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Design of Concession Period Considering Risk Management for a Road Project

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ABSTRACT

The design of concession period for build–operate–transfer (BOT) projects is crucial to financial viability and completion risk management. A systematic analysis shows that concession period design involves the design of concession period structure as well as the determination of the concession period length. The concession period may have a single-period structure or a two-period structure; its length may be fixed or variable. Different designs reflect different risk control strategies for completion time overruns. The single-period concession structure requires the project company to assume completion risk, while the two-period concession structure could, to some extent, reduce the completion risk exposure to the project company, depending on the various parameters. Through Monte Carlo simulation, this paper evaluates the mean net present value (NPV), variance and NPV-at-risk of different concession period structures, so that both the government and the concessionaires can understand their risk exposure and rewards. The paper then analyzes the influence of project characteristics on concession period design to evaluate the feasibility of the design. Expected concession period has been calculated using Monte Carlo simulation method, and expected concession periods have been found to be 28.25 years and 26.46 years based on level of service and 95 % risk consideration.

KEYWORDS: Concession period structure, NPV, Privately financed infrastructure, BOT, Risk management.

INTRODUCTION

Over the past two decades, a great number of infrastructure projects have been developed under concession contracts. According to the ninth annual survey conducted by Public Works Financing (2000), over 1370 infrastructure concessions, with estimated capital costs of over 575 billion US $, have been proposed, awarded or completed under various forms of public–private partnership in over 100 countries around the world since 1985. At the same time, a considerable number of studies on privately financed infrastructure projects have been presented in seminars, conferences and journals, which cover a wide range of topics from project evaluation, risk management and concession design to regulation. Among them, concession period design is an interesting topic of concern to both the public and private sectors and closely related to project participants' financial returns and completion risk management.

This paper systematically explores the types of concession structures for BOT projects and evaluates the effectiveness of different concession period structures on financial return and completion risk management through mathematical analysis and computer simulations. Finally, the paper recommends

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possible concession period structures for covering risk management. Different type BOT structures are presented in Appendix 1.

Design of Concession Period

The design of concession period involves the design of period structure; i.e., the determination of period length and incentive schemes.

Structures of Concession Period

The development of a privately financed infrastructure project goes through three phases; namely: the predevelopment phase, the construction phase and the operation phase. The pre-development phase ends with the award of a concession contract. Only the construction and operation phases are included in the concession period. Therefore, there are two possible period structures:

- The single-period concession, which defines a concession period beginning from awarding the concession agreement to transferring the project back to the government; and
- The two-period concession, which defines a construction period plus an operation period.

The former combines the construction phase and operation phase together; whereas the latter separates the operation period from the construction period. The operation period may be fixed or variable depending on the nature of the contract. Fix operation period may not cover risk; whereas variable operation period may cover risk management of the BOT road project.

Length of Concession Period

Each concession has its duration, which may be fixed or variable. The choice depends on various risk factors such as: completion time, product prices and market demands. Usually, the concession has a fixed period, in which risk factors are managed monitoring vehicle tariff rate from time to time. Sometimes, the concession has a variable period, which may be extended if the specified risk factors are worse than expected or shortened if they are better than expected. For example, in order to deal with demand risk, the concession period can be varied according to the market demand. If the market demand is lower than expected, the concession period will be extended to allow the concessionaire to earn a reasonable return, and *vice versa*. Based on this concept, Engle et al. (1998) suggested the least-present-value of revenue method to determine the concession period of toll roads, so that the franchise length is adjusted endogenously to demand realization.

As a result, single-period structures may have a fixed term or a variable term, and the construction period and the operation period in the two-period structure may each have a fixed term or a variable term.

The length of concession period is mainly related to the recovery of investment and return required by the concessionaire. The general principle of determining the concession-period length is that the concession period should be long enough to allow the concessionaire to recoup investment costs and earn reasonable profits within that period (Smith, 1995). If the two-period concession structure is adopted, the contracted completion time is determined by both the contracting parties through bidding and/or negotiation by referring to the mean completion time or the most likely completion time of similar projects. It can be any time other than the mean completion time or the most likely completion time, as long as both parties agree. It is reasonable to assume the most likely completion time as the contracted completion time for the purpose of analysis in this paper.

Concession Period Structures and Financial Viability

The financial viability of a privately financed infrastructure project largely depends on the length of operation period. In a single-period concession structure, the operation period depends upon the completion of the project (Figure 1). It transfers the completion time risk to the project company. The project company will enjoy the gain generated from earlier operation if the project is completed ahead of the schedule, but bears the loss of revenues resulting from delayed operation if the project is completed behind the schedule (Fig. 1).

