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Estimating the Optimal Time for a Road Concession Contract in Brazil

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Abstract

Brazil has one of the largest road networks managed under concession contracts in the world. The concessions of the Federal Concession Program are divided into three stages. The main aim of this research was to identify critical successful contracts from the Third Stage of the Concession Program. The methodology adopted follows the model proposed by Ng et al. (2007). This model verifies the probability at which the project will be successfully run within the term contract. The results showed a discrepancy between the time contractually agreed and the one simulated by the model for two of the seven contracts signed in the Third Stage of the Concession Program.

Keywords: project analysis, road concessions, project simulation, transport economics

1. Introduction

The hyperinflationary process and the severe crisis that hit Brazil during the 1980s, created the need to redefine the State's role as responsible for the infrastructure investment. This process of change resulted in an increase of the private sector participating in public infrastructure projects. Within this context, during the 1990s the government created a concession program for the federal roads regulated by the Ministry of Transport and the Concession Law. Based on the regulatory framework, offered by the Concession Law, the federal government signed the first road concession contracts. The need to recover and expand the Brazilian road network triggered the concession mechanism whereby the Government gives a private initiative the right to economically exploit a public asset and, in return, the private initiative commits to making the necessary investments. Among the first concessions was the road Presidente Dutra (BR-116), that links the cities of Rio de Janeiro and São Paulo; and the BR-101 road, which runs over the Rio-Niterói bridge. These concessions were part of the first stage of the road concessions in Brazil (Véron & Cellier, 2010).

A new regulatory mark was set up in 2001 when the National Agency for Land Transport (Agência Nacional de Transportes Terrestres - ANTT) was created. In 2006, under the existence of ANTT, the country underwent the second stage of road concessions and the third stage took place in 2013. Currently, Brazil has 120,117 Km of federal roads, of which 10,905.44 Km are managed by private initiatives under concession contracts (ANTT, 2017).

However, private concessions are only possible when the project is economically sustainable and its operation allows for projecting the financial return by the investor, within the time frame set by the concession contract (Queiroz & Izaguine, 2009). For the private investor, signing a concession contract for a road involves risks. On one hand, the revenue comes from toll payments paid by road users, which is uncertain given the demand variation. On the other hand, the concessionaire undertakes investment commitments that may be higher than those foreseen by the contract, for example, due to changes in economic conditions, which could increase operational costs. Summarizing, the concessionaire companies take the market risk.

As would be expected, the first phases of the concession offered the roads that were considered the most profitable and had the lowest risks. Given the reduction on the stock of the most profitable roads, the next stages offered projects of public interest but with a lower expectation of gains and consequently, higher risks. For example, if the expectations about increase on demands of the road are too optimistic, this can create a false expectation for a viable and economically profitable project. However, if after signing the concession contract there is confirmation that the project is unviable, the probability for a contract renegotiation increases. A foreseen perception that the contract is vulnerable to future renegotiations may encourage groups of investors to participate in road concession biddings who see, in the financial fragility of the concession contract, a possibility for future gains in an opportunistic renegotiation of the contract (Guasch et al., 2008).

Due to the economic importance of having an adequate infrastructure, and also taking into account that transport in Brazil is mostly by road, the aim of this research is to identify road concession projects of the third stage of the Brazilian concessions which may be fragile with regards to their ability to return the planned investment within the contractual term.

Considering this, the aim of this study is to estimate the optimum time for each contract for projects from the Third Stage of the Brazilian Road Concession Program, calibrating them with data obtained from the winning companies of this stage and from the National Agency for Land Transport (ANTT). In addition to the companies analyzed, the methodology was also applied to a representative company, containing the average of the sector, together with the amount invested considering the average per km of the companies.

In order to perform such a task, the calculations were made using the simulation model proposed by Ng et al. (2007), which verifies the probability at which the project will be successfully run within the term contract. The simulations indicated, for at least two of the concession contracts, a high risk for the companies failing to comply with the expected investment. This result contributes to the need of reassessing the model used for road concessions in Brazil.

