

A risk-adjusted decoupled-net-present-value model to determine the optimal concession period of BOT projects

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Abstract

Purpose- The NPV method is well-known for its drawbacks. To overcome some of these NPV weaknesses this paper aims to provide a methodology to determine an optimal concession period that treats risk and time separately. The purpose of this paper is to apply the notion of Risk-Adjusted Decoupled Net Present Value (Risk-Adjusted DNPV) to determine a concession period taking into consideration synthetic insurance premiums as compensation for risks. Build-Operate-Transfer (BOT) road projects in the in Vietnam was used as a case study.

Methodology- This paper conducts theoretical and empirical analysis and provides an integrated model for deriving concession periods of any PPP project. The model can capture several contractual issues such as risk costing and other contractual scenarios. Methodologically, the paper addresses both the issues of risk-based cost-benefit analysis and cash flow analysis bearing an emphasis on Risk-Adjusted Decoupled Net Present to compute an optimum concession period.

Findings- The results show that using DNPV will produce a shorter concession period compared to NPV. The consequence of this is that the public sector will gain financially from an earlier transfer of the concession.

Implications- This paper contributes to the PPP literature by combining DNPV and risk to determine the PPP concession period for the mutual benefits both the private and public sectors. The decoupling of risk from traditional NPV computation will allow for risk pricing and tradability through insurance and allocation.

Originality/ value- The attempts to decouple time and risk in the computation of NPV is the added value to the body of knowledge.

Keywords: PPP, BOT, Risk-Adjusted DNPV, concession period

Manuscript type: Research paper

1. Introduction

Public-private partnerships term is used as an approach for private investors to finance, build, and operate public sector projects. The term PPP is used to describe a wide variety of working arrangements from loose, informal and strategic partnerships to design, build, finance and operate (DBFO) type service contracts and formal joint venture companies”.

In a PPP arrangement, the concession period refers to the period of construction and project operation (Zhang, 2009). During this period investors, recuperate their investment through cash flows from the project. The revenue from the project is divided between equity investors, debt investors, contractors, and suppliers. In this cascading network of benefits, the concession period plays a pivotal role in the cost of finance and value for money analysis. The analysis is used to determine the length of the concession period so that concessionaires can make a reasonable return on their investment.

This poses the question what is the optimum (concession) period for operating PPP projects?

One of the most important parameters in PPP contracts is determining the concession period in a BOT project. Zhang & AbouRizk, (2006) argued that the determination of the concession period is paramount for the successful implementation of PPP projects. Hence, determining an optimal concession period to protect the interests of both sectors has attracted the attention of both industry practitioners and academics. However, both the private and public sectors use the present value of the anticipated project cash flow as the main parameters for determining the concession duration. It is reported that this approach only maximizes the concessionaire's benefits (Carbonara et al, 2014). If this is the case, then one might question the presumed gains that might be anticipated under the paradigm of risk transfer to the private sector under PPP. However, to attain equitable risk transfer, which is intertwined with the concession period, researchers and practitioners have suggested a multitude of approaches to assist the PPP procurement decision processes. For

example, Carbonara et al. (2014); and Ng et al. (2007) advocated the use of numerical simulation methods to model uncertainties in the determination of the concession period. Similarly, other authors used Fuzzy and simulation to determine the optimal concession duration under various risks (Khanzadi, 2013, Hanaoka & Palapus, 2012 and Yu, 2013). Other studies undertook the problem from the point of view of game theory as a basis for the bargaining process between the public and private sectors (Bao et al., 2015). This is a reasonable assumption because PPP stakeholders interact with each other on a rational basis. The benefits of this will be possible on the assumption that public and private sectors share the same project data and act with rationality to maximize their benefit (Medda 2007). However, this is not always the case within a competitive commercial environment. These and other publications used NPV to carry out the analysis based on a static point of view, i.e. risk and time are treated in combination to compute the NPV. Thus, this research advocates that the limitations of NPV based methods can be resolved if the time value of the uncertainty associated with future cash flows is separated. To overcome this problem researchers had experimented with using Decoupled Net Present Value (in this method, an investor is viewed as an insurance provider, and investors forecast synthetic insurance premiums as compensation for risks predicted. Besides this treats risk and time separately) for the evaluation of PPP concessions (Espinoza and Rojo, 2015 and Wu et al. 2012). However, the DNPV work of these authors does not take into account other risks which may lead to lower revenue or higher expenditure than expected (Nguyen 2015). Therefore, the purpose of this paper is to incorporate the notion of Risk-Adjusted Decoupled Net Present Value (Risk-Adjusted DNPV) into the model developed by Wu et al. (2012). Risk-Adjusted DNPV treats risk and time factors separately.

The following sections will present decision Models for determining the Concession Period. Then explain the principles of the Risk Adjusted DNPV model, and the application of this method within

the model developed by Wu and others (2012). A BOT project in Vietnam, that was used as a vehicle to demonstrate the model along with its results, is also presented here, as well as discussed analytically.

2. Decision Models for determining the Concession Period

NPV (Net Present Value) is one of the most widely employed methods used to determine the concession period and assess the financial attractiveness of the project (Hanafizadeh et al., 2011). The method allows for future cash flows and their timing to be taken into account. Moreover, it allows investors to compare projects with different risk profiles, and usually, a higher discount rate is selected for riskier projects (Budnick, 1988). Besides, projects are evaluated with regards to potential opportunities, rather than the required period in this approach (Gaily, 2011). Likewise, pay-back time is not required in calculating NPV, which frees it up from an arbitrary threshold (Gaily, 2011). Additionally, it is also well-known for its simplicity (Espinoza and Rojo, 2015). The NPV approach has also been criticised for several aspects. For example, regarding the discounted rate, McSweeney (2006) observed that using a single discounted rate is fraught with drawbacks, as it can produce an incorrect estimation for a project. Moreover, the discount rate is criticised for more being concerned with the source of financing than the project itself, and it is difficult to account for the specific risks that are present in this monetary value (Pergler et al., 2008). Similarly, Doctor et al. (2001) also criticise that the use of the weighted average cost of capital (WACC) to calculate the risk discount rate only takes into account the financial risks, and these are also not specific in each project. These abnormalities in these methods can lead to unreasonable results, which are difficult to explain. Besides, NPV requires that future cash flows are discounted accurately. They need to follow a particular discount rate, and this seems to be very difficult in practical applications. Thus, NPV can appear to be unreasonable for long-term projects

(Doctor et al., 2001). Consequently, underestimation or overestimation results due to unfair discount rates. Furthermore, this method seems to make an unreasonable distinction between a risky project and a long-term project (Žižlavský, 2014).

