corporation so that the interests of both the investor and the government are ensured.

Fuzzy Logic

Fuzzy logic is used increasingly in situations where little deterministic historical data are available (Knight & Robinson 2002). Conventional sets mainly deal with sets whose membership is defined on a yes/no basis; while in fuzzy set theory, membership is not a precise phenomenon (Naderpajouh *et al*, 2007). Fuzzy sets have been designed to deal with a wide range of real-world domains involving linguistic descriptions (Zimmermann, 2001). The fuzzy set based method has been introduced to cope with uncertainties that cannot be quantified due to their qualitative and subjective nature (Sebt *et al*, 2007). Fuzzy logic is derived from fuzzy set theory and deals with a set of objects characterized by a membership function that assigns a grade of membership ranging between zero (no membership) and one (full membership) to each object (Shaheen *et al*, 2007). In the classical theory, an element x does or does not belong to a set X. In the fuzzy-set theory, however, an element may more or less belong to a set: $\mu X(x) \in [0,1]$. In the fuzzy logic, the values are fuzzy numbers and have a specific distribution; for example, fuzzy numbers can be introduced as a single, rectangular, trapezoidal, or triangular number (Mohamed & Mc cowan 2001) (Fig. 1).

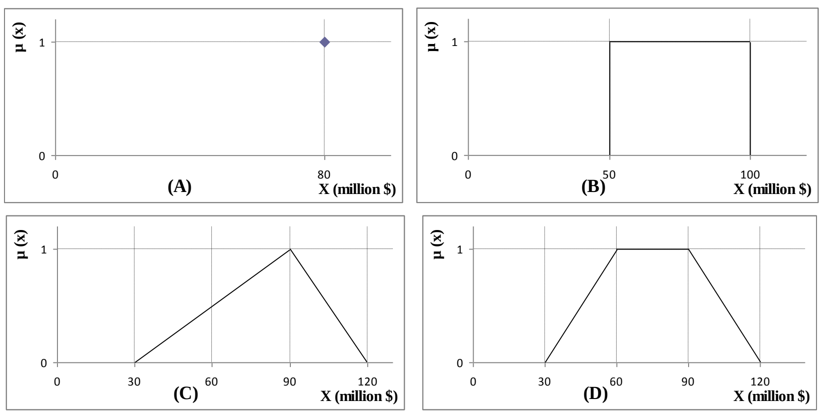

Fig. 1: Different types of fuzzy numbers: a) single value; b) rectangular distribution; c) triangular distribution; d) trapezoidal distribution

Extension Principle

Algebraic operations on real numbers can be extended to fuzzy numbers, i.e. fuzzy variables defined on the real line, by means of the extension principle (Zadeh, 1975; Dong & Wong, 1987). A method based on the α-cut representation of fuzzy sets and interval analysis is used in the extension principle (Mohamed & Mc cowan, 2001). After determination of the input factors affecting the NPV and concession period of a BOT project as fuzzy numbers, the extension principle is employed to determine the NPV value. The extension principle states that if f:R*R→R be a binary operation over real numbers, it can be extended to the operation of fuzzy numbers. The concept of the extension principle is presented as follow:

1. Select a particular α-cut value, where $0 \leq \alpha \leq 1$.
2. The associated crisp value of the input fuzzy numbers corresponding to α is determined as $[a_\alpha , b_\alpha]$.
3. Using the values obtained in the previous step and interval operations, compute the value of NPV which correspond to those input factors.

Steps 1-3 are repeated for as many values of α needed to refine the solution. Covering of the entire range of α-cut makes the output of the model a fuzzy number.

In cases that there is more than one parameter affecting the value of the output (NPV in this example), different combination of associated crisp values obtained in step (2) must be considered and the output of the model must be simulated for different combinations of crisp values of this factor at each α-cut. The output obtained from step (2) is given by: [xα, yα], where xα, yα represents the minimum and maximum of outputs resulting from different combination of crisp values at each α-cut respectively (Nasirzadeh *et al*, 2008; Giatechetti & Young, 1997; Dong & Wong, 1987).