Thus, the work is divided as follows: this introduction, the characterization of the road concessions in Brazil, the methodology used to develop the simulations, the results and their respective discussion and the final considerations.

2. Method

The concession of roads to private companies is a recurring practice in many countries around the world. According to Galilea and Medda (2010), Carpintero and Barcham (2012) and Beria et al. (2015), the beginning of the road concession process started during the 1990s, whereby private companies were conceded to manage some roads, mainly in Latin America and Central and Eastern Europe. Later on, at the end of the 1990s and the beginning of the 2000s. There were also some concessions in Asia, North America and Western Europe.

In Latin America, the alternative of conceding roads became a possibility as some governments started to have more difficulties in continuing to make infrastructure investments at the same level as those in previous decades, even considering that the institutional apparatus of each country continued needing to evolve to reach more suitable levels and, therefore, reduce the likelihood and frequency of contractual renegotiations (Guasch et al., 2008).

After the 1980s, Brazil went through periods of very high inflation, low growth, and widely diverse economic measures to try to restrain the increase in inflation. There was a significant drop in investment in various areas and the same occurred with the infrastructure sector. The average annual investment in the sector fell from 5.2% in the 1980s to 2.1% of the GDP (Gross Domestic Product) in the early 2000s, causing the downfall of the country’s road system. In addition to the fact that roads in Brazil account for for transporting most of the cargo (61%) in Brazil, it is clear that inadequate infrastructure is one of the obstacles for the country’s development (CNT, 2011).

The Brazilian Federal Road Concession Program began to be implemented in 1995 with the bidding of six stretches of road that were operating under the toll system that was implemented directly by the Ministry of Transport. A total length of 1,482.4 Km of roads was conceded, with terms varying from 20 to 27 years (ANTT, 2011). This first bid became a milestone in the Brazilian transition from a model of Producer State, in the infrastructure sectors, to a Regulatory State model. From 2007 to 2008, the second stage of the concession program was launched, with the bidding of more than 3,281 Km of roads, for a concession period of 25 years. Finally, in 2013 the federal concession program initiated the third stage by bidding 3,873 Km of roads.

For all concession contracts signed, the winning bids were those who offered the lowest charge for the toll. The economic-financial balance of the contracts was regulated by the Internal Rate of Return (IRR), established by the ANTT at the time of the bidding contract. The Brazilian government opted, therefore, for a roads concession model whereby the IRR was imposed by the agency itself. The contracts foresaw an annual readjustment of the basic toll according to the inflation variation.

It should be observed that at the time of the first concessions, Brazil was still going through a period of economic instability, with a history of high inflation and high regulatory risk generated by recent legislation and, the regulator was associated with the central federal government. These factors were responsible for the first stage to be marked by high rates of return, ranging from 18% to 25% per year, (Amann et al., 2016).

In spite of the the ANTT being created in 2001, it was only in 2005 that the agency started to carry out studies about the stretches of road to be bid. Therefore, according to Barbo et al. (2010), in 2006 the government announced seven stretches of road included in the second stage. At the time of the second stage, the economic situation in Brazil was more stable than for the first stage, with a better perspective for growth, lower interest rates, inflation under control, and a Country Risk at a lower level than in the 1990s. The issue of the sector regulation was strengthened, as the aim was to improve its mechanisms to ensure the quality of the services provided (Ribeiro & Meyer, 2006). The evolution of the regulatory sector was important to draw up new contracts, aiming to reach greater efficiency so that it could benefit both public power and private initiative, allowing greater benefits to the consumer.