In order to resolve the weaknesses of NPV, several methods have been advocated in the literature; for instance, risk-adjusted NPV presented by Stewart et al. (2001). In risk-adjusted NPV, costs, risks, and time are taken into the account, to determine the real value of the project. In this model, revenues are multiplied with the current risk, while associated costs are multiplied with the likelihood of having to pay each cost. The risk-adjusted value is calculated by subtracting the risk-adjusted payoff from associated costs.

Although these methods have been developed to resolve the weaknesses of NPV, one of the common features of these methods is the aggregation of the discounted rate for risk and time value (Halliwell, 2011). Several researchers have stated that adding risk and time together cannot be a valid approach, because they can get entangled (Zeckhauser and Viscusi, 2008). The idea of calculating NPV with separated risk and time was proposed by Robichek and Myers (1965, 1966), in Certainty Equivalent NPV. Others experimented with the least-present-value of revenue (Vassallo, 2006), a win-win approach to maximize benefits for both contracting parties (Zhang and AbouRizk, 2006), risk exposure of both partners (Chan et al., 2011), and source of funding (Feng et 2019). But none of these models allow for the decoupling of risk from time in NPV computation.

BOT concession model (BOTCcM), was developed by Shen et al. (2007) to determine an alternative concession period for BOT contracts. BOTCcM can provide a time interval for the concession period. On one hand, the starting point of the interval is to protect the interests of the private sector. On the other hand, the second point is designed to protect the interests of the public

sector. The starting point of the interval can be determined by using the idea that the Net Present Value during the concession period should not be less than the investor's expected return on investment (ROI). The endpoint of the interval is determined on the principle that the NPV from the transfer time to the end period, should not be less than zero.

Several models have been established to improve the original BOTCcM. For example, BOTCcM is criticised by Shen et al. (2007) that it does not consider the impact of the involved risks. Shen et al. (2007) present an additional model that covers risk elements. The Monte Carlo simulation was used to simulate variables, such as Annual Capital Investment, Construction Time, Toll price, Annual Traffic Volume, Annual discount rate, and Annual Maintenance Cost. In order to determine a specific concession period, a BOT bargaining concession model (BOTBaC) was developed by Shen et al. (2007). This model is an extension of BOTCcM. The BOTBaC takes into account the bargaining behaviour of both the private and the public sectors. The bargaining theory is based on the principle that an individual's action depends on what the others do in a negotiation (Shen et al. 2007). Based on BOTCcM paradigm, the investor and the government should bargain, until they reach a specific concession period, which balances the interests of both sectors. Further improvement of BOTCcM, is the model developed by Wu et al. (2012). Wu and others criticised that BOTCcM because it does not take into account the net asset value (NAV) at the transfer time. Wu et al. (2012) suggest that the risk concession model (Shen et al. 2007), and BOTBaC model (Shen et al. 2007) give no consideration to the project's net asset value at the transfer time; and that these models should add this item, to determine a more reasonable concession period.

The common feature between all of the previous models is that they base their cash flow computational power on the NPV method which has been criticised from several facets.

One of the common features of NPV based methods is the aggregation of the discounted rate for risk and time value (Halliwell, 2011; Espinoza and Rojo, 2015); since several researchers have stated that adding risk and time together cannot be validated because it is difficult to understand their effect in a unified manner (Zeckhauser and Viscusi, 2008).

Thus, this paper aims to expand the theoretical and empirical analysis of PPP literature by providing an integrated model for deriving concession periods of any PPP project. The model can capture several contractual issues such as risk costing and other contractual scenarios. Methodologically, the paper addresses both the issues of risk-based cost-benefit analysis and cash flow analysis bearing an emphasis on Risk-Adjusted Decoupled Net Present to compute an optimum concession period. Therefore, this work adds to the existing body of knowledge through the attempt to decouple time and risk in the computation of NPV for estimating an optimal concession period.

3. Model theoretical derivation

To estimate the concession period, this paper followed four steps (Nguyen, 2015);

- 1- identify and estimate the impact of the project risks. For this purpose, Delphi method was used to estimate “Frequency of Occurrence” and “Degree of Impact” of each risk in the concession.
- 2- the data from step one is used to determine the losses because of low revenue and high expenditure. Heuristic data about the revenue and expenditure is used to estimate the revenue and expenditure for the future. The heuristic data is also used to determine the construction cost distribution and the volatility of heuristic revenue. From this distribution and the volatility, the risk parameter η is determined. Then, risk parameter η is adjusted by using risk scores from the risk identification stage to form the risk-adjusted parameter $\bar{\eta}$.

- 3- the data from step two is then used in the return evaluation by risk-adjusted DNPV.
- 4- the results from step three are then used by the private sector to optimize the concession parameters.
- 5- based on the optimum parameters defined in step four, the final project evaluation can be made.

3.1 PPP DNPV

DNPV treats risk and time separately. In this method, an investor is viewed as an insurance provider, and investors forecast synthetic insurance premiums as compensation for risks predicted. The value of compensation is seen as synthetic insurance premium, and risks are treated as the cost of the project. According to Espinoza and Rojo (2015), DNPV can be measured as:

$$DNPV = \frac{\tilde{V}_t - \tilde{I}_t - \tilde{R}_t}{(1 + r)^t} \quad (1)$$

Where DNPV_t= Decouple Net Present Value of a project at year t; $\tilde{V}_t$ =Revenue of the project at year t; $\tilde{I}_t$ = Expenditure of the project at year t; r= risk-free rate, and $\tilde{R}_t = \tilde{R}_{Vt} + \tilde{R}_{It}$ which presents for the expected total cost of risk at time t. This can be forecasted as the sum of all sources of risks. From the equation, it can be recognised that it is crucial to estimate the value of $\tilde{R}_t$; $\tilde{R}_t$ can be measured as:

$$\tilde{R}_{Vt} = \eta_v \tilde{V} \quad (2)$$

$$\tilde{R}_{It} = \eta_I \tilde{I} \quad (3)$$

Where η_v and η_I are parameters presenting the riskiness of the project. More specifically, they identify the cost raised due to lower than expected revenue and higher than expected expenditure. Espinoza and Rojo (2015) proposed three methods to estimate risk parameters. These are heuristic methods, probability-based methods, and stochastic methods (option pricing). At the simplest level, risk parameters are estimated by using heuristic data. By using this method, investors estimate the value of risk parameters based on recorded data, literature reviews, or experience. In the probability-based method, the value of η is estimated by using a probability distribution. In the third method, real option pricing method bonds (Black and Scholes, 1973) are used. These methods take into account the variation of revenues or expenditure. On the revenue side, the risk parameter can be seen as a put option, and on the expenditure side, it can be seen as a call option.

