Airport concessions and investment in Brazil: Appearances can be deceiving[1]

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Contents

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Extended Abstract

Several important infrastructure projects in Latin America (LA) have been undertaken thanks to the efforts of the respective governments and have been initially publicly managed. However, most LA countries have suffered strong financial restrictions in the 1980's that led to a lack of public investment capabilities. To deal with the compelling need of investment, these governments undertook important privatizations or concessions, aiming at inducing the private sector to take charge of these investments. However, for the concession to be successful, the private operators' incentives need to be in line with the country's objectives. This paper analyses the incentives in airport concessions in Brazil.

Airport concession contracts are complex and require a set of investments with due dates and penalties in case of non-compliance. However, due to the high costs involved, the operator may find it optimal to postpone or cancel these investments, which frustrates the very objective of the concession. Therefore, a moral hazard problem may take place during the operation period and that will trigger a response in the part of the government. Naturally, a firm that is competing in the concession auction anticipates this moral hazard issue and the government's reaction and takes it into consideration when designing its bid strategy.

This paper presents an integrated analysis of these two steps in the concession relationship between firms competing with each other during the concession auction, and between a concessionaire and the government during the operation period. Our main goal is to understand how the concession design and expectations about the interactions during the operation period affects the behavior of players in the concession auction.

In order to reach that goal, we model the airport concession as two successive games: the first one corresponds to the concession auction and the second one corresponds to the airport operation. The model shows that under certain conditions, the concessionaire may find it optimal not to make the required investment in the traditional concession mechanism.

Furthermore, the government may prefer not to enforce the contract penalties in case of non-compliance with the investment requirement. The model shows that the lower the government's reputation of a contract enforcer, the higher the likelihood that there will be no investment. Furthermore, the model also shows that the lower the expectation of contract enforcement, the higher the equilibrium bids in the concession auction. Therefore, we find a "paradox of concessions" in weak institutions' countries: the more

successful is the concession auctions in the sense of higher equilibrium bids, the more likely it is that the winning firm will not make the investments laid down in the concession contract.

In order to deal with the moral hazard problem in weak institutions' countries, the present paper proposes an alternative concession design that focusses on "benefit-for-investment" rather than on "penalty-for-noncompliance". We compare the two institutional designs and conclude that the benefit-for-investment design: (i) frees the government from the weak institutions' problems; (ii) increases equilibrium bids; and (iii) can be fine-tuned in order to reduce the likelihood of non-investment.

Keywords: Game theory, Mechanism Design, Airport Concession.

1. Introduction

This paper develops a game theoretic analysis of the interaction between the expectation about the enforcement of an airport operation contract and its auction results.

In Brazil, in 2019, there are dozens of privately-operated airports, in build-rehabilitate-operate-transfer-type and in management-type contracts. Although some airports are supported by public funding, the overall airports' privatization programs have projected billions of dollars in private investments and concession fees.

Due to the relevance that private participation acquired in Brazil in the last decade, not only in the airports sector but in the overall infrastructure sector itself, the studies about the expected and unexpected results of concessions became a field of research in itself. Tiriaky (2008) stated that institutions that promote legal certainty and credibility about the contracts' compliance, both for entrepreneur and for the governments, enhance the long-term results for society.

Notwithstanding, Engel, Fischer and Galetovic (2008) argue that in the majority of developing countries governments focus on beginning new projects, rather than on assuring compliance of the running contracts, which affects the governments' overall reliability.

The present study explores the interaction among the expectations about an airport operation under a concession, in relation to its contract enforcement, and its initial auction equilibrim. In order to achieve that goal, we use game theory modeling in three moments.

First, we build an extensive-form game between a concessionaire firm and the government, that we call the “Operation Game”, based on the incomplete information games approach first developed in Kreps and Wilson (1982) and Milgrom and Roberts (1982) and further developed in the context of subnational debt payments in a Federation in Pires and Bugarin (2002) and Bugarin (2006). The game explores the strategic tradeoffs that the concessionaire faces when deciding whether or not to comply with the concession contract’s investment requirement. Moreover, it also analyses the tradeoffs the government faces in deciding whether or not impose the contractual penalties when the firm defaults. The Perfect Bayesian equilibrium of that game highlights a moral hazard issue whereby the concessionaire tends not to make the investment if the required amounts are high compared to the additional gains in profits and if the likelihood that the government will enforce the corresponding penalties are low.