Calculation of NPV

There is a standard procedure for calculating the NPV. The project's NPV can be established by the following equations (Khanzadi *et al.*, 2010; Khanzadi *et al.*, 2012; Shen & Wu, 2005; Shen *et al.*, 2002):

$$NPV = \sum_{T=1}^{T=t_f} \frac{NCF(t)}{(1+r)^t} \tag{1}$$

The equation above can be rewritten as follows:

$$NPV(t) = \sum_{T=1}^{T=tf} \frac{(I(t) - Cm(t))}{(1+r)^t} \tag{2}$$

where NPV (t) denotes net present value in year t, NCF (t) denotes the net cash flow in year t; I(t) =income for the year t, Cm(t) =expense in year t, r =discount rate and t(f) is the project economic life time.

The amount of the project income is obtained from the following formula for the year t:

$$I(t) = q \times p \tag{3}$$

where q is the annual traffic volume and p =toll price. Finally, the value of the NPV is calculated through combining equations 2 and 3 as follows:

$$NPV(t) = \sum_{T=1}^{T=Tf} \frac{((q \times p) - Cm(t))}{(1+r)^t} \tag{4}$$

During the construction period, the capital investment is incurred while there is no revenue. Therefore, equation 4 is refined as follows:

$$NPV(t) = \sum_{T=1}^{T=0} \frac{(-C_c(t))}{(1+r)^t} + \sum_{T=to}^{T=tf} \frac{((q \times p) - Cm(t))}{(1+r)^t} \tag{5}$$

where T_0 is the construction period and Cc (t) is the annual capital investment in year t.

The relationship between the construction period, NPV, and the concession period is presented in Fig. 2.

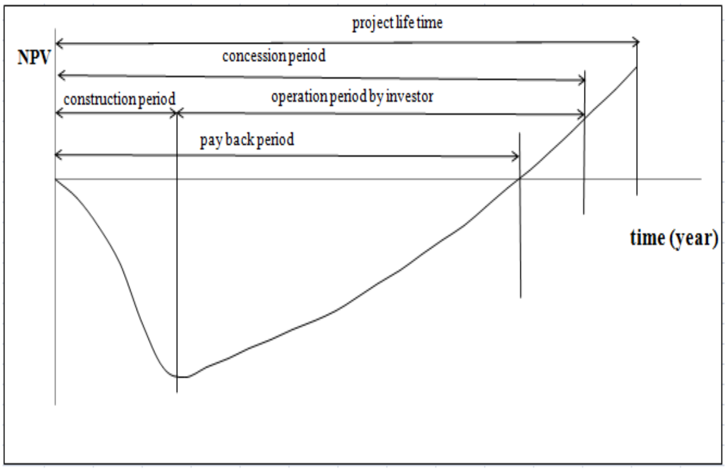

Fig. 2. The relationship between the concession period, NPV and the construction period

Determination of Concession Period Using Fuzzy Logic

Determination of the Values of Uncertain Input Factors

In order to calculate the NPV value, the values of several uncertain parameters affecting a BOT project should be determined. These parameters include the annual capital investment, construction period, annual traffic volume, toll price, annual maintenance cost, and the amount of annual discount rate. The values of these parameters are assessed using fuzzy logic based on the opinions of different experts. The experts could represent their opinions by different types of fuzzy numbers such as triangular, trapezoidal, etc. The proposed methodology is implemented in a real highway project in order to evaluate its applicability and performance. The uncertain parameters affecting the NPV value of this project case example are explained below briefly.

Annual Capital Investment: Cc (t)

It is assumed that the annual capital investment is equal to $C(c) = I / t_0$ during the construction period. Where $t_{(0)}$ is the construction period and (I) is the total capital investment. The total capital investment of the real highway project was determined as a triangular fuzzy number of (120,125,140) million dollars, where 120,125 and 140 represents the minimum, most likely, and maximum values of capital investment, respectively, as shown in Fig. 3.