3.2 Risk-Adjusted DNPV

As stated above DNPV does not take into account other risks which may lead to lower revenue than expected, and to higher expenditure than expected. DNPV presented as by Espinoza and Rojo (2015) does not consider these risks (Nguyen, 2015). Therefore, this work improves DNPV method by taking into account the risks which can influence revenue, and expenditure. More specifically, risk (i.e, risks which influence revenue, and expenditure) scores (collected from surveys and actual case studies in Vietnam) will be used to adjust the risk parameter η_v and η_I . Influential risks will be considered as a function of the probability of occurrence and the degree of impact. Therefore, linguistic judgments were converted to numeric values. More specifically, 5 levels of probability and impact were used which are 0.9 for “very high” and “very large”; 0.7 for “high” and “large”, 0.5 for “medium”, and 0.3 for “low”, and 0.1 for “very low”.

Risk score of risk I assessed by respondent j:

$$R_j^i = Fr_j^i \times Im_j^i \quad (4)$$

Fr_j^i : Frequency of occurrence of risk I assessed by respondent j

Im_j^i : Degree of impact if risk i assessed by respondent j

Risk score of risk i:

$$R^i = \frac{\sum_{j=1}^n R_j^i}{n} \quad (5)$$

According to Cooper *et al.* (2005), risk parameter η_v and η_I can be adjusted by using the following equations:

$$\bar{\eta}_v = \eta_v + \eta_v R_i R_j \dots R_k \quad (6)$$

$$\bar{\eta}_I = \eta_I + \eta_I R_h R_l \dots R_t \quad (7)$$

Where,

$\bar{\eta}_v$: Risk-adjusted parameter for loss due to lower revenue

$\bar{\eta}_I$: Risk-adjusted parameter for loss due to higher expenditure

R_i, R_j, R_k : Risk Score of risk i, j, k which can influence the lower revenue

R_h, R_l, R_t : Risk Score of risk h, l, t which can influence the higher expenditure

From this risk-adjusted parameter, Risk-Adjusted DNPV can be calculated as:

$$Risk\ Adjusted\ DNPV = \frac{\tilde{V}_t - \tilde{I}_t - \tilde{\tilde{R}}_t}{(1+r)^t} \quad (8)$$

Where,

$$\tilde{\tilde{R}} = \tilde{\tilde{R}}_{vt} + \tilde{\tilde{R}}_{It}$$

$$\tilde{\tilde{R}}_{vt} = \bar{\eta}_v \tilde{V}_t \quad (9)$$

$$\tilde{\tilde{R}}_{It} = \bar{\eta}_I \tilde{I}_t \quad (10)$$

Where,

$\tilde{\tilde{R}}_{Vt}$: Loss due to revenue is lower than estimated adjusted by influence factors

$\tilde{\tilde{R}}_{It}$: Loss due to expenditure is higher than expected adjusted by influence factors

$\tilde{V}_t$: Expected revenue

$\tilde{I}_t$: Expected expenditure

4. Model Development

4.1 Optimization of concession parameters to protect the private sector's benefits

In this proposed framework, to protect investors' interests, the following equation must be satisfied (Nguyen, 2015):

$$\text{Risk Adjusted DNPV}^{(1)} \geq I_c R \quad (10)$$

Where,

I_c : Investor Capital investment

R : Expected return rate from investment

The equation (10) can be written as:

$$\begin{aligned} \text{Risk Adjusted DNPV}^{(1)} &= \sum_{t=1}^{T_c} \frac{(\tilde{V}_t - \tilde{I}_t) - (\tilde{\tilde{R}}_{Vt} + \tilde{\tilde{R}}_{It})}{(1+r)^t} = \sum_{t=1}^{T_{con}} \frac{(0 - \tilde{I}_t) - \tilde{\tilde{R}}_{It}}{(1+r)^t} + \\ &\sum_{t=T_{con}+1}^{T_{con}} \frac{(\tilde{V}_t - \tilde{I}_t) - (\tilde{\tilde{R}}_{Vt} + \tilde{\tilde{R}}_{It})}{(1+r)^t} \geq I_c R \end{aligned} \quad (11)$$

or it can be simplified as:

$$\sum_{t=1}^{T_{con}} \frac{(0 - \tilde{I}_t) - \tilde{\tilde{R}}_{It}}{(1+r)^t} + \sum_{t=T_{con}+1}^{T_c} \frac{(\tilde{V}_t - \tilde{I}_t) - (\tilde{\tilde{R}}_{Vt} + \tilde{\tilde{R}}_{It})}{(1+r)^t} \geq I_c R \quad (12)$$

Where,

$\tilde{\tilde{R}}_{Ict}$: Loss on the expenditure side in the construction period

$\tilde{\tilde{R}}_{Imt}$: Loss on the expenditure side in the operational period

Tc = is to transfer

Tcon = construction time

4.2 Optimization of concession parameters to protect the public sector's benefits

In this proposed framework, to protect investors' interests, the following equation must be satisfied:

$$Risk\ Adjusted\ DNPV^{(2)} \geq NAV_{Tc} \quad (13)$$

The equation (10) can be modified as:

$$Risk\ Adjusted\ DNPV^{(2)} = \sum_{t=Tc+1}^n \frac{(\tilde{V}_t - \tilde{I}_t) - (\tilde{\tilde{R}}_{Vt} + \tilde{\tilde{R}}_{Imt})}{(1+r)^t} \geq NAV_{Tc} \quad (14)$$

Where,

Tc: Transfer time

Tcon: Construction time

NAV_{Tc}: Net asset value of the project at its transfer time

$\tilde{\tilde{R}}_{Ict}$: Loss on the expenditure side in the construction period

$\tilde{\tilde{R}}_{Imt}$: Loss on the expenditure side in the operational period

The NAV calculation method used in the paper by Wu *et al.* (2012) has weaknesses. More specifically the depreciation cost in the paper by Wu *et al.* (2012) is determined by straight-line depreciation. It is said that this method is simple. However, its limitation is that the asset is assumed to be used with the same frequency every year (Warran *et al.* 2009). The demand for transport construction changes every year. Therefore, to determine the depreciation cost, in this framework,

the Unit of Production method is used. The idea of this method is that the asset is depreciated based on the unit of production used, and therefore it is suitable for assets relating to traffic levels (Queensland Competition Authority, 1999). Therefore, NAV_{Tc} in this model is determined as:

$$NAV_{Tc} = \text{Original Cost} - \sum_{t=Tc+1}^n \frac{\tilde{D}_t}{(1+r)^t} \quad (15)$$

Where,

$\tilde{D}_t$: Depreciation cost in year t added risk parameter on the revenue side; r: risk-free rate.

