Assessment of Risk Sharing Mechanisms in Road Concessions

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Abstract

At the end of 2022, Brazil's National Land Transport Agency (ANTT) launched a public hearing on the proposal for a new risk allocation model in road infrastructure concession contracts. This study illustrates, using the real options methodology, how the proposed design modifies the concession's risk-return structures and influences the investment decision in the concession and the expected value of the upside risk sharing mechanism (cap) and downside (floor). Our analysis allows the granting authority to calculate the trade-off between the establishment of cap and floor bands, flexibility of Capex triggers (anticipation of the start of the risk sharing mechanism) and potential tariff discounts. The study shows that there is an optimal frontier of efficient portfolios (bands x triggers) that maintains the same risk-return structure and, consequently, discounts. In this sense, the granting power can allocate itself wherever it most desires depending on the concession object, which can be useful for analyzing regulatory impacts caused by this mechanism. This research contributes to the literature on the applications of real options in infrastructure projects, showing how the clauses governing managerial flexibilities in contracts must be carefully designed to achieve the objectives of the government and the private investor.

Keywords: risk sharing mechanism, guarantee, cap and floor, road concessions, Brazil.

1. Introduction

Road concession projects involve various uncertainties, whether in capital and construction expenses, in projecting demand for extended periods (normally around 30 years); in the temporal profile of revenues – separated from expenses, among others specific to the sector (environmental, expropriation, etc.). It represents a sector known for giving rise to a large number of incidents in contract renegotiations[3].

Currently, of the approximately 13 thousand km of federal road network managed through concessions within the scope of the National Land Transport Agency (ANTT)[4], practically a third have problems with works that have been suspended for years, in the process of return or re-tendering, in particular, those carried out in the third stage of the federal highway concession program (Procrofe) in 2013/2014, whose demand estimates were frustrated, following the economic crisis of 2014/2016.

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[3] See Guasch et al. (2014).
[4] Agency responsible for regulating railway and road infrastructure and providing land transport services. Details in: https://www.gov.br/antt/pt-br/assuntos/rodovias/informacoes-gerais

It is a consensus that countless interpretative divergences and uncertainties about the risk matrix have consistently generated several judicial, arbitration and administrative conflicts, especially at each review, where different requests for restoration of economic-financial balance are required. As a way to address this issue, ANTT launched, at the end of 2022, Public Hearing 013/2022, proposing a new risk allocation model in road infrastructure concessions (ANTT, 2022). The initiative is essential given that the sector concentrates the biggest investment bottlenecks in infrastructure in Brazil (1.8% GDP per year, according to Raiser et al., 2017) with investments estimated by Novo PAC at R$ 186 billion for the coming years[5].

Several improvements were addressed in the proposal. With regard to sharing the demand risk, it proposed symmetrical guarantee bands, of +15% and -15% of expected revenue, between the concessionaire and the granting authority, starting from the second year and conditioned on the execution of at least 90 % of investment obligations. Equally innovative propositions are separating the impact of specific risks on revenues (demand) and costs (inputs, exchange rate); the classification of risks by themes (environmental, management, engineering, etc.); the expansion of shared risks (environmental, expropriations, etc.); and consideration of residual risks (impact on costs).

The proposed design focuses on the contract's risk matrix which, combined with the traditional pillars of charges (investment obligations) and service remuneration (toll revenue), is increasingly seen as a fundamental part of the concession's financial balance. This initiative improves predictability in the distribution of risks between the parties, contributing to better governance, efficiency and legal security of the contract, and establishing adequate economic incentives between the public and private sectors. Furthermore, it enhances the participation of fresh players in bidding by improving access to financing options, including the non-recourse project financing model[6].

Based on the experience in the three stages of the Federal Highway Concessions Program, started in the mid-1990s, we can understand how the risk sharing mechanism emerged. Initially, the projects did not incorporate risk matrix concepts. During the second stage (2007/2008), they were gradually treated in a generic and succinct way with the incorporation of investment triggers linked to demand. More details of these concepts were given from the third (2013/2014) and fourth stages (2018). Furthermore, at all stages, the demand risk was (almost) entirely attributed to the concessionaire. As a consequence, several judicial, arbitration and administrative conflicts occurred, especially during annual reviews.

The need for a predictable and efficient risk allocation matrix is part of the structural recommendations for Infrastructure Governance – OCDE [7] or in order to reduce the incidence of recurring renegotiations according to Guasch (2004)[8]. In the literature, it is recommended that the risk be allocated to the party that has the lowest cost to absorb the unwanted event and that best mitigates or manages its consequences. Given that around R$ 27.2 billion will be invested per year

[5] See https://www.gov.br/casacivil/pt-br/novopac/transporte-eficiente-e-sustentavel/rodovias
[6] The New Bidding Law itself (14,133/2021) highlights the risk matrix as a contractual clause that defines risks and responsibilities between the parties and characterizes the initial economic-financial balance of the concession contract.
[7] See https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0460
[8] Other recommendations emphasize the role of regulatory quality, appropriate institutions, auction models with higher grants to the detriment of lower tariffs (associated with opportunistic bidding), better structuring studies, among others.

until 2030 and the Brazilian State has fiscal restrictions, there is a need to increasingly attract private participation in infrastructure projects (CIP-INFRA, 2021; ABDIB, 2022).