It is worth highlighting that after the first stage of concessions, the concept of concession, rather than public work, became consolidated in the contracts, replacing, therefore, unit prices for global ones so that the concessionaire could better allocate the assumed risks. Apart from strengthening the concept of concession instead of public work, there was an increase in the number of companies interested in operating in the sector, helping to keep the global tariffs at levels below those for the first stage (Amann et al., 2016). Another interesting point was that international companies were allowed to participate in the biddings (Véron & Cellier, 2010). The contracts of the second stage of the concession established an IRR of 8.5% per year.

In addition to the lowest offer, the technical competence of the company in question, was analyzed, aiming to reduce the risk of opportunistic behavior and, as a consequence, reduce the frequency of eventual contractual renegotiations, since preliminary technical studies had to be in accordance with expectations close to reality. However, there was still no use of the risk matrix, besides the little incentive to use other revenues as a way to obtain reasonable tariffs (Carpintero & Barcham, 2012).

In 2013, the first public notices for the third stage of the concession program were announced. This phase took place in three stages, for a total length of 7,313.3 km of conceded roads (ANTT, 2016). This is shown in Table A1.

In addition to the previous stages, in the third stage of concessions, there was an improvement in the incorporation of Factor X, an instrument used for the concessionaire company to seek efficient operation so that the productivity gains of the companies could be absorbed, as well as replacing the revenue fee, based on the Long-Term Interest Rate and inflation, by a fee based on the Weighted Average Cost of Capital (WACC) methodology (Ribeiro & Meyer, 2006). Furthermore, these changes signaled the adoption of a price-cap regulatory system. During this stage, ANTT indicated, in the concession contracts, an IRR of 7.2% per year.

As mentioned previously, long-term execution projects are naturally more uncertain due to the inherent difficulty in constructing reasonable scenarios for extended deadlines. Zhang and Cohen (2012) designed a game theory model, which states that proactive governments, in contrast to reactive governments, tend to achieve more success in long-term projects, in view of the project’s cost structure. Differently from the previous stages of the concession program, most contracts from the third stage were signed for a period of 30 years, with the possibility of being extended for the same period, depending on certain conditions.

3. Simulation Model

The concern about possible economic-financial imbalances of the federal concessions contracts is not a new issue, but is rather under constant debate. For the Brazilian case, Paranaíba et al. (2016) report that the projections made for the traffic flow may have spurious results, causing occasionally opportunistic behavior from the winning bids. Bonnafous (2010) presents a theoretical discussion and a numerical simulation on the consequences resulting from a reduction in the IRR for the case for planning the optimal price for concession contracts in the French case. The author highlights two points: i) an IRR that does not pay back the market risk, and the regulatory risk causes the need for public subsidies to rebalance the financial balance of the contract. This may be an undesirable scenario, from the social welfare point of view, if this occurs in an economic crisis with scarcity of public resources; ii) a reduction in the IRR increases the number of potential projects to be disputed in the concession contract since now the current net value is now positive for a group of projects that were not economically viable at the previous rate. This result increases the need for an adequate successful feasibility analysis for the projects presented, aiming to avoid projects with a high likelihood of failure.

Due to the uncertainties of long-term projects, the longer the contract time, the more difficult it is to forecast.

According to Malini (1999), Ng et al. (2007) and Ng and Xie (2008), a commonly used approach is the Monte Carlo simulation, given that due to the uncertainties of this type of project it is possible to perform plausible scenarios with relatively low computational costs. Simulations, using the Monte Carlo simulation, bring with them a random component, to try to estimate how the project can behave over time, not just using linear variations in the models.

Within this scope, and as the aim is to optimize the term of a concession under the PPP (Public Private Partnership) modality, Ng et al. (2007) proposed a simulation model of a contract using an approach for economic viability of projects. In the simulation model proposed by the authors, the concession term is an output, rather than an input parameter. Once the investor has obtained the desired gains, this variable is of the utmost importance for stipulating a reasonable tariff regime and the IRR. When these observations are included in the model, each cycle can be calculated according to the structure of the simulated costs and revenue. With a large enough number of iterations, we can construct an empirical cumulative probability distribution curve related to the predetermined concession period and this information can serve as an instrument for decision making. Figure B1 shows the simulation algorithm proposed by the researchers.