According to the Unit of Production Method (Queensland Competition Authority, 1999), and (Wu *et al.* (2012), the depreciation cost can be measured as:

$$\text{Depreciation cost} = \frac{N_t}{N} (\text{Original Construction Cost}) \quad (16)$$

Where,

N_t : Number of units produced in year t

N: Total number of units predicted though the economic life of the project

It should be noted that in this framework the unit can be traffic demand. Besides, the tolls are fixed through the project's lifecycle.

Therefore,

$$\frac{N_t}{N} = \frac{\text{Revenue in Year } t \text{ without changing in tolls}}{\text{Total revenue without changing in tolls}} \quad (17)$$

Equation 12 can be used for situations where data about traffic demands is missing, but the data about tolls and changes in tolls is available.

It also should be noted that due to the application of DNPV, the construction cost is added by the risk-adjusted parameter on the expenditure side. Therefore, the calculated depreciation costs need to take into account the risk of changes construction cost. Therefore:

$$\tilde{D}_t = \frac{N_t}{N} \left(\sum_{t=1}^{T_{con}} \frac{(\tilde{I}_t + \tilde{R}_{Ict})}{(1+r)^t} \right) \quad (18)$$

Equations 15, 16, 17, and 18 are used to compute the values of IcR , Dt and $NAVTC$. Equations 10 and 13 are used to determine an interval of the concession period which can protect the interests of both the private and public sectors. Equation 14 is used to compute the DNPV. The values of DNPV and PV are computed from revenue, expenditure, and income analysis.

5. Application Case study

5.1 The Process of calculation of Risk-adjusted DNPV for the case study

Figure 1 shows that to apply risk adjusted DNPV, the private investors need to use the heuristic data about the revenue and expenditure to estimate the revenue and expenditure. The heuristic data is also used to determine the construction cost distribution and the volatility of heuristic revenue. From this distribution and the volatility, the risk parameter η can be determined. After that, risk parameter η will be adjusted by using risk scores from the risk identification stage to form the risk-adjusted parameter $\bar{\eta}$. In the next step, DNPV return evaluation can be analysed. This is followed by DNPV return computation.

5.2 Case study description

The case study is a 30.1 km highway project in Vietnam that was planned in 2010 and the contract was signed in August 2011. The authorized state body in the contract is Directorate for Roads of Vietnam (DRV) and private stakeholders set up the SPV. The construction started in October 2011 and finished in April 2014 which was 6 months earlier than planned. The project was planned to collect tolls from the 1st of June 2014 to the 5th of October 2030. However, the start of the toll collection was delayed until the end of 2014. The project risk profile was created based on interviews and surveys with investors in 21 PPP projects including this project, in Vietnam

(Nguyen, 2015). Risks were classified into Construction risks, Market risks, Legal risks, Relationship risks, and Operational risks. These risks are then used in the case study. The risk-adjusted DNPV was used to take into account losses by lower demand than were expected, a higher maintenance cost, and construction cost overrun (Nguyen, 2015).

5.3 Determination of risk parameters

5.3.1 Determination of Risk-Adjusted parameter on the expenditure side for maintenance cost

In terms of the risk-adjusted parameter on the expenditure side, the heuristic method described previously in this paper was used for this project (Nguyen, 2015). The finding from previous research by Paul *et al.* (2014) was applied. The authors found that the cost contingency for maintenance infrastructure in Vietnam was 0.35. Thus, $\eta_I = 0.35$.

This study used a questionnaire to estimate risk scores. The survey was conducted among practitioners who have worked in 76 road and bridge PPP projects. Participants were sponsors, public clients, constructors, lenders, and inspectors. The data from 151 responses were used to compute the risk scores using the AHP method. Based on AHP modelling results, risks scores of Inflation risk, Fluctuation of interest rate, Influence of negative economic events were computed as 0.403, 0.378, and 0.314 respectively (Nguyen (2015). Therefore, the risk-adjusted parameter for the operation period of this project can be measured as:

$$\bar{\eta}_I = \eta_I + \eta_I * R_{M4} * R_{M5} * R_{M7} \quad (\text{from equations 6 and 7})$$

Where,

RM4: Risk score for the inflation risk

RM5: Fluctuation of interest rate

RM7: Risk score for influence of negative economic events

Thus,

$$\bar{\eta}_I = 0.35 + 0.35 \cdot 0.403 \cdot 0.378 \cdot 0.314 = 0.3667$$

5.3.2 Determination of Risk-Adjusted parameter on the expenditure side for the Construction period

In this project, to determine the risk parameter for the construction cost overrun, the probability-based method was applied. The cost overrun statistics of 20 projects were collected. Although the number of projects is only 20, the total number of Vietnamese PPPs which finished their construction period is only 21. Therefore, the figure presents the general situation of the current cost overrun in Vietnamese PPPs. The cost overrun data from these projects is used to develop the distribution for the construction cost of this project.