For the public policy maker (principal), it is essential to understand how such initiatives impact and condition the behavior of concessionaires (agents) in the face of uncertainty. Such mechanisms, as well as incentive policies, subsidies and guarantees given to projects, affect the risk-return profile and, therefore, must be evaluated under the Real Options Approach (ROA), providing better treatment of levels of uncertainty and project management flexibility (Dixit & Pindyck, 1994; Trigeorgis, 1996).

Some academic works have already used ROA to evaluate the mechanism called Minimum Demand Guarantee (MRG), in which the granting authority undertakes to compensate the concessionaire if revenue falls below a pre-established level (Rocha Armada, Pereira, & Rodrigues, 2012; Song, Yu, Jin and Feng, 2018). Others have used ROA to analyze the revenue/demand risk sharing tool called cap & floor (Vasudevan, Prakash, & Sahu, 2018). These two forms of risk mitigation have been used in infrastructure concession contracts in several countries, such as Brazil (Brandão, Bastian-Pinto, Gomes, & Labes, 2012), China (Zhang, Li, Li, & Zhang, 2021) and India (Iyer & Sagheer, 2011).

In this sense, this study illustrates, through a real options model, how the parameters defined in the risk sharing proposed in Public Hearing 013/2022 modify the attractiveness of the concession and the concessionaire's behavior. Furthermore, it allows understanding how the proposed design can impact the investment decision in the concession and the expected value of sharing the upside (cap, ceiling) and downside (floor) risks. We estimate how small variations in the values of the triggers that condition the beginning of sharing impact both the attractiveness of the concession and the amount to be disbursed or appropriated by the granting authority. We also analyze how these mechanisms can provide tariff discounts and reallocation of guarantees based on risk-return metrics.

The study differentiates itself by quantifying the potential tariff discount that can be provided by the cap and floor mechanism and by the flexibility of Capex triggers (earlier start of bands). Furthermore, we show that there is an optimal frontier of efficient portfolios (bands x triggers) that allow maintaining the same risk-return structure. With this, the granting power can allocate itself wherever it most desires depending on the concession object, calculating this trade-off between establishing bands and making triggers more flexible.

After this introduction, we present a literature review on the topics: road concessions, application of the real options approach in these types of projects and risk metrics. In section three, we develop a real options model to evaluate the impact of the risk sharing mechanism. Then, in section four we present a numerical application and in section 5 we discuss the results. The conclusions of the study are presented in section 6. An Appendix is intended for further discussions and proposed variations on the analyzed model.

2. Literature Review

2.1. Road Concessions

Infrastructure projects are characterized by long maturity periods, high capital investments and high uncertainty that create significant risks and can make obtaining financing difficult. In Brazilian road concessions, the demand risk, seen as one of the main risks in this type of project, has always been allocated, totally or almost entirely, to the concessionaire. However, this design does not prove to be more efficient since most of the demand risk is beyond the control of the private agent.

In this sense, since 2019, ANTT has been studying best practices for road concessions regarding the issue of demand risk sharing. The most recent initiative took place at the end of 2022, when ANTT launched Public Hearing 013/2022 to collect suggestions and contributions with regard to the new proposed risk allocation model, thus allowing the construction of a new contractual model of governance of risks in road infrastructure concession contracts (ANTT, 2022).

In this Public Hearing, ANTT investigated a set of innovations already promoted in the risk matrices of contracts signed from 2019 to 2022 (ANTT, 2022). For example, the risk sharing initiative related to maintenance works and service level was promoted in contracts BR-101/290/386/448/RS, BR-364/365/MG/GO and BR-101/SC. The exchange rate protection mechanism was promoted in contracts BR-116/101/SP/RJ, BR-116/465/493/RJ/MG and BR-040/495/MG/RJ. In the latter, mechanisms for mitigating revenue risks and sharing risks related to environmental license conditions were also promoted.

The use of mechanisms such as these seeks to make investments in road concessions more attractive to private agents. Other forms of risk mitigation in infrastructure projects have been applied in practice and discussed in the literature. One of them is the MRG, in which the granting authority undertakes to compensate the concessionaire if revenue falls below a pre-established level (Rocha Armada, Pereira, & Rodrigues, 2012; Song, Yu, Jin, & Feng, 2018) .

Another scheme is the cap & floor mechanism, where in addition to an MRG – floor, a revenue ceiling is also established, above which the concessionaire reimburses the granting authority for any gains obtained above the – cap level (Vasudevan, Prakash, & Sahu , 2018). These two forms of risk mitigation have been used in infrastructure concession contracts in several countries, such as Brazil (Brandão, Bastian-Pinto, Gomes, & Labes, 2012), China (Zhang, Li, Li, & Zhang, 2021) and India (Iyer & Sagheer, 2011).