3.1 The Model Parameters

The simulation model to be executed has a number of parameters that provide the initial calibration. The three main ones are described below:

Maintenance Period (Mc): refers to the term contract, starting from the operationalization and maintenance time, since it is assumed that, in principle, the roads already exist. The term may not be precise, as delays can occur due to uncertainties inherent to projects;

Discount rate: is the minimum rate established by the investor so that the project is economically viable. The discount rate is the IRR that makes the NPV equal to zero, in the company's cash flow. Moreover, due to the uncertainties inherent to projects and in order to execute the project, the investor uses a minimum rate of return. However, as the aim of the company is to maximize profits and, as a consequence, minimize costs, a rate of return, which can be considered the ideal during the term contract, may be set by the company;

Tariff regime: this can be set based on data from similar projects, or according to the value the user would be willing to pay for the toll service, in addition to vehicle traffic estimates.

In addition to the basic parameters, the model can also consider, for example, the existence of inflation for the analysis period, since this is a natural characteristic of the economy. The parameters that suffer from the influence of economic or financial phenomena are listed below:

Annual cost in t (C_t): the total cost of the project is taken into consideration; that is, costs for the project design, operationalization, management, maintenance, personnel, among others. It is important to identify those factors with a higher potential risk, establishing an empirical relation or an adopted distribution for each risk factor identified, as well as examining the impact of these factors on the total cost of the project;

Operational revenue in t (R_t): the revenue of this kind of contract is generated when the final consumer uses the service provided and; it is represented by the number of users and the established tariff regime. While the tariff regime is a deterministic parameter, the number of users can vary according to: the economic development level of the place where the toll is installed, the willingness of the user to pay for it, the existence of alternative routes, etc;

Income in t (I_t): the annual income in the operational period is represented by the difference between revenue and total cost for that year.

After considering the deterministic and stochastic part of the model proposed by Ng et al. (2007), some hypothesis have to be considered for the execution of the model. The first of them is that the investment schedule should follow the proportion of: 10%, 20%, 30%, 20% and 20% for the first five years, starting at the second year of the contract. For the sake of simplicity, it is assumed that there is a period of five years called Construction, which is dedicated to restoration work, road maintenance, etc over 5 years. Additionally, it is assumed that the economy presents an average inflation (Note 1) of 5%, with a standard deviation of 20%. The volume of traffic also presents an increase (or decrease) based on a standard deviation of 20%.

4. Results and Discussion

Initially, a simulation was carried out for each of the seven stretches of road contracted in the Third Stage (Stages: I, II and III) of the Federal Road Concession Program, which were calculated separately. Afterwards, a simulation with a representative company of the sector was carried out, using as a basis the average of the sector;

the investment value to be entered as a parameter was calculated from the average of the length of the stretch of road and the average invested per km. The flow for a period of twelve months for each kind of vehicle was considered. The basic tariff was also considered for each kind of vehicle.

However, as there was no information concerning specifically the flow of buses for all the companies, a weighted average was calculated between the flow and the tariff charged to trucks and buses so that the initial average flow of cars, heavy vehicles (trucks and buses) and motorcycles were put in the model.

Therefore, the focus of the simulations were the contracts from the Third Stage of the Road Concession Program for those stretches of road that had contracts already signed and already operating regularly. Table A2 shows the starting date for each contract signed for the Third Stage of the Road Concession Program.

To carry out the simulation for each contract, the following parameters were used: traffic flow, operational costs, average tariff for each kind of vehicle and an annual growth rate of the flow as informed by the winning bids of the concession in their respective contract projects. To calibrate the model, the total value, as informed by the company, was divided by the contractual term. For the revenue, using the information concerning the flow for twelve months, a projection was made for the 30 years by applying an X growth/interest rate and then dividing by 30 to obtain the average. Following Technical Report nº 318/2013/STN/SEAE/MF, the IRR indicated for the Third Stage of the Road Concession Program was 7.2%, which will be used as the initial reference in the calculations. The parameters, operational costs and growth of traffic flow, are shown in Table A3.