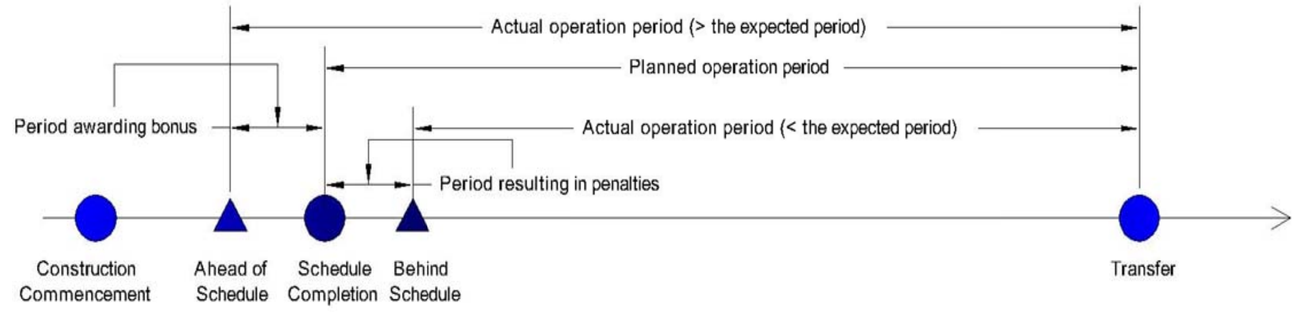

Figure 1: Single Stage Concession Period

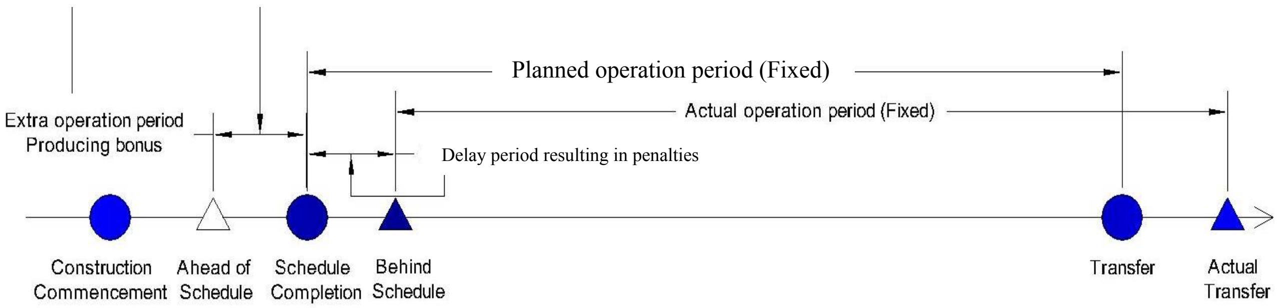

Figure 2: Two-Stage Construction

In two-period concession structures, the operation period is fixed and independent from the construction period (Fig. 2). Fig. 2 shows that there is an extra operation period if the project is completed ahead of the schedule, in which the operating income of the concessionaire shall be more than the actual income.

LITERATURE REVIEW

In infrastructure development through public-private partnerships (PPPs), governments worldwide often preset the concession period to a fixed length and then invite the private sector to bid on other aspects of the project. This practice has potential economic, financial and social problems. To overcome these problems, a win–win concession period determination methodology is used, in which PPPs are addressed as a principal-agent maximization problem. Both deterministic and simulation-based methods are provided to determine the concession period, with detailed step-by-step procedures. These methods take into consideration the financial characteristics of PPPs and the construction and operation requirements. In particular, the simulation-based approach combines the critical path method and Monte Carlo simulation technique in an effort to quantify construction and market risks for informed decision making (Zhang, 2009).

The factors and the corresponding sub-factors affecting the length of the concession period for a BOT tunnel project have been discussed. This includes five steps; namely: identifying the influential factors of concession period length determination, identifying the sub-influential factors, quantification of the factors, variable ranking and variable testing. The influential factors and sub-factors were identified through an extensive review of literature and a questionnaire survey. Then, qualitative factors were quantified, and all the factors were scaled and ranked by Entropy method and finally tested by a Support Vector Machine based prediction model. In the end, a set of key influential factors of concession period length was developed. It was expected that the developed factors can improve the accuracy and effectiveness of concession period length determination (Lam and Yung, 2013).

The concession period is an important issue in the contractual arrangement of build-operate-transfer (BOT) projects, such as: highways, bridges and tunnels. In determining the concession period, it is predominantly the toll revenue and construction costs that affect how long the concessionaire needs to be in operation after the completion of the project. Stochastic revenue and cost model are major factors to determine a concession period under multiple constraints in planning a BOT infrastructure project. The stochastic process is converted into an equivalent discrete form, and its parameters are estimated using historical data. Based on the process, a principle-agent problem is addressed as a solution to the conflict between the owner and the concessionaire. This methodology incorporates these stakeholders' interests in terms of 1) incentive constraints, and 2) participation constraints. In a case study, a numerical simulation has been carried out to assess the risk of toll revenue and construction costs when applied in practice, and to demonstrate the applicability of the stochastic revenue and cost model (Xu and Moon, 2013).

A concession period is a key decision variable in the arrangement of a build-operate-transfer (BOT)-type contract. Recently, an innovative BOT concession model (BOTCcM) was developed to quantitatively determine the value of a concession period. The model could propose an interval for possible negotiations between a host government and a private investor. Nevertheless, this paper identifies a major limitation of this model and proposes an alternative model for improvement. Under a BOT arrangement, the project becomes a property of the host government upon its transfer. The project's net asset value at the transfer time is usually significantly greater than zero, representing revenue to the host government. This revenue, thus, cannot be ignored. However, this revenue was not considered in the analysis of BOTCcM. This study improves the second critical point in BOTCcM by considering project net asset value at the transfer time. The application of the new model is demonstrated by using the same example case quoted in BOTCcM and shows that a significantly different decision will be made when project net asset value at its transfer time is considered (Shen et al., 2012).

Many US transportation public-private partnerships (PPPs) are based on the concession model, under which the structure of user fees and the agreement duration are central to ensure a fair balance of risk and reward between the public and private participants. Yet, previous studies of toll-rate structuring and concession-length determination have treated these two variables largely independently. Toll charges, for instance, are typically established as either supply-based, linked to the cost of constructing, maintaining and/or operating the facility; or demand-based, adjusted to influence driver behavior in certain ways such as through variable time-of-day congestion charges. Concession lengths are designed separately to enable tax-depreciation advantages for the private sector and/or to mitigate traffic-demand risk. Considering these two variables together, though, provides new opportunities to improve the risk-and-reward profile for both partners. A review and comparative analysis of dual-variable approaches, illustrated by projects in which these strategies have been used, offer additional tools to consider in structuring future PPP procurements

(Gross and Garvin, 2009).