2.1. ROA applied to Road Concessions

Infrastructure investment analysis has been an active field of research in recent decades. Discounted Cash Flow (DCF) is the most common method for evaluating an infrastructure project. However, thanks to the seminal work developed by Black and Scholes (1973) and Merton (1973) for the pricing of financial options, new methods were developed that applied these concepts to the evaluation of real assets under uncertainty and flexibility, such as ROA.

In recent years, ROA has found many applications in road infrastructure projects. Alonso-Conde, Brown and Rojo-Suarez (2007), for example, use this tool to calculate the government guarantees established in the Melbourne CityLink project and analyze whether they affect investment incentives and whether the public sector may be transferring considerable value to the private sector. Brandão and Saraiva (2008) also evaluate government guarantees in a PPP project. To this end, the authors consider market data from the BR-163 highway project and propose a Minimum Traffic Guarantee (MTG) model to assess the impact of government guarantees on the project risk and the expected value of the liability. resulting government.

Huang and Chou (2006) complement the analysis of the Taiwan high-speed train project carried out by Bowe and Lee (2004), considering an MRG and an abandonment option during the preproduction and construction phase of the project. Their results show that when the MRG level increases, the value of the abandonment option decreases and that, at a certain MRG level, the abandonment option will become useless. Attarzadeh, Chua, Beer, and Abbott (2017) are also concerned with the issue of effectively mitigating the impact of revenue uncertainty in BOT (Build-Operate-Transfer) projects. In this sense, they propose a model for calculating equitable limits on guaranteed revenue for the private agent. The authors apply their model to road and power plant PPP projects in Iran. Their conclusions show that the proposed systematic negotiation mechanism offers benefits to both the public and private sectors.

Buyukyoran and Gundes (2018) propose a model to evaluate MRG in a toll road BOT project, considering that future demand is the most critical risk factor affecting the financial viability of the project. In this sense, they combine an optimization approach with Monte Carlo simulation to identify the optimal upper and lower limits of guarantees. Likewise, Carbonara and Pellegrino (2018) develop a model to calculate the optimal revenue floor and ceiling values, in order to create a win-win condition for the concessionaire and the government. The authors apply this model to the case of the Messina Strait Bridge and conclude that this mechanism can support the government's decision-making process in evaluating the amounts of public subsidies needed to make the project attractive to private investors.

Jin, Liu, Sun, and Liu (2019) address not only the problem of optimizing the MRG level, but also the issue of the length of the lease period. They propose an imperfect information trading model based on the real options approach and show that the duration of the concession period is inversely proportional to the level of MRG, with this correlation being influenced by the probability of reaching the equilibrium rate of return on the investment. More generally, Rouhani et al. (2018) analyze the main revenue risk-sharing approaches developed around the world that are designed to mitigate concessionaire risk and thus encourage private participation in concessions. These approaches depend on the risk level of demand, the risk preferences of both partners and the nature of the project. In doing so, they provide recommendations on how revenue risk-sharing strategies should be targeted under alternative economic and social conditions and specific project contexts.

2.3. Risk-Return Metrics

In this section we present some risk-return metrics. Our intention is not to present all the measures existing in the literature. To do this, we suggest reading the articles by Campani (2022a, 2022b) for Investing.com.

We only focus on three measures: Value at Risk; Sharpe ratio; and Omega Measure. According to Jorion (1996), Value at Risk – VaR_α – was proposed as the maximum risk at a confidence level α. The definition of $VaR\alpha$ is presented in equation (1):

$$VaR_\alpha(X) = inf\{m|P[X-m>0] \leq \alpha\} = inf\{m|P[X-m<0] \leq 1-\alpha\} \quad (1)$$

where X is the financial position, $\alpha \in 0,1[$ and $m \in \mathbb{R}$.

To select an investment, it is necessary to measure its performance in terms of risk-return. Although there are several other proposals in the literature, the performance measure developed by Sharpe (1966), known as the Sharpe Index (SI), has become the standard performance measure of the traditional investment analysis methodology. This index can be described according to equation (2):

$$SR = \frac{\mu_p - r_f}{\sigma_p} \quad (2)$$

The financial interpretation of the Sharpe ratio is that this measure measures the excess return of the portfolio in relation to the return of the risk-free asset ($\mu_p - r_f$) per unit of risk, represented by the standard deviation of the portfolio σ_p. Since we are working with monetary values in this study, we consider that the numerator of this fraction will be the average of the simulations of the result of each scenario under analysis and that the denominator will be the standard deviation of these simulations.

The Omega measure (Ω), proposed by Keating and Shadwick (2002), has the characteristic of considering all moments of the distribution of returns and not just the mean and variance, as occurs with the Sharpe ratio.