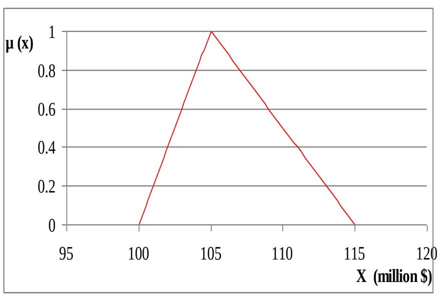

Fig. 3. Total capital investment

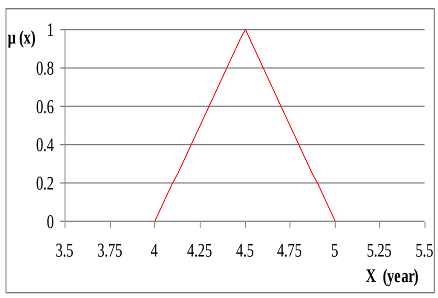

Fig. 4. Construction Duration

Construction Duration: t_0

The concession period is composed of the construction and operation periods. Under normal conditions, the time required for completing the project may not have a certain value. The construction period for the real highway project was estimated as a triangular fuzzy number of (4,4.5,5) years as shown in Fig. 4. In BOT projects, the investor would like a longer operation period by shortening the construction period, given that the concession period remains the same.

Toll Price: (P)

The project incomes achieved from the toll prices is used to recover the initial investment as well as the operation and maintenance costs. The value of toll price depends on several parameters. Toll price may be changed in line with market changes or policy changes (Shen and Wu 2002). The host government specifies toll price value for different years during project lifetime. In cases that the value of toll price is high, the number of users may decrease. Similarly, in cases that toll prices is low, the payback period may increase.

For the example project, it is assumed that the toll price is equal to 0.5 dollar per vehicle during the first 5 years of operation period and is increased stepwise after each 5-year period. The toll price estimated by different experts for this highway project is shown in Fig. 5.

Annual Traffic Volume: (q)

There are different methods to determine the annual traffic volume, such as counting the number of vehicles. However, it is difficult to predict the traffic volume by certainty. In this highway project case example, the traffic volume was determined as a triangular fuzzy number of (16,17,17.4) million vehicles (Fig. 6).

The traffic volume increases annually. In this research, however, it has been assumed that the traffic volume is increased every 5 years. Table 1 provides the summary of the predicted values of traffic volume throughout the project life cycle. The data included in the table are presented graphically in Fig. 6.

Annual Operation and Maintenance Cost: (Cm)

The operation and maintenance cost should embrace all the expenses incurred in the operation period such as operating, managing, and maintaining the facility. It is considered necessary to i) identify the major risk factors that could have serious effects on the cost; ii) establish an empirical or assumed distribution for each of the identified risk factors (in any discrete or continuous form); and iii) examine the effects of risk factors on the cost (Thomas *et al*, 2007, Cagno & Milano, 2001).

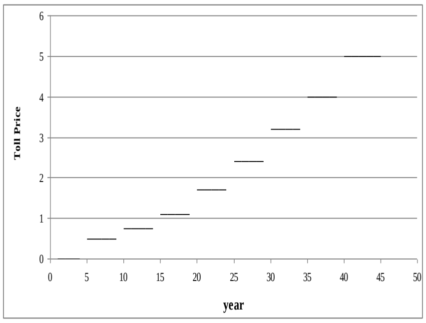

Fig. 5. Toll price in different years

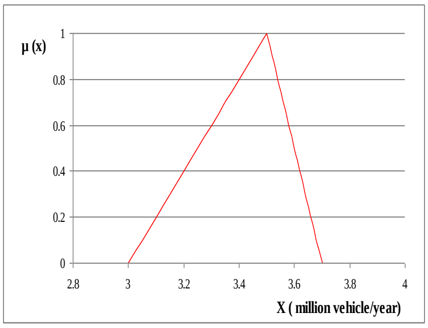

Fig. 6. Annual traffic volume

In this research, the operation and maintenance (o&m) cost have been considered as a triangular fuzzy number for the first year of the operation and it has been assumed that the operation and maintenance cost is increased every 5 years afterwards. For the first year of the operation, the annual maintenance cost was determined as a triangular fuzzy number of (8, 9, 12) as shown in Fig. 7. In table 2, the operation and maintenance costs have been presented in the form of a triangular fuzzy number throughout the project life cycle.

Annual Discount Rate: (r)

Annual discount rate is used to determine the current values of a project's future expenses and incomes. Therefore, the value of a project's NPV could be calculated. The discount rate for this project was predicted as a triangular fuzzy number of (7, 7.5, 8) percentages, as shown in Fig. 8. It is assumed that the discount rate is fixed during the project life cycle.