The results obtained show that three concession contracts have a probability above 90% for recovering the investment expected within the term of the concession. Company II would have its investment project paid in 22 years, with a NPV of R$16,8872 million. Company III showed a NPV of R$6,9037 million from the simulation, therefore its project becomes viable in 29 years. Finally, the project of Company VII could be paid back in the 27th year of the contract, with a NPV of R$3,5993 million. With an IRR of 7.2%, the probability of the project being viable is now 91.7%.

Two companies presented a probability of success between 80% and 89%. For Company IV, there was a probability of 80% for the project to become viable in the 27th year of the contract, whereas for Company V the probability was 89%, and its project was paid back in the last year of concession.

In these simulations, companies I and VI did not obtain results considered satisfactory. For both, the algorithm did not converge to a period of time in which the NPV would be positive, generating the value zero for the success of the project within the term expected by the stretch of road concession public notice. There are two possibilities for the unfeasibility of these projects: either their operational cost is too high, or the expected traffic flow growth is too low. Table A4 shows new specific simulations for these companies when changing the operational cost and the expected traffic flow growth.

For Company I, maintaining the operational cost at the original value of 16.85% requires the concession project to have a success probability above 80% only with a projection for traffic flow growth starting at 6.4% per year. This projection represents an increase of 4.4 percentage points (or 166%) in relation to the projection made by the company at the time of planning the viability of the concession project. Even for this case, the average time estimated to pay back the investment would be 39 years. This result would imply in the need for renegotiating the concession contract with the federal government giving a longer period for the companies to carry out the works foreseen in the public notice.

The simulation for Company VI shows results which are even more difficult for projecting the viability of success of the road concession project. This company, at the time of drawing up its economic feasibility project, projected a growth of 2.5% on traffic flow and an operational cost of 25.41% of the revenue. The simulations carried out indicate that probabilities of success above 90% can only be achieved by reducing the operational cost projection and increasing the projection of the traffic flow. Nevertheless, given the parameters considered here, the gap between the time signed in the contract and the time considered "optimum" is still maintained.

These results may be due to poor management or contractual planning, or an agency problem in the call for tenders process to fill the vacancies for the project operationalization. In other words, it can be concluded that there is room for opportunistic behavior that can lead to contractual renegotiations, entailing additional costs for the taxpayer[2].

5. Final Considerations

Given the need to expand the road network, one of the instruments used by the Brazilian government was the regulatory mark concerning the Concession Law. Within this context, the aim of this article was to estimate the optimal contract time for each project from the Third Stage of the Brazilian Road Concessions. To do this, the simulation model proposed by Ng et al. (2007) was used, together with data provided by the companies involved and also by the National Agency for Land Transport (ANTT).

Road concession contracts are characterized by being long term and are, therefore, subject to the occurrence of different unforeseen events during the negotiation phase. Thus, bidding with a wide range of competition from different national and international groups of investors helps to obtain projects that are efficient and economically viable. The Brazilian government opted to fix the IRR on the bidding for concession from the Third Stage of the Brazilian Road Concessions. The previous analysis that the IRR would not pay the investment properly could drive away good companies from the sector, while at the same time attract opportunistic investors that see the financial vulnerability of the project as a possibility for future gains in an inevitable contract renegotiation. To some extent, the simulations carried out in this study demonstrated that the Brazilian road concessions were implemented based on a model that is fragile in obtaining economically viable projects.