For this reason, the Omega measure is a universal performance measure that can be applied to any portfolio, regardless of the premise adopted in modeling asset returns. The Omega measure can be described by the alternative formula developed by Kazemi, Schneeweis & Gupta (2004) described in equation (3):

$$\Omega(L) = \frac{E[max(r_p - L;0)]}{E[max(L - r_p;0)]} \quad (3)$$

where $\Omega(L)$ is the Omega measure of portfolio performance; L is the minimum required return on the portfolio (parameter defined by the investor); and r_p is the portfolio return. As we are working with monetary values in this study, we consider that the numerator of this fraction will be the average of the simulations of the result of each scenario under analysis that are above the 95% percentile and that the denominator will be the average of these simulated values that are below the percentile 5%.

It should be noted that the Sharpe ratio does not work for asymmetric distributions, unlike the VaR and the Omega measure. This characteristic is a point of attention, since demand uncertainty (represented by a lognormal distribution, as suggested in the literature and explained in detail in the next section) together with the cap and floor mechanism introduce asymmetries to the NPV (Net Present Value) distributions of concessions.

3. Model

As is standard in the literature, we consider that the main source of uncertainty that affects the private agent's return on investment and the investment decision is the demand D_t, which we assume follows a Geometric Brownian Motion (GBM), as shown in equation (4):

$$dD_t = \mu D_t dt + \sigma_D D_t dz_t \quad (4)$$

where dD_t is the incremental change in demand during the time interval dt; μ represents the expected growth rate of demand; σ_D is demand volatility; and $dz_t = \varepsilon\sqrt{dt}$ represents the standard Wiener increment, where $\varepsilon \approx N(0,1)$.

To model this uncertainty, we use the discrete-time version of the MGB. Through the Itô process, we define equation (5) that considers discrete annual periods:

$$D_{t+1} = D_t e^{\left(\mu - \frac{\sigma_D^2}{2}\right)\Delta t + \sigma_D \varepsilon \sqrt{\Delta t}} \quad (5)$$

As revenue is a direct function of demand, we can determine it from equation (6):

$$R_t = D_t \times T \times \omega \quad (6)$$

where R_t are total revenues in year t; D_t is the traffic demand in year t; T represents the toll fee, which we assume constant, and ω is the Equivalent Vehicle Multiplier Factor (EVMF), which is used to normalize traffic data between automobiles and freight vehicles. After that, we calculate the cash flow using equation (7):

$$F_t = \left[R_t\left(1-\gamma_t\right) - \delta - \Gamma\right]\left(1-\pi\right) + \delta \quad (7)$$

where γ_t represents the variable cost index in relation to R_t; π is income tax; Γ represents fixed costs and δ is depreciation, which is an annual capital expenditure for the operational maintenance of the infrastructure.

To calculate the project's NPV, we apply equation (8):

$$NPV = \sum_{t=1}^{n} \frac{F_t}{(1+r)^t} - \chi_t \quad (8)$$

where r is the risk-free rate and χ_t represents the Capex (Capital Expenditure) made each year of the concession. In this study, we consider that Capex is diluted over the first 10 years of the concession.

As demonstrated by Brandão & Saraiva (2008), the risk sharing mechanism (cap & floor or collar option) can be modeled as a set of European options with maturities between 1 and n years. Due to the floor, the concessionaire has a series of puts against the government, while the cap provides the government with a series of puts against the concessionaire. Thus, we assume that, at each time t, there are two absorbing barriers (cap & floor) in the revenue function, as shown in equation (9)[9]:

$$R_t^{A^*} = \max\left(\min\left(R_t^A, 115\% R_t^P\right), 85\% R_t^P\right) \quad (9)$$

where R_t^A is the current revenue at t; $R_t^{A^*}$ is the adjusted revenue at t; and R_t^P is the projected revenue for t.

Based on this model, we use a numerical application, considering a hypothetical 30-year federal highway concession project using typical data practiced in Brazil.

4. Numerical Application

In this numerical application, we assume a project without any type of incentive (demand sharing bands) as our base scenario. Table 1 presents the parameters adopted in this research. These values are based on a typical toll road concession project in Brazil.

[9] A versão apresentada neste estudo se assemelha ao modelo proposto no Anexo 14 do contrato de concessão da BR-277/373/376/476 e PR-418/423/427. Para maiores informações, Sugerimos consultar o link: https://www.gov.br/antt/pt-br/assuntos/rodovias/novos-projetos-em-rodovias/br-277-373-376-476-pr-e-pr-418-423-427/arquivos-para-download/edital-e-anexos/anexos-contrato-parana-lote-1