Long-term concession agreements as a kind of Public-Private-Partnership (PPP) have been applied in infrastructure projects with equity participation by private sector. The concession approach to project financing has many advantages over traditional methods and as many concerns with non-traditional techniques. The growth of demand on financing infrastructure projects with public sector makes these projects deliver to the private sector throughout long-term concession agreements. Long-term concession is to cover infrastructure gap, reduce public concerns and protect the public interest on one hand and, on the other hand, to encourage private initiative and benefit from the involvement of the private sector particularly in the designing, building, financing, operating and maintenance of infrastructure projects. The most important criteria of long-term concessions in the structure of matrix are represented in four approaches: public objective, project properties, project implementation and environmental conditions. It is shown that various terms of contract can be investigated by considering these criteria in two infrastructure case studies of initial concessions in the United States (Farshchian et al., 2012).

The output of simulations was the cumulative distribution of NPV. Besides the mean value and the variance, the results were also analyzed by using the NPV-at-risk method developed by Ye and Tiong (2000a), which is defined as a particular NPV that is generated from a project at some specific confidence level. According to the method, the NPV-at-risk with a 95% confidence level was used as one of the indicators of the concession period design performance.

Model Concession of Agreement, Government of India recommended that a road shall be constructed at level of service B and concession may be terminated at level of service C /D depending on the concession agreement (MCA, 2009).

Bagui and Ghosh (2009) studied and designed a concession period considering various aspects; namely: level of service and financial internal rate of return. Upper and lower limits of concession periods have been fixed and the expected concession period has been determined using Monte Carlo simulation method.

Limitations

Concession period has been designed based on concession model agreement, Government of India, level of service and NPV at 95 % risk. The concession period depends on other parameters, like: actual construction cost, actual traffic and delay in construction.

OBJECTIVE AND SCOPE

Based on previous studies and needs of research, concession period shall be determined considering other major risks of the project; i.e., considering risk management so that the concessionaire shall benefit from the project.

Based on this objective, the scope of work has been identified as follows:

- Adopting fix and variable concession period;
- Covering risk by adjusting toll rate for fixed concession period;
- Covering risk by adjusting concession period; and
- Adjusting concession period for traffic risk and construction cost risk.

Proposed Methodology for Concession Period

Initial concession period shall be fixed based on the following two criteria:

- Concession period based on level of services.
- Concession period based on NPV/FIRR:
  a) Concession period at NPV≥0, FIIR≥ discount rate.
  b) Concession period based on NPV at 95% risk.

Concession Period Covering Risk Management

Major risks are:

- Delay in construction period;
- Variation in construction cost;
- Variation in traffic;

- Financing methods and supply; and
- Contracting challenges.

In the proposed method of designing concession period, different risks mentioned above should be protected so that the project is taken by the concessionaire.

A hypothetical case study has been considered for finalizing the concession period of a project covering the following risks:

1- Concession period will be reviewed if delaying construction is due to Government's fault, like: delay in land acquisition, delay in utility shifting, environment and forest clearance; i.e., Government involvement.
2- Project has been bided based on project cost fixed by the Government with ± 5 % cost variation. Concession period will be increased or decreased if variation of cost is more than ± 5 % (generally up to 15% or more).
3- Concession period will be revised if variation in traffic is more than ± 5 % of the projected traffic (generally up to 15%).

The concession period of the case study has been determined adopting the considerations stated above.

CASE STUDY

A hypothetical case study has been considered for bypass construction. Original existing road is a 56 km long road passing through a congested urban area (20 km), and the road will be upgraded to six lanes with the provision of a new six lane bypass and a total length of the road of 50 km.

The financial analysis has been carried out to evaluate the financial strength of the project from an investor's point of view. Obviously, the exercise presumes that the project is an economically viable option. In this exercise, all the costs and the benefits are based on the market prices.

Costs

The costs to be considered for commercial viability analysis consist of:

- *Base cost of construction;*
- *Annual and periodic repair and maintenance cost;*
- *Toll administration cost.*

Base Construction Cost: The cost for the construction of the road has been calculated and found to be Rs 7500 million (1 USD =55 Indian Rupees), including cost of antiglare screen barrier which is assumed to be installed on the median of the road.

Operation and Maintenance Costs (O & M Costs): Operation and maintenance costs are major expenses for the road project under BOT format during the operation period of the project. These consist of two costs; i.e., maintenance cost and toll operation cost which are described separately.

Maintenance Cost: This includes annual maintenance cost and periodic maintenance cost. Aannual maintenance cost is taken as Rs 12.5 million (repair of potholes, cracks, patches, cleaning of structure… etc.) and the periodic strengthening overlay is of the functional type required for roughness improvement. Periodic overlay is applied periodically (normally required every five years). Periodic maintenance cost is considered as Rs 190 million.

Operation Cost: This consists of the following:

- Salary of all employed people for collection of toll; and
- Maintenance charge of computer system, generators' cost, electric bills, ticket printing charges… etc.

Administrative toll cost has been taken as Rs 6 million per year.

An annual inflation has been calculated based on Consumer Price Index.

Discount Rate: In the real world, the currency value usually depreciates year by year. Accordingly, the value of time should not be neglected. The discount rate has been determined by the interest rate of the long/ medium-term loan, the return on equity and the debt / equity ratio (Chen, 1998).

It has been presented in the following equation:

Discount Rate = Debt proportion × Debt interest rate+ Equity proportion × Return on Equity

In the present study, interest rate of debt and return on equity have been adopted 15 % and 20%, respectively, based on the present market scenario in India. Financial analysis has been carried out and financial parameters are plotted graphically varying equity from 10% to 90% and varying traffic / revenue from 60% to 100 % of the base traffic.