Although the simulation model has some limitations, the algorithm shows differences between the term signed in the contract and the expected term obtained by using the data provided by the companies. Intuitively, this result point out a possible problem in the regulation of these contracts, despite the evolution of the sector as a whole. Thus, an evolution in road regulations is necessary, making rules clearer, so that highly qualified companies can participate and compete in tenders, therefore preventing future opportunistic behavior. Moreover, it would be interesting for ANTT to provide more flexibility concerning the IRRs, which would possibly increase competition among companies interested in participating in concession contracts.

Finally, as future work, we suggest the possibility of building more sophisticated models, which could include other parameters concerning, for example, the companies themselves, as well as other economic factors. This could make the dynamics even more realistic and, as a consequence, provide a more accurate analysis.

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Notes

Note 1. http://www.ipeadata.gov.br - Average rate of inflation of the Brazilian economy for the period 2002-2012. For additional information please see at: http://www.ipeadata.gov.br

Note 2. The possibility for renegotiating the concession terms has already appeared in the news. For example, the newspaper "Estado de São Paulo", in a report on June 6th, 2017 announced that the federal government intends to extend the terms contracts for road concessions for another twelve years. Among the stretches of road mentioned are Company I and Company VI. Please refer to: http://economia.estadao.com.br/noticias/geral,medida-provisoria-pode-alongar-prazo-de-concessoes-de-rodovias,70001827528

Appendix A

Table A1. Third stage of the federal road concession program

PHASE I		
Roads	Stretch	Length (km)
BR-040/DF/GO/MG (Via 040)	Brasília - Juiz de Fora	936.8
BR-116/MG	Além Paraíba - Divisa Alegre*	816.7
TOTAL		1,753.5
PHASE II		
Road	Stretch	Length (km)
BR-101/ES/BA (Eco101)	Border RJ/ES States – Mucuri	475,9
PHASE III		
Roads	Stretches	Length (km)
BR-101/BA	Mucuri - Feira de Santana*	772.3
BR-050/GO/MG (MGO Rodovias)	Road junction with BR-040/GO – Border MG/SP States	436.6
BR-262/ES/MG	Viana – Monlevade*	375.6
BR-153/TO/GO (Galvão Rodovias)	Aliança do Tocantins – Anápolis	624.8
BR-060/153/262/DF/GO/MG (Concebra)	BR-060, From exit of BR-251 (DF) up to exit of BR-153/GO; BR-153, exit to BR-060/GO up to exit of Br-262/MG; BR-262, exit of-153/MG up to exit of BR-381 (Betim)	1176.5
BR-163/MS (MSVia)	Border MT/MS States – Border MS/PR States	847.2
BR-163/MT (CRO (Rota do Oeste))	Sinop - Border MT/MS States	850.9
TOTAL		5,083.9

Source: ANTT, 2016; EPL, 2016. Stretches with (*): stretches that are part of this phase of concessions but no concession contract was signed.

Table A2. Stretches of road conceded and analyzed from Third stage

Company Identification	Company	Term Contract (years)	Date of signature	Concession Starting Date	Toll payment Starting Date
I	Via 040	30	03/12/2014	04/22/2014	07/30/2015
II	Eco101	25	04/17/2013	08/10/2013	05/18/2014
III	MGO Rodovias	30	12/05/2013	01/08/2014	04/12/2015
IV	Galvão	30	09/12/2014	10/31/2014	03/2015
V	Concebra	30	01/31/2014	03/05/2014	06/07/2016
VI	MSVia	30	03/12/2014	04/11/2014	05/14/2015
VII	CRO	30	03/12/2014	03/21/2014	09/06/2015

Source: companies' websites and ANTT (2016).