Table 1 – Parameters and data based on a typical toll road concession in Brazil

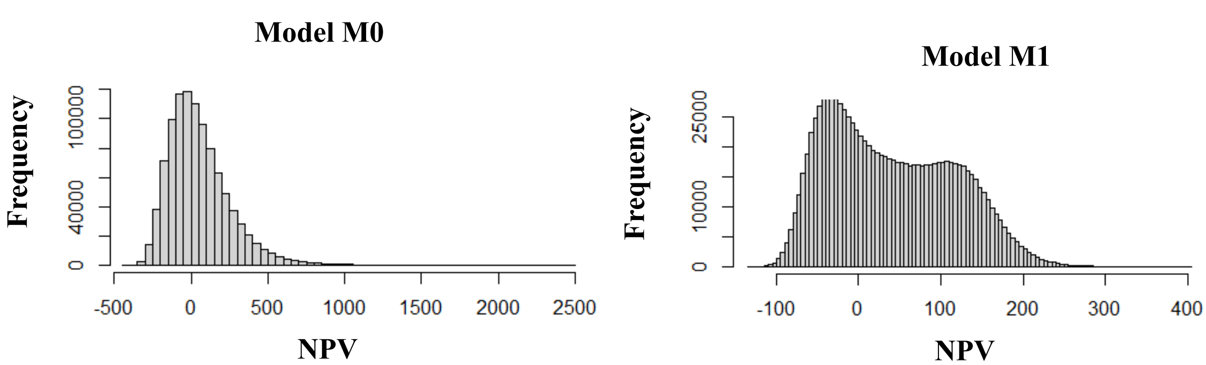
Contract term (n)	30 years
Capex (χ)	R$ 300 million
Fixed cost (Γ)	R$ 30 million per year
Variable cost (γ)	35% of revenues
Tax rate (π)	34%
Depreciation (δ)	R$ 10 million per year
Risk-free rate (r_f)	4.08% per year
Equivalent Vehicle Multiplier Factor (EVMF)	2.2
Tariff	R$ 8.20 / vehicle
Initial annual demand, at t = 0 (D_0)	3,650,000 vehicles
Expected demand growth rate (μ)	2.00% per year
Volatility (σ_D)	10.00% per year

Note: We consider that Capex occurs during the first 10 years of the concession and on a uniform basis, that is, in the amount of R$ 37.14 million each year (year 1 to year 10).

5. Results

5.1. Impact of Cap and Floor for the Concessionaire

The results show that the sooner the cap & floor mechanism is introduced in the concession, the less dispersed (and more asymmetric) the distribution of the project's NPV (concession) becomes and the better the risk-return metrics analyzed in this research. Figure 1 presents the Monte Carlo simulation and Table 2 presents descriptive statistics of this simulation and the risk-return metrics applied to the project's NPV as the demand risk sharing mechanism is inserted into the concession.



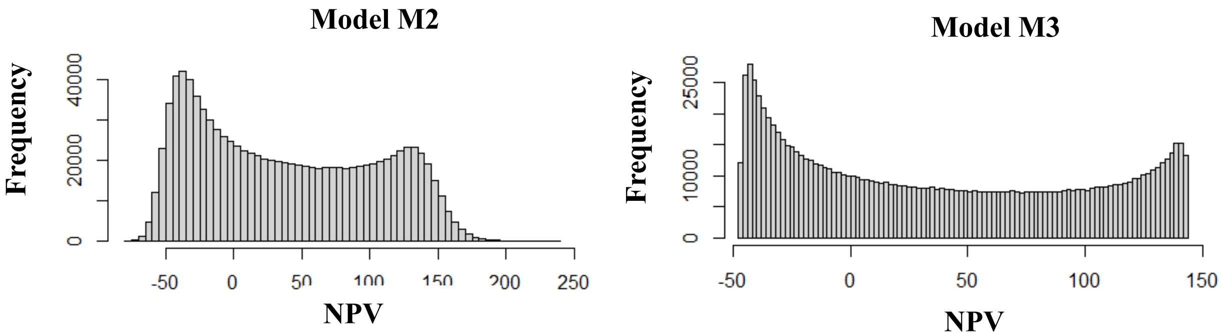


Figure 1 – Impact of the cap and floor mechanism on the project's NPV for the concessionaire

Note: **Base Case (Model M0)** – project without any type of incentive; **Model M1 – Cap & Floor – from years 9 to 30** (the mechanism starts when 90% of Capex is realized and we assume that this occurs in year 9, a format that is currently practiced in Brazil); **Model M2 – Cap & Floor – from year 5 to 30** (30 (the mechanism starts when 50% of Capex is realized and we assume that this occurs in year 5); and, **Model M3 – Cap & Floor – from year 1 to 30** (the mechanism starts when 10% of Capex is realized and we assume that this occurs in year 1).

Tabel 2 – Descriptive statistics and risk-return metrics on the project NPV simulation for the concessionaire

Model	**Scenario**	**Mean (R$)**	**Min (R$)**	**Max (R$)**	**VaR5% (R$)**	**SD (R$)**	**SR**	**Omega**	**Tariff (R$)**
M0	**Base Case**	50.16	-410.44	2.473.04	-204.64	197.00	0.25	2.38	8.20
M1	**C&F year 9** (Capex 90%)	38.97	-130.82	401.45	-65.51	76.26	0.51	2.53	8.20
M2	**C&F year 5** (Capex 50%)	37.63	-79.70	237.59	-48.60	65.14	0.58	2.84	8.20
M3	**C&F year 1** (Capex 10%)	37.00	-46.03	142.72	-43.16	61.82	0.60	3.13	8.20

Note: **Base Case (Model M0)** – project without any type of incentive; **C&F year 9 (Model M1)** – the mechanism starts when 90% of Capex is realized and we assume that this occurs in year 9, a format that is currently practiced in Brazil; **C&F year 5 (Model M2)** – the mechanism starts when 50% of Capex is realized and we assume that this occurs in year 5; and, **C&F year 1 (Model M3)** – the mechanism starts when 10% of Capex is realized and we assume that this occurs in year 1.