Debt Repayment Schedule: Debt repayment schedule has been adopted as 10 years.

Base Traffic: Tollable traffic has been considered and base year traffic is reported in Table 1.

Table 1. Base Year Traffic

Vehicle	**Number**
Car (NT)N	2146
Car (OT)	2300
Bus	281
Light Commercial Vehicle +MINI BUS	1116
2-Axled Truck	2977
3-Axled Truck	5359
Multi-Axled Truck	1382

Growth Rate: Table 2 shows the growth rate of vehicle mode.

Table 2. Growth Rate of Vehicles

Vehicle Type	**Growth Rate (%)**			
	2000-2004	**2005-2009**	**2010-2014**	**2015 onwards**
Car (NT)	9.00	7.00	5.00	5.00
Car (OT)	9.00	7.00	5.00	5.00
Bus	7.00	5.00	5.00	5.00
Light Vehicle +MINI BUS	7.00	5.00	5.00	5.00
2-Axled Truck	6.00	5.00	5.00	5.00
3-Axled Truck	6.00	5.00	5.00	5.00
Multi-Axled Truck	7.00	5.00	5.00	5.00

Toll Rate: Toll rate vehicle mode has been fixed by the Government of India and is presented in Table 3. Toll rate shall be revised @ 5 - 8.3 % in consultation with the concessionaire and client. Per km rate is also varied depending on cost of project and type of project. Rate is too much for tunnels, bridges, elevated highways and flyover projects.

Table 3. Toll Rate

Vehicle Type	**Toll Rate (Rs / km) in 2010 by NHAI**
Car, van ,jeep	0.89
LCV	1.56
Bus, Truck, Heavy truck	3.12
MAV	5

Concession Period: Concession period consists of two parts. These are: construction period and operation period. Construction period has been considered 3 years and operation period has been adopted 27 years.

Escalation Rate: Escalation rate has been adopted 6% to determine Total Project Cost (TPC).

Interest Rate during Construction: Interest rate has been considered 15% to determine TPC.

DETERMINATION OF CONCESSION PERIOD

Concession Period Based on Level of Service

Indian Roads Congress (IRC) 64:1990 is the basic guideline for capacity analysis of roads.

IRC :64-1990 recommended that capacity of four lane dual carriageway with paved shoulders is 40,000 Passenger Car Units (PCU) at Level of Service (LoS) B. The value may be increased by 40% and 80% for

LoS C and LoS D, respectively. Capacity of six lane dual carriageway with paved shoulders is 60,000 PCU at Level of Service (LoS) B and 108,000 PCU at LoS D.

The proposed growth factors of vehicles have been reported in Table 4. PCU of left and right carriageways and total PCU are presented in Tables 5 and 6. From Table 6, it is found that the capacity of the road is found to be 108,000 PCU between 2037 and 2038. Therefore, concession period will be terminated at 2038 when the road reaches LoS D. Concession period is found 29 years based on technical viability (Level of service D, Concession period=2038-2010+1=29 years approximately). Concession period will be reduced to 24 years for LoS C considering PCU of 85102 close to 84000 in year 2033 (Concession period=2033-2010+1=24 years approximately).

Table 4. Proposed Growth Factor

Years	BUS	LCV	2-AXLE	3-AXLE	MAV	Taxi
2011-2015	5.16	7.5	5.38	7.47	8.3	5
2016-2020	5	5.5	5	5.47	6.3	5
2021-2025	5	5	5	5	5	5
>2005	5	5	5	5	5	5
PCU	3	1.5	3	3	4.5	1

CONCESSION PERIOD BASED ON NPV/FIRR

Concession Period Based on NPV Zero

Minimum concession period is obtained when NPV is 0 or the discount rate is equal to financial internal rate of return. Financial analysis has been carried out taking different viable equity portions into account, and the concession period has been calculated at FIRR is equal to discount rate. These data are plotted and presented in Fig.3. From this figure, it is found that the concession period increased with increasing the proportion of equity. Maximum equity proportion is found to be 25 % and concession period is found to be 30 years. Concession period is found 29 years based on technical viability of the project; i.e., based on level of service D. Financial internal rate of return is found 16.16%; i.e., same as discount rate and NPV is equal to zero at equity 23.2%. Project is not viable for the case of equity more than 23.2 %.

Discount rate and FIRR with different equities are plotted in Fig. 3. Discount rate line separates feasible zone and infeasible zone of equity. Form Fig. 3, it is found that the maximum equity limit is 23.2 % and that the project is infeasible for the case of equity more than 23.2 %.

Allowable concession period is 29 years and maximum equity investment is 23 % (say).

Considering both aspects, the concession period has been adopted as 29 years and the maximum equity is found 23.2 % (Fig. 4).

The concessionaire covers the probability risk of the project by limiting its equity proportion. Generally, equity portion varies from 10 % to 30 % for a BOT project.

The concessionaire may propose 15 % equity (Generally recommended by the Government of a Country) for the base case (base traffic and base cost). NPV and FIRR (Equity) have been found Rs 750 million and 17.34 %. Discount rate at 15% equity is 15.75 %. Therefore, equity has been considered 15% for the case study.

Concession Period Covering Construction Cost Risk and Traffic Risk

Actual construction cost may be increased/ decreased depending on the actual execution of the work. Actual cost varies within ± 15% of the base cost in scenario analysis.

Concession period may be increased to between 30 and 31 years. The project is infeasible if the actual project cost exceeds the base cost by 15% or more. In this case, the concession period will be 30.2 years for the case of variable concession period.