Insert figure 1 here

From figure 1, it can be seen that the expected value was located at P50, the potential loss for expenditure is on the right side part of P50, and the value of the loss is located at the centre of gravity of the truncated area which is the location of P21. The value of P21 can be determined by using the Inverse Normal Distribution function with the mean of 33.33 and the standard deviation of 5.613 (Nguyen, 2015). Using the probability-based method described by Espinoza and Rojo (2015), the risk parameter on the expenditure side for construction period can be determined as:

$$\eta_{Icon} = \frac{\Pr[It > \tilde{It}] \cdot (P21 - P50)}{(P50)} = \frac{0.5 \cdot (37.86 - 33.33)}{33.33} = 0.0679$$

Similarly, using questionnaires, risks scores of Difficulty in Land acquisition and resettlement is 0.314. Thus,

$$\bar{\eta}_{Icon} = \eta_{Icon} + \eta_{Icon} * R_{M4} * R_{M5} * R_{M7} * R_{C7} \quad (\text{from equations 6 and 7})$$

where,

R_{M4} : Risk score for Inflation risk

R_{M5} : Risk score for Fluctuation of interest rate

R_{M7} : Risk score for Negative economic events

R_{C7} : Risk score for Difficulty in Land acquisition and resettlement

Thus,

$$\bar{\eta}_{Icon} = 0.746 + 0.746 * 0.502 * 0.403 * 0.378 * 0.314 = 0.0695$$

5.3.3 Determination of the risk-adjusted parameter on the revenue side

The annual variation of traffic demand from 2003 to 2010 analysed and used to project the expected revenues. Because the heuristic data about the variation of traffic demand in this highway is available, the option pricing method was used.

After placing the risk parameters on the revenue side (η_v), the risk-adjusted parameters can be determined by using equation 6:

$$\bar{\eta}_v = \eta_v + \eta_v * R_{M7} * R_{L5} * R_{C10}$$

Where,

R_{M7} : Risk score for Influence of Negative economic events

R_{L5} : Risk score for Restriction on tolls

R_{C10} : Delay in other infrastructures relating to the project

Risk scores of Restriction on tolls and Delay in other infrastructures relating to the project were determined as 0.318 and 0.308. Therefore,

$$\bar{\eta}_v = \eta_v + \eta_v * R_{M7} * R_{L5} * R_{C10} = \eta_v + \eta_v * 0.378 * 0.318 * 0.308$$

Risk-adjusted parameters on the revenue side are shown in table 1. In this table, the risk scores for influence factors are also shown.

Insert table 1 here

From these risk-adjusted parameters, losses that can be made because of lower revenue and higher expenditure can be determined. From that, the return analysis can be made. Table 2 shows the details of the return analysis by the risk-adjusted DNPV and NPV for this project.

Insert table 2 here

From table 2, it can be seen that the project is profitable in both evaluations. In general, in Risk-adjusted DNPV Evaluation, investors will start to make a profit in 2029, whereas, in NPV evaluation, they can make a profit beginning in 2032. Because the project is beneficial, concession parameters can be optimized. The section below shows how parties can optimize concession parameters.

6. Optimization of concession parameters

The concession parameters, which are subjected to optimization, include the concession period, and returns obtained during the concession period. The concession period should be able to protect the interest of both sectors.

In order to optimize the concession parameter, the expected return from the investor (IcR), depreciation cost of the project ($(Dt)^{\sim}$), and net asset value of the project (NAVTC) need to be determined. From the contract, it is shown that the expected rate of return for investors (R) is 12.83 percent. Using this value together with the forecasted expenditure, the expected return each year can be determined.

It is important to note that in the contract, there is no mention about the economic life of the project. However, according to Shen et al. (2007), economic life of a transportation project can be 50 years. Therefore, in this project, it is assumed that the economic life of the project is 50 years. Using equation 19, and 20 and 21 and 22 the value of IcR , $(Dt)^{\sim}$ and NAV_{Tc} can be determined. It should be noted that the Risk-adjusted DNPV (1) and NPV (1) are obtained from the return analysis part in table 2. The risk-adjusted DNPV (2) and NPV (2) are inversed with DNPV (1) and NPV (1). In other words, Risk-adjusted DNPV (2) and NPV (2) are cumulative from the 40th year to the 1st year.

Insert table 3 here

Using table 3 and equations 11 and 14, the concession period can be found to protect the interests of both sectors.

The benefit of the private sector can only be protected if equation 11 is satisfied. In other words, equation 8 is satisfied if the value in column 5 is not less than the value in column 6 in the same year.

More specifically, according to equation 11, investors can get the expected return if the project is transferred to the government from 2032 to 2040. During this period, the profit that investors can obtain increases from 5.9 million pounds at the end of 2032 to 12.23 million pounds at the end of 2040. In these years, the expected return (IcR) is always smaller than the Risk-Adjusted DNPV (1). This means investors can obtain more than expected. There is one year that investors should consider, which is the year 2038. This is because in the maintenance plan for that year, there will be a large amount of comprehensive work and if the project is transferred after this year, the investors have to be responsible for this work, and their benefit will reduce remarkably. It can be seen that the profit decreases from 12.38 million pounds at the end of 2037 to 10.05 million pounds at the end of 2038.

On the other hand, to protect the interest of the public sector, equation 14 needs to be satisfied. In other words, the value in column 9 is not less than the value in column 8 in the same year. Therefore, the project can be transferred to the government in any year since 2014, except for the year 2037 and 2038. During this period, as mentioned previously, the government will be responsible for a large amount of comprehensive maintenance if they get the project in 2038. This brings a drop from 1.01 million pounds from 2037 to - 0.15 million pounds in 2038. The government must be aware that the easier project that is being transferred, the more profitable it is for the public sector.

Figure 2 compares the determined concession period determined by different models, and in the contract. The figure shows that the transfer time should be from 2032 to 2037, or in 2039.

It can be seen in figure 2 that the transfer time in the contract agreement is 2030, and according to the project evaluation by NPV, used by investors, by that time investors just achieve a little benefit as the project just goes through the breaking point. However, Risk-adjusted DNPV shows that investors start to create profits since the end of 2028.

It should be noted that in this research an interval of the concession period is determined, and the specific time of transferring is left to the negotiation based on the results of this model. The suggestion to carry out further research to find a specific transfer time will be provided in future research.

Insert figure 2 here

Previous studies have combined the time of value parameters with the risks to assess the return from PPP projects. This outcome of the assessment was used to determine the concession period. In coupling time of value money and risks, this may lead to overestimating the benefits to the private sector at the expense of the public sector's value for money benefits (Feng et al. 2019).

One needs to bear in mind that the longer the concession period is, the more the private sector will spend extra funding for maintenance and assets replacement. In the same vein, if the concession period is shorter, this may result in the private sector not spending much on maintenance. This will affect that when the project is transferred to the public sector, it will be in suboptimal conditions resulting in additional investment from the public sector to keep the project operating. The results in this study suggest that the concession period should be shortened when the financial gains from the project are not proportional to the initial investment. This finding is in line with the view that *“a longer concession period is more beneficial to the private investor, but a prolonged concession period may induce loss to concerned government”* (Carbonara et al., 2014).