We also emphasize that the average NPV in models M1, M2 and M3 does not change and that the small decrease observed tends to decrease the greater the number of simulations adopted.

a) Tariff discount complying with the VaR5% restriction of Model M0

Analyzing the possibility of a tariff discount, we created the restriction that all scenarios reach the VaR5% of the base case (Model M0), which is – R$ 204.64. However, we emphasize that we could use any other risk-return metric. Table 3 presents descriptive statistics of the results and shows the percentage of tariff discount that could be applied in each scenario. Note that the scenario that promotes the incentive to share risk for a longer period of time (Model M3 – cap & floor from year 1 to 30) is the one that allows for a greater discount.

Table 3 – Tariff discount provided by cap and floor based on a VaR5% restriction

Model	**Scenario**	**Min (R$)**	**Max (R$)**	**$VaR_{5\%}$ (R$)**	**SD (R$)**	**Tariff discount (%)**	**Tariff (R$)**
M0	**Base Case**	-410.44	2.473.04	-204.64	197.00	0.00%	8.20
M1	**C&F year 9** (Capex 90%)	-254.30	136.51	-204.64	55.59	-27.07%	5.98
M2	**C&F year 5** (Capex 50%)	-228.10	-13.14	-204.64	46.07	-29.27 %	5.80
M3	**C&F year 1** (Capex 10%)	-209.07	-77.87	-204.64	42.95	-30.49%	5.70

Note that, for the project analyzed, there is no great advantage in anticipating the triggers (Capex). However, this result is dependent on the project and respective data used in the numerical application. We also emphasize that discounts may depend on the risk-return metric adopted. The use of other risk-return measures as conditions for determining the tariff discount and the use of only the floor as a mechanism to encourage private agent participation in the concession are presented in the Appendix of this text.

5.2. Impact of Cap and Floor for the Government

Next, we analyze what this cap & floor mechanism can generate in terms of Sum of Losses and Gains for the Government (SLG – losses arising from the guarantee given to the concessionaire by the Government and gains arising from the return of revenue to the Government by the concessionaire). This analysis is relevant for the granting authority, especially considering the context of fiscal restrictions and the possibility of using the upside for other unattractive PPPs.

We found that the sooner the risk sharing mechanism (insurance) is introduced, the more dispersed the distribution of the GSP generated for the public agent becomes and there is a worsening of the risk-return metrics analyzed in this research. Table 4 presents descriptive statistics of this simulation and the risk-return metrics applied to the GSP for the Government as the mechanism is inserted into the concession.

Note, comparing Tables 2 and 4, that as the concessionaire improves its risk-return metrics, the government worsens with the anticipation of risk sharing mechanisms (cap & floor) in the concession.

Table 4 – Descriptive statistics and risk-return metrics on the SLG simulation for the Government

Model	Scenario	Mean (R$)	Min (R$)	Max (R$)	$VaR_{5\%}$ (R$)	SD (R$)	SR	Omega	Cap (%)	Floor (%)
M1	**C&F year 9** (Capex 90%)	25.97	-678.83	4.987.84	-348.98	285.38	0.091	2.28	115%	85%
M2	**C&F year 5** (Capex 50%)	29.05	-782.58	5.169.42	-379.12	327.48	0.089	2.21	115%	85%
M3	**C&F year 1** (Capex 10%)	30.51	-846.59	5.216.58	-387.35	358.10	0.085	2.19	115%	85%

a) Flexibility 1: anticipation of the risk sharing mechanism (reduction of the floor and maintenance of the cap) complying with the VaR5% restriction of Model M1

The tool makes it possible to estimate how indifferent the granting authority would be, in terms of risk x return, in bringing forward the risk sharing mechanism proposed for the first year.

We created the restriction that all scenarios reach the VaR5% of year 9 (base case M1) which is – R$ 348.98, envisioning the possibility of reducing the percentage of the floor (i.e., a lower floor guarantee value by the government) and maintenance of cap. Table 5 presents descriptive statistics of the results and shows the percentage of floor reduction that could be applied in each scenario.

Note that if you choose to bring forward the risk sharing mechanism for the first year (Model M3 – cap & floor from year 1 to 30), the granting authority is indifferent to Model M1 if it reduces the floor by 3.76%. This type of analysis provided by asymmetric risk-return metrics makes it possible to estimate the impacts on the granting authority of flexibilities in the risk sharing mechanism, as greater incentives (insurance) present a cost to be considered.