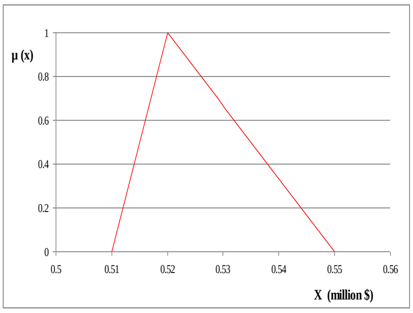

Fig. 7. Annual maintenance cost

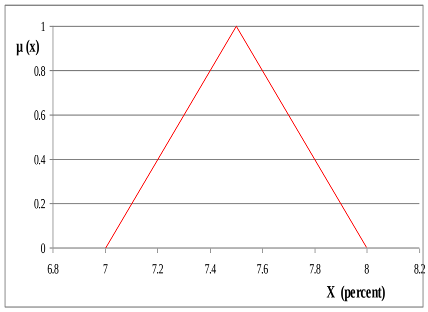

Fig. 8. Annual discount rate

Determination of the NPV

After determining the values of different input parameters, the NPV value is calculated using equation 5 considering the effects of risks and uncertainties as explained below. Since input parameters are fuzzy numbers, the extension principle is used to determine the NPV value.

Table 1. Annual traffic volume

YEAR	MIN	Most likely	MAX
5	3	3.5	3.7
10	4.83	5.635	6.105
15	7.05	8.23	9.16
20	10.30	12.01	13.74
25	15.03	17.54	20.60
30	21.95	25.60	30.91
35	32.04	37.38	46.36
40	46.78	54.58	69.54

Table 2. Annual maintenance cost

YEAR	MIN	Most likely	MAX
5	0.51	0.52	0.55
10	0.918	0.936	0.99
15	1.56	1.59	1.68
20	2.65	2.71	2.86
25	4.51	4.60	4.86
30	7.67	7.82	8.27
35	13.03	13.29	14.06
40	22.16	22.59	23.90

A particular α-cut value is selected, where $0 \le \alpha \le 1$. (2) The associated crisp values of the fuzzy number of the value of different input factors correspond to α are determined as $[a_\alpha, b_\alpha]$. (3) The NPV value is calculated with these crisp values as input to the model. Since the crisp inputs depend on the selected α-cut, the output of the model is valid for the same value of α–cut (4) Steps 1-3 are repeated for as many values of α needed to refine the solution. Covering the entire range of α–cut makes the NPV value a fuzzy number. The NPV value has been calculated for the highway project throughout the project life cycle. In Fig. 9, the resulted fuzzy number of NPV values is presented for 6 different years. Finally, the NPV value variations are depicted throughout the project life cycle in Fig. 10.