Next, we build an incomplete-information normal-form auction game between firms that compete for the concession that we call the “Concession Auction”. The main novelty of our approach is that the bidding firms in the Concession Auction anticipate the equilibria in the Operation Game and take that anticipation into account when designing their bid strategies. The main result of the resulting equilibrium is that the bidders internalize the expected penalties for (possibly) defaulting so that the stronger is the government reputation in the sense that she will enforce these penalties, the lower the equilibrium bids. This leads us to concluding on the “Paradox of Concessions” in weak institutions’ countries: The more successful a concession auction is in the sense of yielding higher than expected equilibrium bids, the more likely the winning firm will default the investment requirement.

Finally, in order to cope with the adverse “Paradox of Concessions”, we propose a new mechanism, alternative to the traditional concession mechanism (TM), which we call the Bonification Mechanism (BM). The BM replaces the punishment to a noncomplying concessionaire with a deduction in the due concession fees if the investment is completed. Our theoretic analysis shows that, compared to the TM, the BM increases overall bids in the concession auction and can be fine-tuned in order to adjust the probability that the investment is made by the concessionaire according to the best interest of the government.

In addition to this introduction the paper is organized as follows. Next section presents a very brief history of airport concessions in Brazil. Section 3 discusses the paper’s integrated approach to analyze an airport concession including both the concession auction and the subsequent operation game. Section 4 starts solving the integrated model by backwards induction by modeling and solving operation game. Next, section 5 models and solves the auction game. Section 6 discusses the phenomenon we call the paradox of concessions. Then, section 7 proposes the alternative mechanism design of the Bonification Mechanism that could be used to offset the paradox of concessions. Finally, section 8 concludes on a discussion on the findings and the limitations of the present modeling approach.

2. Airport concessions in Brazil: a brief historical review

Brazilian public airports (i.e. those that cannot deny traffic) network was mainly state run until the beginning of the 2010’s. The main airports were operated by Infraero, a federal government owned company created in 70s, and some regional airports were operated by states or municipalities’ agencies.

Following airlines prices and routes deregulation in the 1990’, and a favorable economic environment, the air traffic experienced a rapid increase in 2000’s, with enplanements growing from 38 million in 2001 to 100 million in 2011. However, investments in airport infrastructure didn’t follow these dynamics, which lead to a decrease in the level of services in airports and apron constraints.

In the years 2000, a series of events triggered the federal decision to concede airports operations: i) the schedule to receive the 2014 FIFA World Cup and 2016 Olympic Games; ii) the Gol Airline flight 1907 mid-air collision catastrophe in 2006; iii) the Tam Airline flight 3054 overrun accident catastrophe at Congonhas airport in 2007; and iv) the air traffic services strike that followed them, leading to an aviation crisis.

Then, in 2011 the federal government granted the first airport operation concession in Brazil, a greenfield project to build and operate for 28 years the São Gonçalo do Amarante/RN airport (ASGA), which substituted the previous Natal/RN airport in 2014. Following, the airports of Guarulhos/SP, Campinas/SP and Brasilia/DF were conceded in 2012, Confins/MG and Rio de Janeiro-Galeão/RJ in 2014, and Fortaleza/CE, Salvador/BH, Florianópolis/SC and Porto Alegre in 2017. Last, in 2019 three clusters, summing up 12 airports, were conceded.

Presently, the majority of passengers are enplaned in conceded airports. The concessions program is considered successful due to the increase in the airports’ service level, the entrance of internationally experienced operators and the high concession fees earned by the government. However, several problems started to manifest in some airports, which have been worsened by an economic turndown in the past several years in Brazil.