Table 5. PCU of Left Carriageway

Year	BUS	LCV	2-AXLE	3-AXLE	MAV	Taxi	PCU (LHS)
2010	105	372	1028	1699	424	1310	12272
2011	110	400	1083	1826	459	1419	13144
2012	116	430	1142	1962	497	1536	14079
2013	122	462	1203	2109	539	1664	15083
2014	124	475	1227	2167	555	1802	15570
2015	131	511	1293	2329	601	1952	16684
2016	137	539	1358	2457	639	2114	17654
2017	144	568	1426	2591	679	2289	18682
2018	152	600	1497	2733	722	2479	19773
2019	159	633	1572	2882	768	2685	20928
2020	167	667	1651	3040	816	2908	22154
2021	175	701	1733	3192	857	3149	23357
2022	184	736	1820	3352	900	3410	24629
2023	193	773	1911	3519	945	3694	25973
2024	203	811	2006	3695	992	4000	27394
2025	213	852	2107	3880	1041	4332	28895
2026	224	894	2212	4074	1094	4692	30483
2027	235	939	2322	4278	1148	5081	32162
2028	247	986	2439	4491	1206	5503	33938
2029	259	1035	2560	4716	1266	5960	35816
2030	272	1087	2689	4952	1329	6454	37804
2031	286	1141	2823	5199	1396	6990	39907
2032	300	1199	2964	5459	1465	7570	42133
2033	315	1258	3112	5732	1539	8198	44489
2034	331	1321	3268	6019	1616	8879	46984
2035	347	1387	3431	6320	1696	9616	49627
2036	365	1457	3603	6636	1781	10414	52425
2037	383	1530	3783	6968	1870	11278	55390
2038	402	1606	3972	7316	1964	12214	58532
2039	422	1686	4171	7682	2062	13228	61862
2040	443	1771	4379	8066	2165	14326	65391
2041	465	1859	4598	8469	2273	15515	69134
2042	489	1952	4828	8893	2387	16803	73102
2043	513	2050	5070	9337	2506	18197	77312
2044	539	2152	5323	9804	2632	19708	81778

Table 6. PCU of Right Carriageway and Total PCU

Year	BUS	LCV	2-AXLE	3-AXLE	MAV	Taxi	PCU(RHS)	PCU Total
2010	91	335	1030	1700	424	1500	12374	24646
2011	96	360	1085	1827	459	1575	13206	26350
2012	101	387	1144	1963	497	1654	14096	28175
2013	106	416	1205	2110	539	1736	15048	30131
2014	108	428	1230	2169	555	1823	15482	31052
2015	113	460	1296	2331	601	1914	16529	33213
2016	119	485	1361	2458	639	2010	17427	35081
2017	125	512	1429	2593	679	2111	18374	37057
2018	131	540	1500	2734	722	2216	19373	39146
2019	138	570	1575	2884	768	2327	20427	41355
2020	145	601	1654	3042	816	2443	21538	43692
2021	152	631	1736	3194	857	2566	22615	45972
2022	160	663	1823	3354	900	2694	23746	48375
2023	168	696	1914	3521	945	2828	24933	50906
2024	176	731	2010	3697	992	2970	26179	53573
2025	185	767	2111	3882	1041	3118	27488	56384
2026	194	805	2216	4076	1094	3274	28863	59346
2027	204	846	2327	4280	1148	3438	30306	62468
2028	214	888	2443	4494	1206	3610	31821	65759
2029	225	932	2565	4719	1266	3790	33412	69229
2030	236	979	2694	4955	1329	3980	35083	72887
2031	248	1028	2828	5203	1396	4179	36837	76744
2032	260	1079	2970	5463	1465	4388	38679	80812
2033	273	1133	3118	5736	1539	4607	40613	85102
2034	287	1190	3274	6023	1616	4838	42644	89628
2035	301	1249	3438	6324	1696	5080	44776	94402
2036	316	1312	3610	6640	1781	5334	47015	99440
2037	332	1378	3790	6972	1870	5600	49365	104756
2038	348	1446	3980	7320	1964	5880	51834	110366
2039	366	1519	4179	7686	2062	6174	54425	116287
2040	384	1595	4388	8071	2165	6483	57146	122538
2041	403	1674	4607	8474	2273	6807	60004	129137
2042	424	1758	4838	8898	2387	7147	63004	136106
2043	445	1846	5079	9343	2506	7505	66154	143466
2044	467	1938	5333	9810	2632	7880	69462	151240

In case the concession period is fixed to 29 years, toll rate adjustment will be carried out. Basic toll rate of vehicle mode has been increased to 3%, and FIRR and NPV are found 15.76 % and Rs 2 million, respectively, when the project cost increases by + 15%. Variations of FIRR and NPV at other construction cost variations are presented in Fig. 5 and Fig. 6.

Other variations occur in the worst case when the construction cost increases by 15 % and the traffic decreases by 15%. This is shown in Fig. 7. For the case of variable concession period, the concession period will be adjusted when the actual cost increases by more than 15% of the base cost. There is no need for the adjustment of concession period for other two cases presented in Fig. 7 (base cost case and 85% of the base cost case). Toll rate will be adjusted for the case of fixing the concession period at 29 years. Toll rate adjustment is shown in Fig. 8.