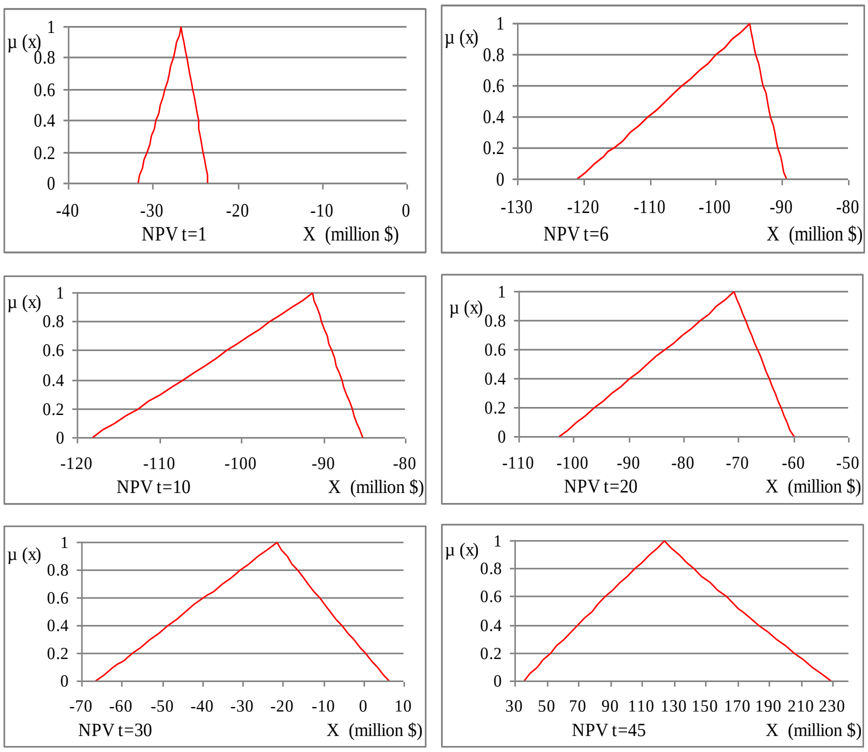

Fig. 9. The fuzzy number of NPV values for 6 different years

Determination of the Concession Period

After determining the NPV values, the concession period can be calculated. The flowchart diagram of the fuzzy logic based approached proposed for determining the concession period is shown in Fig. 11. In order to determine the concession period, first the total amount of investment should be calculated. The capital investment is calculated at different values of α-cut using the following equation (Khanzadi *et al* 2010, Shen & Wu 2002).

$$I(p) = \left| \min_{t=1}^{t=tf} \{NPV_t\} \right| \qquad (6)$$

If the value of α-cut is selected as one, the capital investment is calculated as 96 million dollars. The investor's expected rate of return is considered as 20 percent. Therefore, the expected return on the investment is equal to 96*0.2= 19.2 million dollars. Using Figure 10, it is conceived that the investor can achieve his expected profit after 35.2 years and the project can then be transferred to the host government. Similarly, if α-cut is selected as zero, the amount of capital investment is calculated as 90 and 122 million dollars for the right and left values of NPV, respectively. Assuming an expected rate of return of 20 percent, the amount of investor's expected return on the investment is equal to 18 and 24.4 million dollars for the left and right values of NPV, respectively. Finally, the left and right values of the concession period are calculated as 30.5 and 44.4 years.

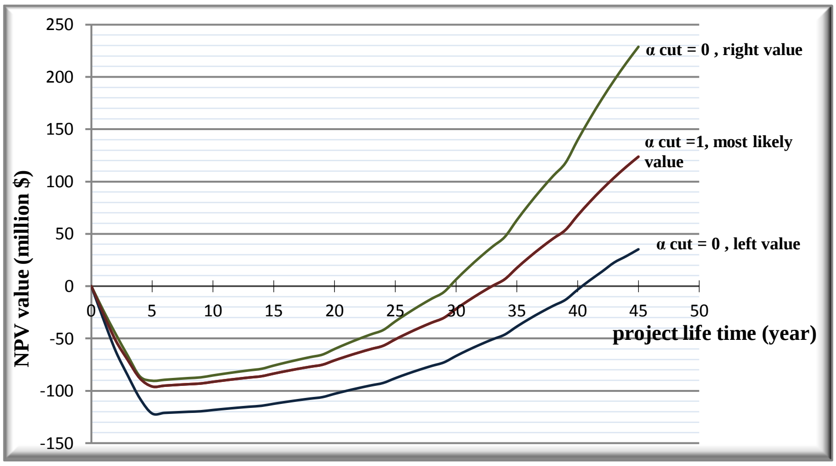

Fig. 10. NPV value variations throughout project life cycle

In order to determine the fuzzy number of the concession period, the above-mentioned calculations should be repeated for different values of α-cut. The fuzzy number of the concession period is shown in Fig 12. It should be noted that the fuzzy number of concession period is depended on the investor's expected rate of return. The proposed methodology has the great capability for allowing the project manager to impose his risk acceptance level to determine the length of concession period at different confidence levels by selecting an appropriate α-cut level. As an example, if α-cut (risk level) is selected as 1, the uncertainties inherent in the evaluation process are ignored and a crisp value for the concession period is resulted as 35.2 years. Similarly, in the other extreme condition where α-cut is chosen as zero, the uncertainties inherent in the evaluation process are fully considered and possible variation in the results may be obtained. However, in this case the widest range of concession period would be achieved as an interval of 30.5 to 44.4 years.

The centre of area method is utilized for defuzzification of the achieved fuzzy number of concession period (Zimmermann, 2001). Using the proposed defuzzification method, the length of concession period was determined as 36.7 years.