Table 1 sums up the main characteristics of the first six conceded airports. The others are recent (auctions in 2017 and 2019), and we only present their auction results. With different allegations, the first six airports of the concession programs demanded to federal government more than 80 applications of the "financial economic rebalance" instrument that sums up to a required reimbursement of more than R$ 15 billion (about US$3.7 billion[4]). However, the federal government conceded a mere R$ 300 million (US$73 million) of reimburses, sustaining that the other demands were unfounded. Some of these airports are now having difficulty to pay the concession fees. For example, the Rio de Janeiro-Galeão airport concessionaire committed to an average concession fee of near R$ 800 million per year (in 2014 values), plus 5% of gross revenues. But, in 2017, it had revenues of R$ 900 million, and most of these were consumed by costs.

Table 1. Summary data about the Brazilian airport concessions

Auction year	Airport	Main characteristics
2011	São Gonçalo do Amarante Airport/RN (ASGA)	Reserve price: R$ 51,7 million[5] Winning bid: R$ 170 million[6] Expected passengers 4,7 million (2020) Realized passengers: 2,4 million (2018) Expected investments: R$ 650 million Difficulties faced: Postponed concession fees payment
2012	Brasília/DF	Reserve price: R$ 580 million[7] Winning bid: R$ 4,51 billion[8] Expected passengers 22 million (2016) Realized passengers: 17,5 million (2018) Expected investments: R$ 2,8 billion Difficulties faced: Postponed concession fees payment
2012, Guarulhos/SP	2012, Guarulhos/SP	Reserve price: R$ 3,4 billion Winning bid: R$ 16,2 billion Expected passengers 45 million (2016) Realized passengers: 41,2 million (2018) Expected investments: R$ 4,6 billion Difficulties faced: Postponed concession fees payment

[4] According to the average October exchange rate of US$1=R$4.086. See: https://economia.acspservicos.com.br/indicadores_iegv/iegv_dolar.html
[5] https://www.anac.gov.br/noticias/2011/marcado-leilao-do-aeroporto-de-sao-goncalo-do-amarante
[6] https://www.anac.gov.br/noticias/2011/primeiro-aeroporto-federal-e-concedido-a-iniciativa-privada
[7] https://www.anac.gov.br/noticias/2012/leilao-acontece-nesta-segunda-06-02
[8] https://www.anac.gov.br/noticias/2012/leilao-de-aeroportos-tem-agio-medio-de-347

2012	Campinas/SP	Reserve price: R$ 1,5 billion Winning bid: R$ 3,8 billion Expected passengers 15 million (2016) Realized passengers: 8,7 million (2018) Expected investments: R$ 8,7 billion Difficulties faced: Default on concession fees, Judicial recovery, risk of bankruptcy
2013	Rio de Janeiro-Galeão/RJ	Reserve price: R$4,8 billion[9] Winning bid: R$ 19,0 billion[10] Expected passengers: 28 million (2018) Realized passengers: 14,8 million (2018) Expected investments: R$ 5,7 billion Difficulties faced: Postponed concession fees payment
2013	Confins/MG	Reserve price: R$ 1,1 billion Winning bid: R$ 1,8 billion Expected passengers 14,4 million (2018) Realized passengers: 10,3 million (2018) Expected investments: R$ 3,5 billion Difficulties faced: Postponed second runway construction
2017	Salvador/BA	Reserve price: R$ 310 million[11] Winning bid: R$ 660 million Expected investments: R$ 2,3 billion[12]
2017	Porto Alegre/RS	Reserve price: R$ 31 million Winning bid: R$ 290 million Expected investments: R$ 1,9 billion
2017	Fortaleza/CE	Reserve price: R$ 360 million Winning bid: R$ 425 million Expected investments: R$ 1,4 billion
2017	Florianópolis/SC	Reserve price: R$ 53 million Winning bid: R$ 83 million Expected investments: R$ 960 million
2019	Central-west Cluster	Reserve price: R$ 800 thousand[13] Winning bid: R$ 40 million Expected investments: R$ 387 million (5 first years)
2019	South-east Cluster	Reserve price: R$ 47 million Winning bid: R$ 437 million Expected investments: R$ 302 million (5 first years)
2019	North-east Cluster	Reserve price: R$ 171 million Winning bid: R$ 1,9 billion Expected investments: R$ 788 million (5 first years)