Table 5 – Discount on the floor provided by the $VaR_{5\%}$ restriction on the GSP simulation for the Government

Model	Scenario	Mean (R$)	Min (R$)	Max (R$)	$VaR_{5\%}$ (R$)	SD (R$)	Floor Discount (%)	Cap (%)	Floor (%)
M1	**C&F year 9** (Capex 90%)	25.97	-678.83	4.987.84	-348.98	285.38	0.00%	115.00%	85.00%
M2	**C&F year 5** (Capex 50%)	40.00	-759.77	4.420.29	-348.98	320.88	-2.82%	115.00%	82.60%
M3	**C&F year 1** (Capex 10%)	46.12	-796.16	4.515.92	-348.98	324.38	-3.76%	115.00%	81.80%

Other conditions can be analyzed, such as increasing the percentage of the cap (>115%) and maintaining the floor (85%) obeying the same restriction considered above (VaR5% of Model M1). The impact on the government of using only the floor as a mechanism to encourage private agent participation in the concession is shown in the Appendix of this text.

6. Conclusion

To be developed.

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Appendix – Sensitivities of the Proposed Model

A.I) Impact of Cap and Floor for the Concessionaire

a) Tariff discount complying with the Sharpe ratio restriction of Model M0

We also created the restriction that all scenarios reach the SR of the base case (Model M0), which is 0.25. Table A.1 presents the descriptive statistics of the results and the percentage of tariff discount that could be applied in each scenario. Note that the scenario that promotes the incentive to share risk for a longer period of time (Model M3 – cap & floor from year 1 to 30) continues to be the one that allows for the greatest discount. However, we highlight that this restriction promotes tariff discounts lower than $VaR_{5\%}$, which were presented in the text in section 5.

Table A.1 – Tariff discount provided by the cap and floor based on the Sharpe ratio restriction

Model	**Scenario**	**Min (R$)**	**Max (R$)**	**SD (R$)**	**SR**	**Tariff discount (%)**	**Tariff (R$)**
M0	**Base Case**	-410.44	2.473.04	197.00	0.25	0.00%	8.20
M1	**C&F year 9** (Capex 90%)	-140.48	367.95	59.89	0.25	-3.05%	7.95
M2	**C&F year 5** (Capex 50%)	-100.70	199.04	59.76	0.25	-3.29%	7.93
M3	**C&F year 1** (Capex 10%)	-65.59	116.25	59.48	0.25	-3.66%	7.90

b) Tariff discount obeying the Ω restriction of Model M0

Considering a third risk-return metric, we create the restriction that all scenarios reach the Ω of the base case (Model M0), which is 2.38. Table A.2 presents descriptive statistics of the results and shows the percentage of tariff discount that could be applied in each scenario. The results are similar to the previous ones; however, we highlight that this restriction promotes significantly lower tariff discounts than VaR5% and SI.

Table A.2 – Tariff discount provided by the cap and floor based on the Ω restriction

Model	**Scenario**	**Min (R$)**	**Max (R$)**	**SD (R$)**	**Omega**	**Tariff discount (%)**	**Tariff (R$)**
M0	**Base Case**	-410.44	2.473.04	197.00	2.38	0.00%	8.20
M1	**C&F year 9** (Capex 90%)	-139.27	379.93	75.78	2.38	-0.61%	8.15
M2	**C&F year 5** (Capex 50%)	-89.12	211.81	64.28	2.38	-1.22%	8.10
M3	**C&F year 1** (Capex 10%)	-55.81	129.49	60.61	2.38	-1.83%	8.05

It should be noted that the objective is not to compare the best risk-return measure. This is what the private agent will decide. Our point is to say that the sooner the cap & floor mechanism is inserted into the concession, the greater the potential tariff discount will be.

A.II. Impact of Floor for the Concessionaire

Now, we only simulate the effect of the floor on the value of the project for the concessionaire. Figure A.1 presents the Monte Carlo simulation and Table A.3 presents descriptive statistics of this simulation and the risk-return metrics applied to the project's NPV for the concessionaire as the mechanism is inserted into the concession. The results show that the earlier the floor is introduced into the concession, the less dispersed the distribution of the project's NPV becomes and there is an improvement in risk-return metrics. Note that in this case, with just the floor, the concessionaire is free to achieve the upside of revenues that exceed the limit established by the ceiling that was abolished. This can benefit both the concessionaire and the government by allowing the incorporation of an option to expand road capacity.