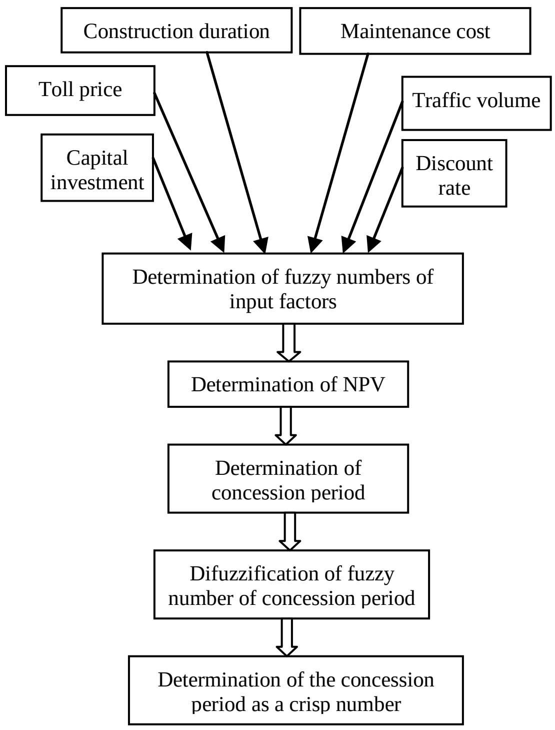

Fig. 11. The flow diagram of determining the concession period

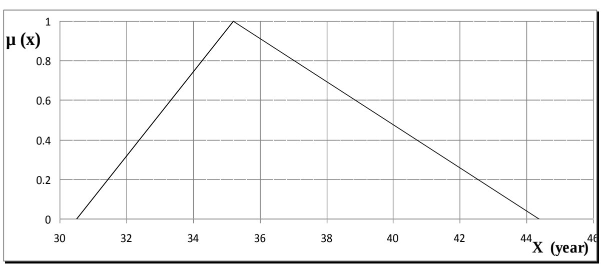

Fig. 12. Fuzzy number of concession period

Conclusions and Remarks

A key parameter of BOT projects is the agreement on the length of concession period. A prolonged concession period may result in the government's loss. On the other hand, if the concession period is too short, the investor would either reject the contract offer or would be forced to increase the operation fees of the project in order to recover the investment costs and to make a certain level of profit. Consequently, the risk burden caused by short concession period would be shifted to those who use the facilities. The concession period is usually determined based on the analysis of the return on investment (ROI) or net present value (NPV). However, the concession period could not be determined properly if the impacts of existing risks and uncertainties are not taken into account. In this research, the possibility theory (Fuzzy Logic) was employed to consider the effects of risks and uncertainties. The values of different input factors affecting the concession period were determined by fuzzy numbers based on the opinions of different experts involved in the project. The extension principle was used for calculating the NPV in order to determine the concession period. Since the input parameters are fuzzy numbers, the NPV value and the resulted concession period were also determined as fuzzy numbers. Using the proposed approach, the value of concession period can be determined at different confidence levels. Finally, the centre of area method was utilized for defuzzification of the achieved fuzzy number of concession period and a crisp value for the concession period was derived. The proposed model is not very sensitive to the moderate changes in the shape of input fuzzy numbers and does not require the analyst to assume a particular correlation between input parameters. The proposed methodology was implemented in a real highway project to evaluate its applicability and performance and the optimal length of concession period was determined. It is believed that the proposed methodology presents an alternative and robust tool which can determine the concession period efficiently.

Acknowledgement

Authors would like to thank the financial support received for this Research from Payame Noor University (PNU).

References

American Psychological Association (1972). *Ethical standards of psychologists*. Washington, DC, American Psychological Association.

Cagno E, di Milano P. (2001). "Risk analysis to assess completion time of a tram-line". *Project Manage*, 7(1), 26–31.

Dong. w. m. & Wong .f .s. (1987). "Fuzzy weighted averages and implementation of the extension principle". *j.fuzzy sets and system*, 21(2), 183-199.

Giatechetti, R. & Young, R. (1997). "A parametric representation of fuzzy numbers and their arithmetic operation". *Fuzzy Sets and Systems*, 91(2), 185-202.

John. W. Creswell. (2009). *Research design*. Qualitative, quantitative and mixed methods approaches, third edition. SAGE publication.

Khanzadi, M.; Nasirzadeh. F. & Alipour. M. (2010). "Using Fuzzy-Delphi Technique to Determine the Concession Period in BOT Projects". *IEEE*. 978-1-4244-6928-4/10, pp.442-446.