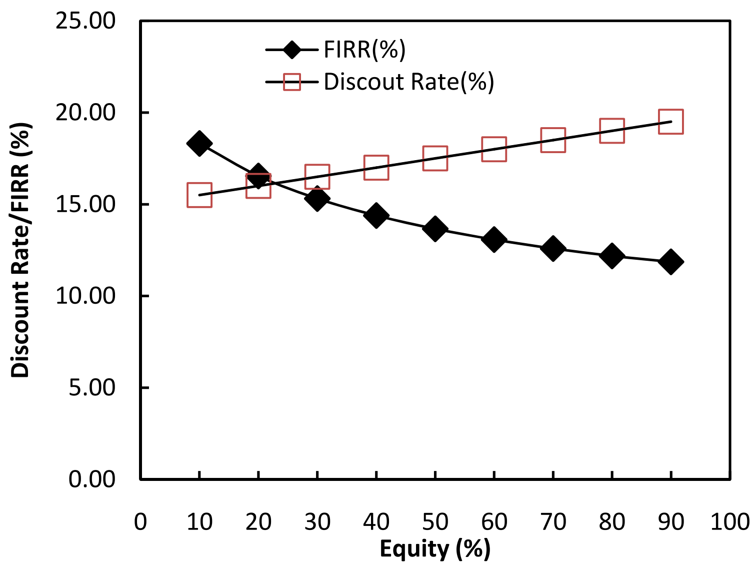

Figure 3: Variation of FIRR and Discount Rate with Varying Equity

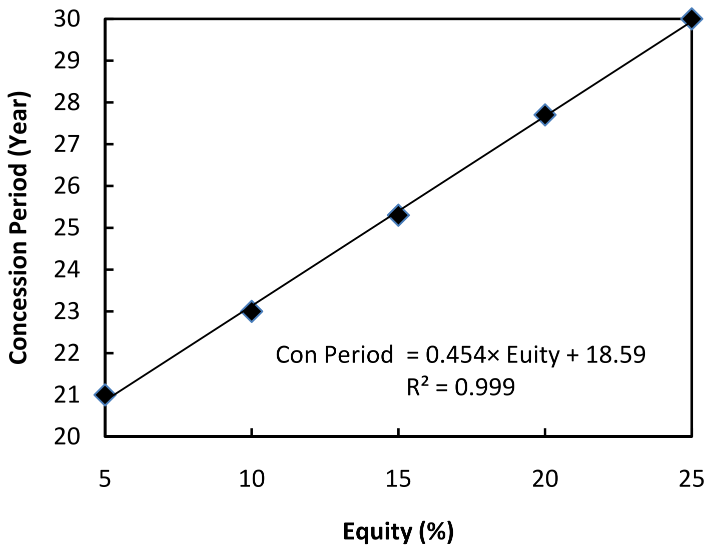

Figure 4: Variation of Concession Period at Discount Rate Equal to FIRR or NPV Zero

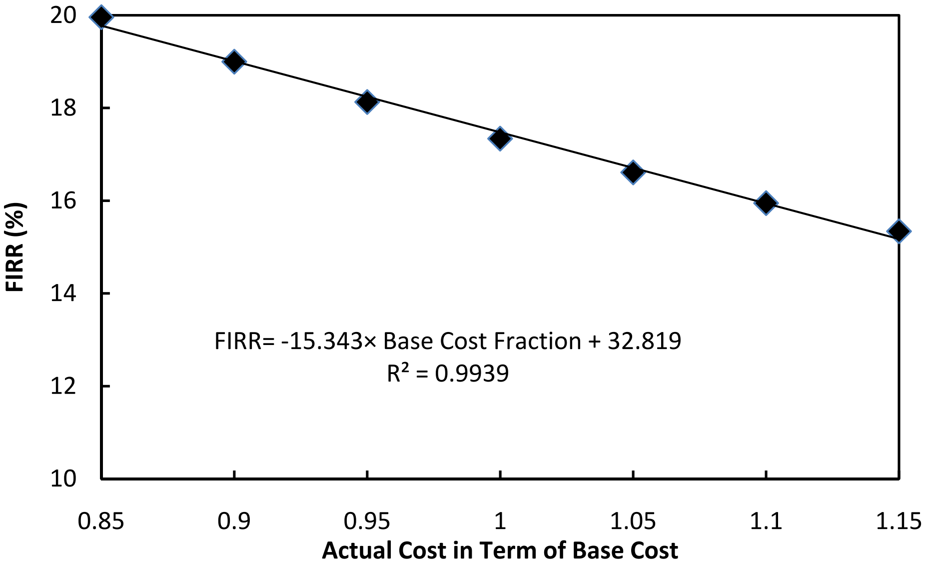

Figure 5: Variation of FIRR at a Concession Period of 29 Years with Varying Cost with Base Traffic

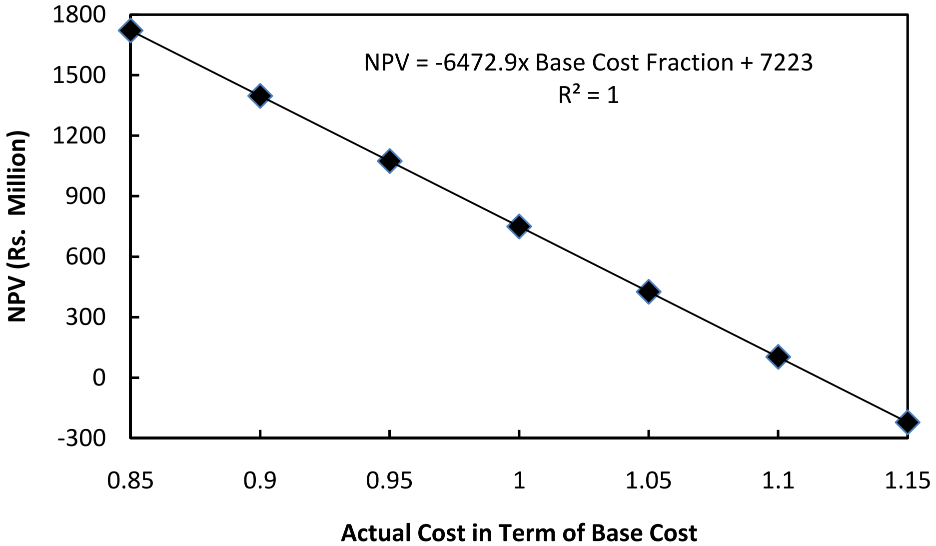

Figure 6: Variation of NPV at a Concession Period of 29 Years with Varying Cost with Base Traffic