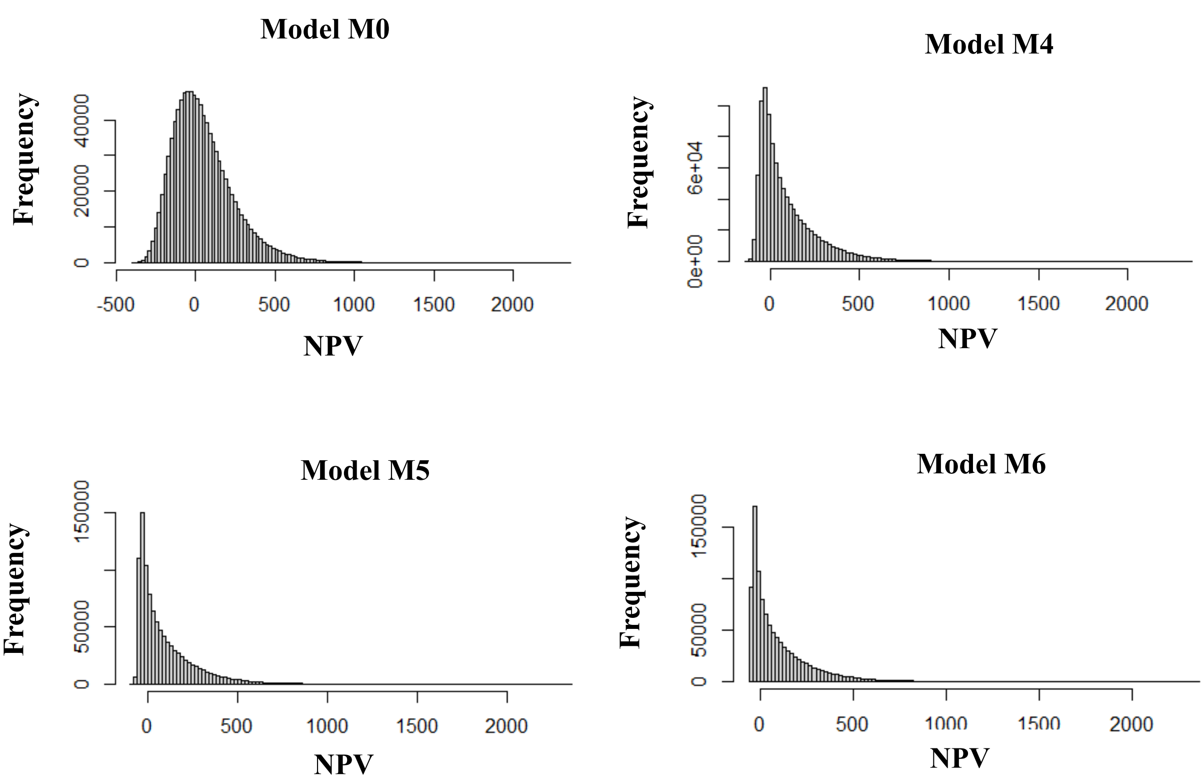

Figure A.1 – Impact of the floor mechanism on the project's NPV for the concessionaire

Table A.5 – Descriptive statistics and risk-return metrics on the project NPV simulation for the concessionaire

Model	Scenario	Mean (R$)	Min (R$)	Max (R$)	$VaR_{5\%}$ (R$)	SD (R$)	SR	Omega	Tariff (R$)
M0	**Base Case**	50.00	-393.97	2.348.82	-204.20	197.16	0.25	2.39	8.20
M4	**Floor year 9** (Capex 90%)	88.57	-129.63	2.348.82	-65.45	164.18	0.54	7.53	8.20
M5	**Floor year 5** (Capex 50%)	92.20	-82.49	2.348.82	-48.58	161.39	0.57	10.63	8.20
M6	**Floor year 1** (Capex 10%)	93.42	-46.03	2.348.82	-43.18	160.57	0.58	12.86	8.20

Note: **Base Case (Model M0)** – project without any type of incentive; **Floor year 9 (Model M4)** – the mechanism starts when 90% of Capex is realized and we assume that this occurs in year 9; **Floor year 5 (Model M5)** – the mechanism starts when 50% of Capex is realized and we assume that this occurs in year 5; and, **Floor year 1 (Model M6)** – the mechanism starts when 10% of Capex is realized and we assume that this occurs in year 1.

A.III. Impact of Floor for the Government

Finally, we only analyze what the floor can generate in terms of Contingent Liabilities (CL) for the Government. We found that the earlier the floor is introduced into the concession, the more dispersed the distribution of the CL generated for the public agent becomes and there is a worsening of the risk-return metrics analyzed in this research. Table A.6 presents descriptive statistics of this simulation and the risk-return metrics applied to the CP for the Government as the mechanism is inserted into the concession.

Table A.6 – Descriptive statistics and risk-return metrics on the CL simulation for the Government

Model	Scenario	Mean (R$)	Min (R$)	Max (R$)	$VaR_{5\%}$ (R$)	SD (R$)	SR	Cap (%)	Floor (%)
M4	**Floor year 9** (Capex 90%)	-89.86	-666.46	0.00	-349.09	119.02	-0.755	115.00%	85.00%
M5	**Floor year 5** (Capex 50%)	-98.30	-754.55	0.00	-379.26	129.15	-0.761	115.00%	85.00%
M6	**Floor year 1** (Capex 10%)	-101.16	-807.72	0.00	-387.88	132.11	-0.765	115.00%	85.00%

Note that it is not possible to calculate the Omega measure given that in these scenarios the distribution of results is limited to zero, that is, there are no positive values for the government when we only deal with the incentive related to the floor guarantee. Another point that must be considered is that all Sharpe ratios have negative values. This is because the average is negative in all scenarios.