Table A3. Parameters for operational costs and traffic flow growth, based on technical studies for each stretch of road

Company	Operational Cost (%)	Growth of Traffic Flow (%)	Total Traffic Flow (millions)	Term Contract (years)	Time for NPV ≥ 0	NPV	Probability of Success
I	16.85	2.40	30.074	30	--	--	-
II	14.00	4.00	27.094	25	22	16.8872	0.932
III	21.20	3.70	20.568	30	29	6.9037	0.957
IV	16.00	2.40	31.256	30	27	18.4094	0.800
V	14.44	3.32	57.998	30	30	5.2958	0.890
VI	25.41	2.50	17.245	30	--	--	--
VII	15.82	2.74	30.194	30	27	3.5993	0.917

Source: ANTT, 2016.

Table A4. Simulations in the parameters of Company I and Company VI

Company I (Term contract: 30 years)				Company VI (Term contract: 30 years)			
Operational Cost (%)	Traffic flow growth (%)	Time for NPV ≥0	Probability	Operational Cost (%)	Traffic flow growth (%)	Time for NPV ≥0	Probability
12.85	3.4%	--	0.250	17.41	3.5%	--	0.000
14.85	3.4%	--	0.200	21.41	3.5%	--	0.000
16.85	3.4%	--	0.100	25.41	3.5%	--	0.000
12.85	4.4%	82	0.508	17.41	4.5%	--	0.160
14.85	4.4%	--	0.406	21.41	4.5%	--	0.133
16.85	4.4%	--	0.336	25.41	4.5%	--	0.066
12.85	5.4%	45	0.720	17.41	5.5%	63	0.376
14.85	5.4%	47	0.662	21.41	5.5%	79	0.304
16.85	5.4%	50	0.614	25.41	5.5%	--	0.178
12.85	6.4%	37	0.886	17,41	6.5%	44	0.688
14.85	6.4%	38	0.842	21.41	6.5%	48	0.566
16.85	6.4%	39	0.820	25.41	6.5%	53	0.432
12.85	7.4%	32	0.974	17.41	7.5%	37	0.838
14.85	7.4%	33	0.952	21.41	7.5%	39	0.784
16.85	7.4%	34	0.930	25.41	7.5%	42	0.694
-	-	-	-	17.41	8.5%	33	0.944
-	-	-	-	21.41	8.5%	34	0.918
-	-	-	-	25.41	8.5%	36	0.848
-	-	-	-	17.41	9.5%	30	0.988
-	-	-	-	21.41	9.5%	31	0.974
-	-	-	-	25.41	9,5%	31	0.958

Source: Designed by the authors.

Appendix B

Figure B1. Simulation diagram to determine the concession term

Step 1	The simulation cycle is initiated, (total of 1000 replicas) given $t = 0$ and $NPV = 0$.
Step 2	Given $t = t + 1$. 1. The initial parameters of the contract are entered. 2. The random number of a normal distribution, for determining the risk values, is generated. 3. The (initial) cost for the year t, Ct, is calculated, or determined, according to the risk values generated in the previous step. 4. C_t is discounted in order to calculate the NPV using the expected rate of return.
Step 3	Do we have $t = T_c$? If Yes, go to Step 4. Otherwise, return to Step 2.
Step 4	Given $t = t + 1$ 1. The random number of a normal distribution, for determining the risk values, is generated. 2. The (initial) cost for the year t, Ct, is calculated, or determined, according to the risk values generated in the previous step. 3. C_t is discounted in order to calculate the NPV using the expected rate of return
Step 5	Random number of a normal distribution is generated for determining the number of users for year t; Tariff regime x number of users => Operational Revenue, Rt.
Step 6	1. The income for year t is calculated: $I_t = R_t – C_t$. 2. I_t is discounted in order to calculate the NPV using the expected rate of return.
Step 7	Is $NPV \geq 0$? If Yes, go to Step 8. Otherwise, return to Step 4, the operation is repeated until at least one $NPV \geq 0$ is obtained; only then it can be proceeded to Step 8.
Step 8	The concession term is t.
Step 9	The cycle is ended.

Source: Adapted from Ng et al. (2007).

Note. The simulations were carried out using the statistical software *R* (*R Core Team*, 2015).