In terms of practice, the results of this research project can bring advantages to the public and private sectors and improve the operation of PPP construction projects as it focused on how risk can be treated as a separate entity from the value of money. Moreover, although this research project focuses on the Vietnamese construction industry, the results should be useful, not only in this country but also in other countries, particularly developing countries in South East Asia.

The revenues and expenditures in projects, or other entities, are linked by definition, and through several mechanisms, e.g. contracts, fiscal policy, level of debt, economic activities, etc. The initial PPP project revenue is based on the forecast of service usage over a long period. The demand for project services tends to be variable over the concession period. The variation is dependent on many project contextual factors. For example, school and hospital projects are dependent on population growth, and for toll road on economic activities. Moreover, the revenue forecast spans over the concession period. This raises the question of revenue forecast accuracy (Flyvbjerg, 2005). If the revenue forecast is lower than the actual one, then this will have a direct consequence on the availability of funds for servicing the operation and the maintenance cost. This is why the

demand risk is always an integral part of the PPP concession contract. Generally, this risk is allocated to the procurer, only if and when it falls below an agreed level. Several cases were reported in the literature where the concession period is adjusted or cancelled due to demand and revenue risks (Liu et al. 2019). However, Liu et al (2017) pointed out that volatile projects' flexibility in the concession period has little influence on the project debt. The authors went on to suggest that the minimum revenue guarantee is more suitable to these types of projects, whereas payment based on availability is more appropriate for lower volatility. However, the concession period can be increased to fully amortize major initial investments. Similarly, if the revenue is higher than it should be, that may signify that the distribution of the concession is not fairly priced and allocated. However, this also might suggest that the private sector is efficient in the operation of the project, or equally, the demand for the project services are higher than forecasted (Wang and Liu 2015). Consequently, this will increase public sector debt (Du et 2019). This implicitly will be assumed as a liability on the public sector balance sheet leading to further expenditure requirements. Equally, one also might argue that the longer the concession period is, the better the construction quality of the infrastructure project when is handed over to the public sector. To solve the conundrum of the relationship between expenditure and revenue risks, it was suggested to use revenue sharing to avoid excessive returns for the concessionaire (Du et al., 2019, Liu et 2017).

7. Conclusion

Determining the concession period is one of the most important decisions to be made in PPP contracts. The concession period must be reasonable to protect the interest of investors and the host government. This paper has shown that evidence exists in both academic and practice literature to suggest models are based on NPV technique, which has several limitations. To

overcome some of these problems this work has attempted to apply the notion of Risk-adjusted DNPV in determining the concession period. Risk-adjusted DNPV is applied to the Net Asset Value model

The proposed framework takes into consideration risks that influence the life cycle of PPP projects, the concession period, Delphi techniques, and mathematical modelling to estimate the optimum concession period. Case studies from Vietnam were used to demonstrate the applicability of the framework. The result shows that there is a significant difference between the concession determined by other models and the proposed model. The findings suggest that the concession period should be ended before the due date. The results show that the public sector is paying above what it should be paying.

The concession period is affected by the decoupling of NPV. This finding may suggest that the interest rate and risk pricing ought to be treated separately during the value for money analysis process. The application of the framework suggests that it can be utilised as mechanisms for assessing and allocation risk as well as determining the optimum concession duration. However, further work is needed to make the DPV method more generalised to all types of projects. Further research could investigate the influence DPV on different funding sources to prove the effectiveness and robustness of its value in determining the concession period.

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Table 1 Risk adjusted parameters on the revenue side for different year in No 18 Highway Project

Year	Risk Parameter on the revenue side η_v	Risk factor 1 (M7. Influence of negative economic events)	Risk factor 2 (L5. Restriction on toll and tariff)	Risk factor 2 (C10. Delay in other infrastructures relating to the project)	Risk Adjusted Parameter on the revenue side $\bar{\eta}_v$
2011	0.0000	0.378		0.308	0.00000
2012	0.0000	0.378		0.308	0.00000
2013	0.0000	0.378		0.308	0.00005
2014	0.0002	0.378		0.308	0.00018
2015	0.0004	0.378	0.318	0.308	0.00043
2016	0.0007	0.378	0.318	0.308	0.00076
2017	0.0011	0.378	0.318	0.308	0.00118
2018	0.0016	0.378	0.318	0.308	0.00167
2019	0.0022	0.378	0.318	0.308	0.00224
2020	0.0028	0.378	0.318	0.308	0.00289
2021	0.0035	0.378	0.318	0.308	0.00364
2022	0.0043	0.378	0.318	0.308	0.00450
2023	0.0053	0.378	0.318	0.308	0.00548
2024	0.0064	0.378	0.318	0.308	0.00663
2025	0.0077	0.378	0.318	0.308	0.00796
2026	0.0092	0.378	0.318	0.308	0.00951
2027	0.0109	0.378	0.318	0.308	0.01134

2028	0.0130	0.378	0.318	0.308	0.01347
2029	0.0154	0.378	0.318	0.308	0.01599
2030	0.0183	0.378	0.318	0.308	0.01895
2031	0.0216	0.378	0.318	0.308	0.02244
2032	0.0256	0.378	0.318	0.308	0.02657
2033	0.0303	0.378	0.318	0.308	0.03145
2034	0.0359	0.378	0.318	0.308	0.03722
2035	0.0425	0.378	0.318	0.308	0.04406
2036	0.0503	0.378	0.318	0.308	0.05215
2037	0.0595	0.378	0.318	0.308	0.06175
2038	0.0705	0.378	0.318	0.308	0.07313
2039	0.0835	0.378	0.318	0.308	0.08661
2040	0.0989	0.378	0.318	0.308	0.10261

Table 2 Return analysis by risk adjusted DNPV and NPV

Year	Revenue (million pounds)	Expenditure (million pounds)					Income	$\bar{\eta}_v$	$\bar{\eta}_{Icon}$ (for Construction period)	$\bar{\eta}_{Im}$ (for Maintenance)	$\bar{R}_{vt}$	$\bar{R}_{It}$	Risk adjusted DNPV	NPV
		Management Cost	Maintenance	Tax	Investment	Total								
2011	0.19	0.03	0.0051	0.0369	1.36	1.40	-1.21		0.0695			0.09	-1.31	-1.21
2012	0.82	0.11	0.0228	-0.10682	13.58	13.60	-12.78		0.0695			0.94	-13.84	-12.59
2013	0.91	0.12	0.0251	-1.20693	12.44	11.38	-10.47		0.0695			0.86	-23.30	-20.90
2014	1.00	0.14	0.0345	-1.10228	5.96	5.03	-4.03	0.00018	0.0695	0.3667	0.0002	0.41	-26.68	-23.74
2015	5.13	0.55	0.0608	-0.43564		0.18	4.95	0.00043		0.3667	0.0022	0.02	-23.26	-20.63
2016	4.64	0.47	0.0669	0.09205		0.63	4.01	0.00		0.3667	0.0035	0.02	-20.73	-18.