Concession Period Based on NPV at 95 % Risk

Concession period will be based on NPV at 95% risk. NPV at 95% risk with different coefficients of variations is found to be Rs 690, 630, 570 and 510 million for coefficients of variation of 0.05, 0.10, 0.15 and 0.20, respectively. Concession periods have been calculated for NPV of Rs 690, 630, 570 and 510 million and concession periods have been tabulated in Table 7 for an adopted equity of 15%.

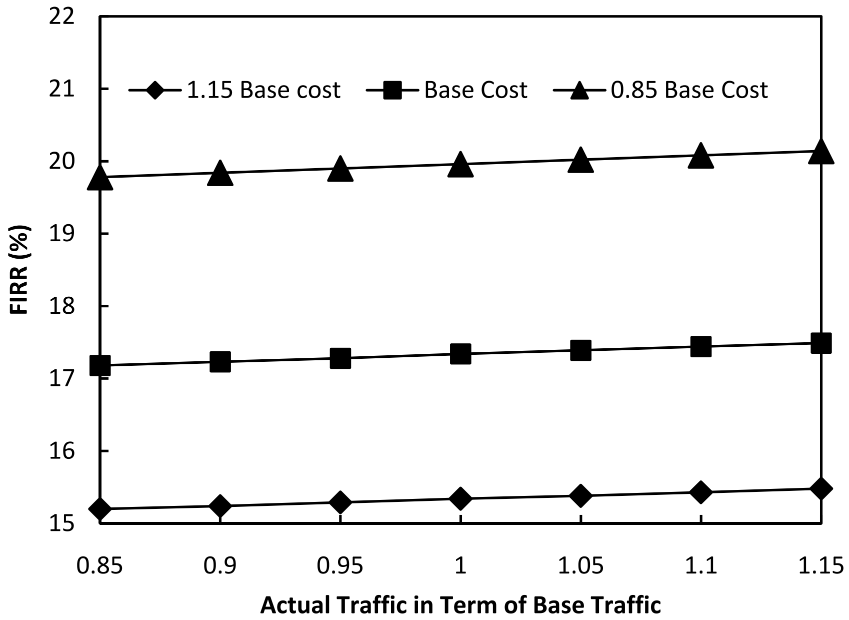

Figure 7: Variation of FIRR at a Concession Period of 29 Years with Varying Traffic and Cost

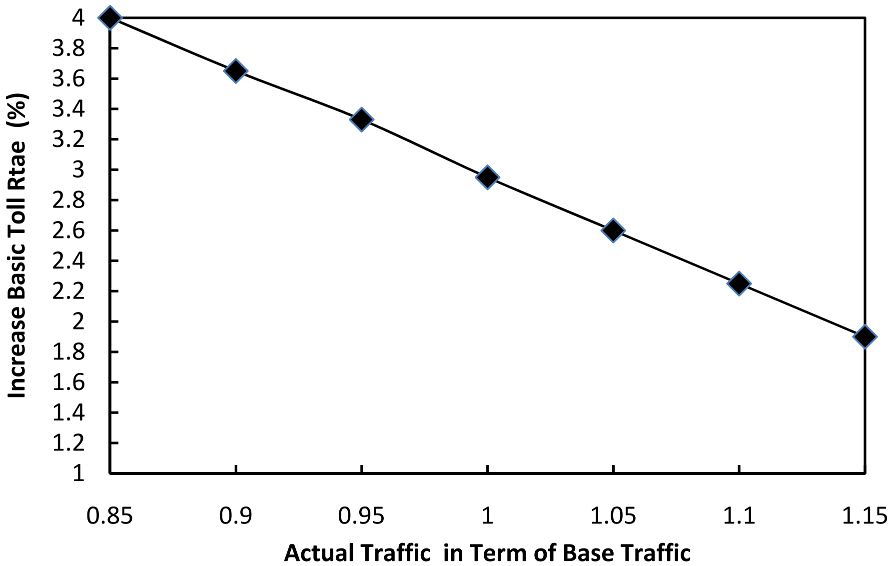

Figure 8: Toll Rate Adjustment

Table 7. Concession Period NPV at 95 % Risk

NPV (Rs million)	Coefficient of Variation	Concession Period (Year)	FIRR (%)
740	0.010	28.94	17.30
720	0.025	28.82	17.15
690	0.050	28.26	17.10
630	0.100	28.13	17.05
570	0.150	27.89	16.95
510	0.200	27.54	16.86

Concession period selected by these methods does not cover the various risks involved in a BOT project. There are several risks in a BOT project. These are: traffic risk and construction cost risk.

MONTE CARLO SIMULATION TECHNIQUE FOR EXPECTED CONCESSION PERIOD

Concession periods obtained using various methods are presented in previous sections. These vary widely. Therefore, the expected concession period has been calculated using Monte Carlo Simulation Technique.

The Monte Carlo Simulation Technique (MCST) is based on the generation of multiple trials to determine the expected values of random variables. The basis of this method is presented by the following relationship:

$$\Pr\left\{\left\{ \frac{1}{N}\sum_{N} \xi - \mu \right\}\frac{3\sigma}{\sqrt{N}} \le \text{ defined value}\right. \quad (1)$$

where

σ = Standard deviation of the random variable;
N = Number of iterations;
ξ = Actual value; and
μ = Average value.