Khanzadi, M.; Nasirzadeh. F. & Alipour. M. (2012). "Integrating system dynamics and fuzzy logic modeling to determine concession period in BOT projects". *J. Automation in construction*, 22, 368-376.

Knight, Karla & Fayek. Robinson. Aminah, (2002). "Use of Fuzzy Logic for Predicting Design Cost Overruns on Building Projects". *J. Constr. Eng. Manage*, 128(6), 503-512.

Kumaraswamy .M. M, & Zhang. X. Q, (2001). "Governmental role in BOT-led infrastructure development". *International Journal of Project Management*, 19(4), 195-205.

Kumaraswamy, M. M. & Morris, D. A. (2002). "Build-operate-transfer-type procurement in Asian Mega projects". *J. Constr. Eng. Manage*, 128(2), 93–102.

Levy, S. M. (1996). *Build, operate, transfer: Paving the way for tomorrow's infrastructure*. Wiley, New York, 18–20.

Liou. Fen-May & Huang. Chih-Pin. (2008). "Automated Approach to Negotiations of BOT Contracts with the Consideration of Project Risk". *J. Constr. Eng. Manage*, 134(1), 18–24.

Mohamed, S. & Mc cowan, A. (2001). "Modeling project investment decisions under uncertainty using possibility theory". *International Journal of Project Management*, 19(4), 231–241.

Naderpajouh, N. Afshar. A. & Mirmohammadsadeghi, S. (2007). "Fuzzy Decision Support System for Application of Value Engineering in Construction Industry". *international journal of civil engineering*, 4(4), 261-273.

Nasirzadeh, F.; Afshar, A. & Khanzadi, M. (2008). "System Dynamics Approach for Construction Risk Analysis". *international journal of civil engineering*, 6(2), 120-131.

Project Management Institute (2004), *A guide to the Project Management Body Of Knowledge (PMBOK guide)*. 2004 edition, Project Management Institute, USA.

S. Thomas Ng.; J. Z. Xie; M. Skitmore, & Y. K. Cheung, (2007b). "A fuzzy simulation model for evaluating the concession items of public private partnership schemes". *Automation in construction*, 17(1), 22–29.

S. Thomas Ng.; J. Z. Xie; Y. K. Cheung & M. Jefferies, (2007a). "A simulation model for optimizing the concession period of public private partnerships schemes". *International Journal of Project Management*, 25(8), 791–798.

Sebt. M. H.; Rajaei. H. & Pakseresht. M. M. (2007). "A Fuzzy Modeling Approach to Weather Delays Analysis in Construction Projects". *international journal of civil engineering*, 5(3), 169-181.

Shaheen, A.; Fayek, A. & Abou Rizk, S. (2007). "Fuzzy numbers in cost range estimating". *J. Constr. Eng. Manage*, 133(4), 325–34.

Shen, L. Y. & Wu, Y. Z. (2005). "Risk concession model for build operate transfer contract projects", *J. Constr. Eng. Manage*, 131(2), 211–220.

Shen, L. Y. Bao, H. j. Wu.y. z. & Lu, w. s. (2007). "Using Bargaining-Game Theory for Negotiating Concession Period for BOT-Type Contract". *J. Constr. Eng. Manage*, 133(5), 385–392.

Shen, L. Y.; Li, H., & Li, Q. M. (2002). "Alternative concession model for build operate transfer contract projects". *J. Constr. Eng. Manage*. 128(4), 326–330.

Yiannis Xenidis & Demos Angelides (2005). "Identification and classification of risks in a new modeling process for BUILD – OPERATE – TRANSFER projects". *Association of Researchers in Construction Management*, 2(4), 803-12.

Yiannis Xenidis & Demos Angelides (2005). *A fuzzy model for assessing the* *risk in Build-Operate-Transfer projects*. 11th International Fuzzy Systems Association World Congress on Fuzzy Logic, Soft Computing and Computational Intelligence. Beijing. China.

Zadeh. L. A. (1975). "The concept of a linguistic of a variable and its application to approximate reasoning", *Inform. Sci*, 8(3), 199-249.

Zimmermann, H.J. (2001). *Fuzzy Set Theory and its Application.* 4th edn, Kluwer Academic Publishers, Boston, Drodrecht and London.