								07 6						3 9
2 0 1 7	4.8 8	0.49	0.073 6	0.0 96 81		0. 6 6	4. 22	0. 00 11 8		0.366 7	0. 00 57	0. 03	-18.30	- 1 6. 2 8
2 0 1 8	5.3 6	0.54	0.783 8	0.0 99 46		1. 4 2	3. 95	0. 00 16 7		0.069 5	0. 00 90	0. 05	-16.24	- 1 4. 5 3
2 0 1 9	5.9 0	0.59	0.303 8	0.1 14 99		1. 0 1	4. 89	0. 00 22 4		0.069 5	0. 01 32	0. 02	-13.89	- 1 2. 6 0
2 0 2 0	5.4 0	0.43	0.097 9	0.1 07 09		0. 6 4	4. 77	0. 00 28 9		0.366 7	0. 01 56	0. 04	-11.81	- 1 0. 9 2
2 0 2 1	5.8 9	0.47	0.107 7	0.1 16 72		0. 7 0	5. 19	0. 00 36 4		0.366 7	0. 02 14	0. 04	-9.74	- 9. 2 9
2 0 2 2	6.4 2	1.09	1.147 6	0.1 16 92		2. 3 5	4. 07	0. 00 45 0		0.069 5	0. 02 89	0. 08	-8.28	- 8. 1 6
2 0 2 3	7.0 0	0.56	0.130 3	0.1 38 65		0. 8 3	6. 17	0. 00 54 8		0.366 7	0. 03 84	0. 05	-6.23	- 6. 6 2
2 0 2 4	7.6 3	0.61	0.489 3	0.1 47 65		1. 2 5	6. 38	0. 00 66 3		0.069 5	0. 05 06	0. 03	-4.30	- 5. 2 1

2 0 2 5	8.3 1	0.67	0.157 7	0.1 64 70		0. 9 9	7. 33	0. 00 79 6		0.366 7	0. 06 62	0. 06	-2.28	- 3. 7 7
2 0 2 6	8.5 5	0.68	12.58 16	0.0 45 21		1 3. 3 1	- 4. 76	0. 00 95 1		0.069 5	0. 08 14	0. 87	-3.74	- 4. 6 0
2 0 2 7	9.2 4	0.74	0.190 8	0.1 82 80		1. 1 1	8. 12	0. 01 13 4		0.366 7	0. 10 47	0. 07	-1.88	- 3. 3 3
2 0 2 8	9.9 7	0.80	0.209 9	0.1 97 38		1. 2 1	8. 77	0. 01 34 7		0.366 7	0. 13 44	0. 08	-0.05	- 2. 1 1
2 0 2 9	10. 77	0.86	1.345 3	0.2 01 99		2. 4 1	8. 36	0. 01 59 9		0.069 5	0. 17 22	0. 09	1.53	- 1. 0 8
2 0 3 0	11. 63	0.93	2.460 0	0.2 08 08		3. 6 0	8. 04	0. 01 89 5		0.366 7	0. 22 04	0. 90	2.76	- 0. 1 9
2 0 3 1	11. 52	0.92	0.279 4	0.2 27 56		1. 4 3	10 .0 9	0. 02 24 4		0.366 7	0. 25 85	0. 10	4.35	0. 8 0
2 0 3 2	12. 44	1.00	0.307 3	0.2 45 71		1. 5 5	10 .8 9	0. 02 65 7		0.366 7	0. 33 05	0. 11	5.90	1. 7 5
2 0 3 3	13. 43	1.07	0.338 1	0.2 65 30		1. 6 8	11 .7 6	0. 03 14 5		0.366 7	0. 42 25	0. 12	7.42	2. 6 7
2 0 0	14. 51	1.16	4.499 0	0.2 45 19		5. 9 0	8. 60	0. 03		0.069 5	0. 54 01	0. 31	8.38	3. 2 7

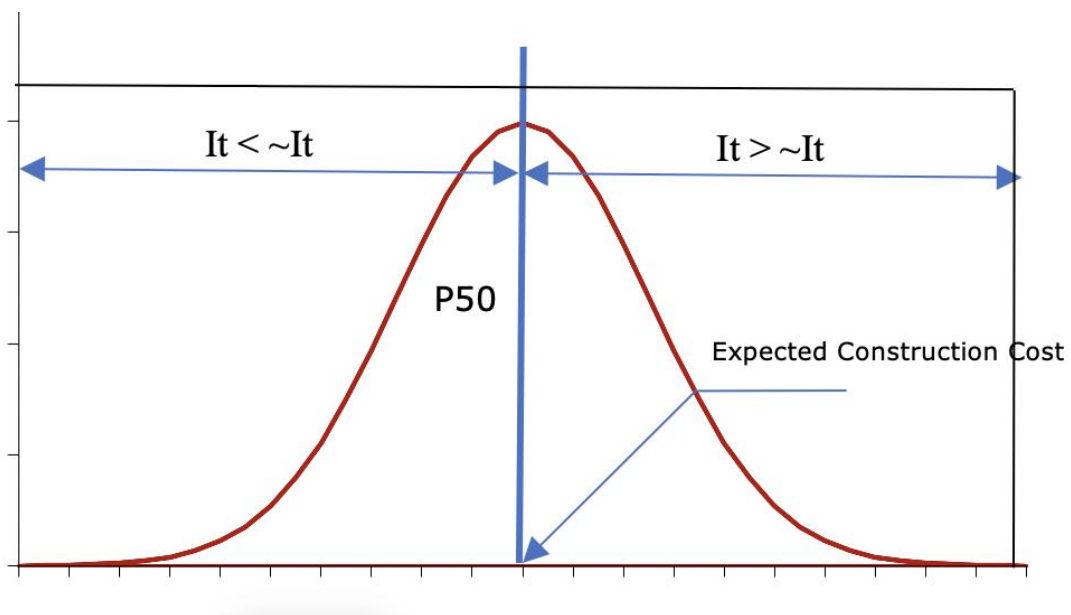
3 4								72 2						
2 0 3 5	15. 67	1.25	0.409 1	0.3 09 30		1. 9 7	13 .7 0	0. 04 40 6		0.366 7	0. 69 04	0. 15	9.84	4. 1 1
2 0 3 6	15. 38	1.23	0.450 0	0.3 03 19		1. 9 8	13 .4 0	0. 05 21 5		0.366 7	0. 80 24	0. 17	11.12	4. 8 5
2 0 3 7	16. 62	1.33	0.495 0	0.3 27 36		2. 1 5	14 .4 6	0. 06 17 5		0.366 7	1. 02 60	0. 18	12.38	5. 5 6
2 0 3 8	17. 94	1.44	39.48 63	- 0.0 35 97		4 0. 8 9	- 22 .9 4	0. 07 31 3		0.069 5	1. 31 22	2. 75	10.05	4. 5 6
2 0 3 9	19. 38	1.55	2.044 1	0.3 67 16		3. 9 6	15 .4 2	0. 08 66 1		0.366 7	1. 67 86	0. 75	11.07	5. 1 6
2 0 4 0	20. 93	1.43	0.658 8	0.4 12		2. 5	18 .4 3	0. 10 26 1		0.366 7	2. 14 78	0. 24	12.23	5. 8 0