There are numerous commercial packages that run Monte Carlo Simulation; however a basic spreadsheet program can be used to run the simulation. In this case, the generation of multiple trials has been implemented by propagating a basic formula as many times as the number of iterations required by the model.

Expected value has been determined using Monte Carlo Simulation Technique, assuming that an activity has two probable ranges of values (upper limit and lower limit).

The general scheme of Monte Carlo Simulation Technique is as follows:

- Generation of random values of each range of concession periods obtained using various methods as stated above;
- Addition of each series of random variable values to determine the average value; and
- The expected concession period has been obtained as the average value of random values.

Determination of the Number of Iterations

Monte Carlo Simulation Technique provides an estimate of the expected value of random variable and also predicts the estimation error, which is proportional to the number of iterations.

The total error ε is given by:

$$\varepsilon = \frac{3\sigma}{\sqrt{N}} \quad (2)$$

where

σ = Standard deviation of the random variable; and
N = Number of iterations.

An upper bound of standard deviation can be estimated by calculating the standard deviation between maximum, minimum and average values of random variables.

Expected concession period has been determined using Monte Carlo Simulation Technique (with 2 % error). Expected values with probable errors have been calculated and are presented in Table 8.

Table 8. Expected Concession Period

Method	Expected Concession Period (Year)	Error (%)	FIRR (%)
Concession Period at 95% Risk Method	28.25	0.12	17.10
Based on LoS C and LoS D for base case	26.46	1.49	17.45

CONCLUSIONS

The design of concession period not only addresses the relationship between the construction period and the operation period, but also deals with time-overrun risk in project construction. Different concession period structures expose the project company to different levels of completion risk and have different impacts on financial viability. After all, the choice of appropriate period structures and effective incentive schemes is largely based on risk–return trade-off of the contracting parties. A well-designed concession period can create a 'win-win' solution for both project promoter and the host government. Based on the present study, the following conclusions may be drawn:

- Initial concession period may be fixed satisfying that both level of service and time period for NPV are equal to zero condition. This is the maximum concession period. The maximum concession period has been calculated as 29 years and 24 years for levels of services D and C, respectively.
- Concession period may be determined based on NPV at 95% risk varying coefficients of variation from 0.01 to 0.20 or more. Concession period decreases with increasing the coefficient of variation.
- Net present value and financial internal rate of return vary linearly with a negative slope with equity.
- Feasible rage of equity may be determined using FIRR, discount rate *vs.* equity graphs. Maximum limit of equity for this case study has been found 23.2%.
- Maximum concession period at NPV is zero varies with equity linearly with a positive slope according to the equation:
  Concession period= 0.454 ×Equity, $R^2=0.999$
- For the base case, financial internal rate of return increases with increasing base traffic linearly with a positive slope and *vice versa* as shown in Fig.7.
- Project may be viable by adjusting toll rate for the case of increasing project cost / decreasing base traffic or both as shown in Fig.8.
- Expected concession period has been determined using Monte Carlo Simulation Technique, and expected concession periods have been found to be 28.25 years and 26.46 years based on 95 % risk consideration and level of service.

Appendix 1. Different BOT Formats

BOT Format	Description
♦ BOT; Build, Operate and Transfer	A private party or concessionaire retains a concession for a fixed period from a public party, called principal (client), for the development and operation of a public facility. The most important advantages of BOT are: utilization of private sector's investment instead of public sector's investment, transferring all the risk to private sector, transferring technical knowledge as one of the most important benefits of this method for developing countries, in addition to that political resistance in using the private sector is less than in other methods because the project will be owned by the government finally. Disadvantages: These kinds of projects are very complicated from the viewpoint of technical and financial issues and need high-level experts and consultants, increasing expenditures of users in operation time, contrast between benefits of private sector and public sector.
♦ DBFOT; Design, Build, Finance, Operate and Transfer	A contract under the principles of the private finance initiative, whereby the same supplier undertakes the design and construction of an asset and thereafter maintains it for an extended period, often 25 or 30 years. Advantages and disadvantages are similar to those of BOT.
♦ BOOT; Build, Own, Operate and Transfer	Projects of the Build, Own, Operate and Transfer (BOOT) type involve a private developer; financing, building, owning and operating a facility for a specified period. At the expiration of the specified period, the facility is returned to the Government. Advantages: This method could have benefits for public and private sectors, such as: strong financial incentives for the BOOT operator, transferring construction and long-term operating risks onto the BOOT provider, risk mitigation through the involvement of multiple participants, increasing the project certainty and early interest recovering through involving a BOOT operator, encouraging maximum innovation allowing to have the most efficient designs, high accountability for the asset design, construction and service delivery due to recovery of expenditures and enhancing BOOT operators and project management knowledge through experience, minimal costs of company structuring matters.

	Disadvantages: The defects of this model are described as: higher cost for the end user due to the BOOT provider accountability of 100 percent financing and on-going maintenance, negative reaction of community to private sector involvement, not realizable full benefits of economic development, a sole sourced BOOT provider, time consuming and resource hungry management and monitoring of the operating contract with the BOOT operators, requirement of a rigorous selection process in selecting a BOOT partner.
♦ BOO; Build, Own and Operate	The Build, Own and Operate (BOO) project operates similarly to a BOOT project, except that the private sector owns the facility in perpetuity. Advantages and disadvantages are similar to those of a BOT project. Private sector entity will have responsibility for financing and constructing the building or facility and maintaining and servicing it throughout the contract term. It is used mainly for the construction of new buildings.

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