Table 3 Return analysis for optimizing concession parameters

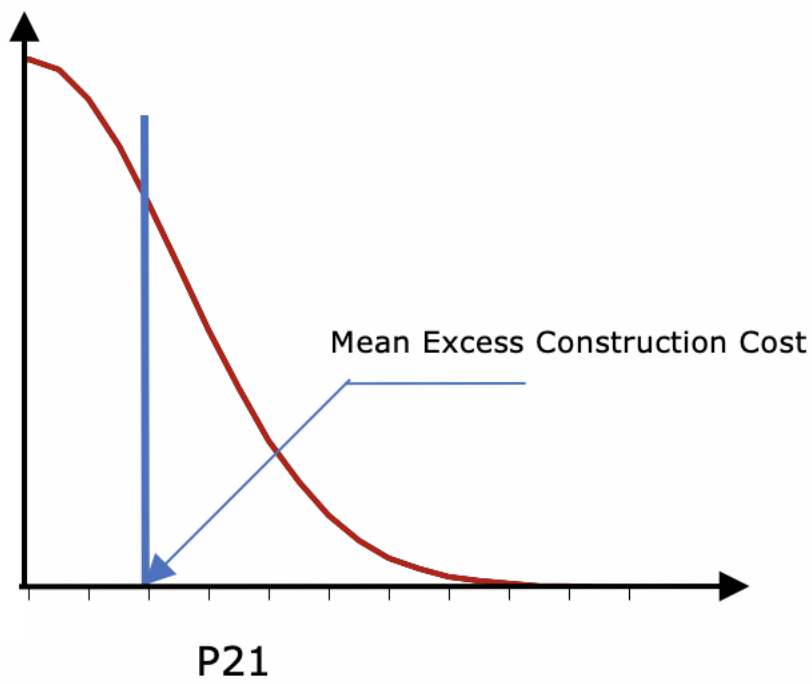
Year	Revenue (mil. pounds) Revenue	Expendi- ture (mil. pounds)	Incom- e	Risk Adjust- ed DNPV ⁽¹⁾	IcR	$\tilde{D}_t$	NAV _{Tc}	Risk Adjust- ed DNP V ⁽²⁾
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2011	0.19	1.40	-1.21	-1.31	0.19			
2012	0.82	13.60	-12.78	-13.84	1.90			
2013	0.91	11.38	-10.47	-23.30	3.21			
2014	1.00	5.03	-4.03	-26.68	3.74	0.08	23.30	35.52
2015	5.13	0.18	4.95	-23.26	3.76	0.16	21.22	38.91
2016	4.64	0.63	4.01	-20.73	3.81	0.50	19.16	35.48
2017	4.88	0.66	4.22	-18.30	3.86	0.80	17.33	32.95
2018	5.36	1.42	3.95	-16.24	3.96	1.11	15.66	30.53
2019	5.90	1.01	4.89	-13.89	4.02	1.46	14.13	28.47
2020	5.40	0.64	4.77	-11.81	4.06	1.84	12.74	26.12
2021	5.89	0.70	5.19	-9.74	4.10	2.19	11.49	24.04
2022	6.42	2.35	4.07	-8.28	4.22	2.57	10.35	21.96
2023	7.00	0.83	6.17	-6.23	4.25	2.99	9.31	20.51
2024	7.63	1.25	6.38	-4.30	4.30	3.44	8.37	18.46
2025	8.31	0.99	7.33	-2.28	4.34	3.93	7.50	16.52
2026	8.55	13.31	-4.76	-3.74	4.81	4.47	6.71	14.50
2027	9.24	1.11	8.12	-1.88	4.84	5.03	6.00	15.97
2028	9.97	1.21	8.77	-0.05	4.88	5.62	5.35	14.11
2029	10.77	2.41	8.36	1.53	4.94	6.27	4.76	12.28

203 0	11.63	3.60	8.04	2.76	5.04	6.97	4.23	10.70
203 1	11.52	1.43	10.09	4.35	5.08	7.72	3.74	9.46
203 2	12.44	1.55	10.89	5.90	5.11	8.47	3.30	7.88
203 3	13.43	1.68	11.76	7.42	5.14	9.27	2.91	6.33
203 4	14.51	5.90	8.60	8.38	5.24	10.14	2.55	4.80
203 5	15.67	1.97	13.70	9.84	5.27	11.08	2.22	3.84
203 6	15.38	1.98	13.40	11.12	5.30	12.09	1.92	2.39
203 7	16.62	2.15	14.46	12.38	5.33	13.09	1.66	1.10
203 8	17.94	40.89	-22.94	10.05	5.81	14.17	1.42	-0.15
203 9	19.38	3.96	15.42	11.07	5.86	15.33	1.21	2.18
204 0	20.93	2.5	18.43	12.23	5.88	16.23	1.04	1.15

Figure 1: Potential loss distribution due increase of construction cost in the case study project



(a) Construction Cost Distribution



(b) Potential Loss distribution for construction expenditure

Figure 2. Transfer Time in different models for the case study project