[9] https://www.anac.gov.br/noticias/2013/anac-aprova-edital-de-leilao-de-galeao-e-confins
[10] https://www.anac.gov.br/noticias/2013/leilao-do-galeao-e-de-confins-tem-agio-medio-de-253
[11] https://www.anac.gov.br/noticias/2017/aeroportos-sao-arrematados-por-3-72
[12] https://www.anac.gov.br/noticias/2017/leilao-de-quatro-aeroportos-acontece-nesta-quinta-16-03
[13] https://www.anac.gov.br/noticias/2019/governo-obtem-r-2-377-bilhoes-em-concessao-de-aeroportos-em-blocos

Source: ANAC, concession contracts and press releases, available in pages https://www.anac.gov.br/assuntos/paginas-tematicas/concessoes and as indicated in footnotes.

This may come from a seemingly excessive optimism in the period of the concession auctions. For example, the market studies of Campinas airport forecasted the airport would have 15 million passengers in 2016, but the realized traffic was less than 9 million. Campinas airport is today the clearer example of failure, having defaulted both the payments of the concession fees and the public funding loans as well, so that it is officially under bankruptcy risk ("judicial recovery")[14].

Arguing that the economic turndown frustrated the air transport sector's growth, the concessionaires requested the government to reduce the concession fees for some years and pay higher values by the end of the concession. This only could be done by a law, that required parliament approval. In face of a general default risk in the concession fees payments, the federal government passed in Congress Law nº 13.499 in 2017 to allow concessionaires to postpone the concession fees payments, in response to a formal demand from the Brasilia, Rio de Janeiro, Guarulhos and ASGA airports.

3. The concession mechanism: an integrated analysis

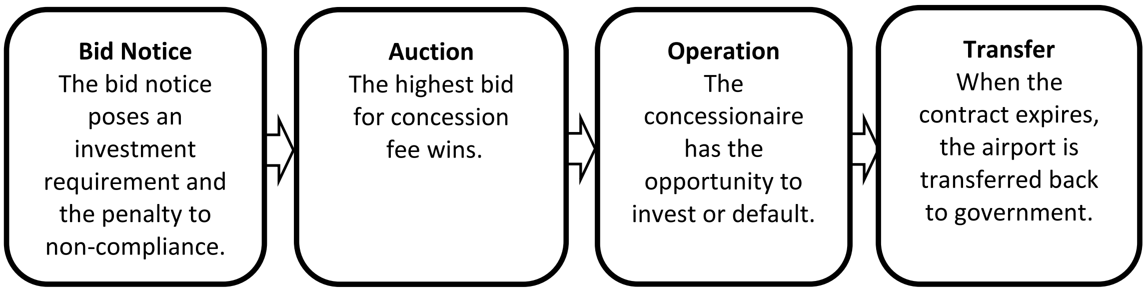
An airport concession involves a very complex chain of steps, analysis, interactions and decisions, such that could hardly described in this paper. For the sake of this analysis, we simplify the concession's essential elements in Figure 1.

The first phase is the Bid Notice, posing an investment requirement[15] and a penalty to be enforced in case of non-compliance. The second phase is the first price auction, where the highest bid wins. The third phase begins after the signature of the concession contract, when the concessionaire operates the airport and has the opportunity of not complying with the investment requirement. In case of non-compliance, the government shall decide whether or not enforce the penalty. The last phase comprises the end of the concession, when the airport is returned back to government.

[14] Recuperação judicial. To this date, the actual bankruptcy has been successively postponed by trying to negotiate selling the airport or by appealing to the Courts.

[15] Here we are not considering a safety or security requirement, because these are not object of a concession contract, but of aviation regulations applicable to all airports, public or private run. Instead, we focus on infrastructure capacity or level of service requirement, that the concessionaire may not have a natural incentive to comply with. The level of service represents the airport performance on the passengers' point of view and is a function of the waiting times, of the people concentration in areas and of subjective evaluation of passengers.

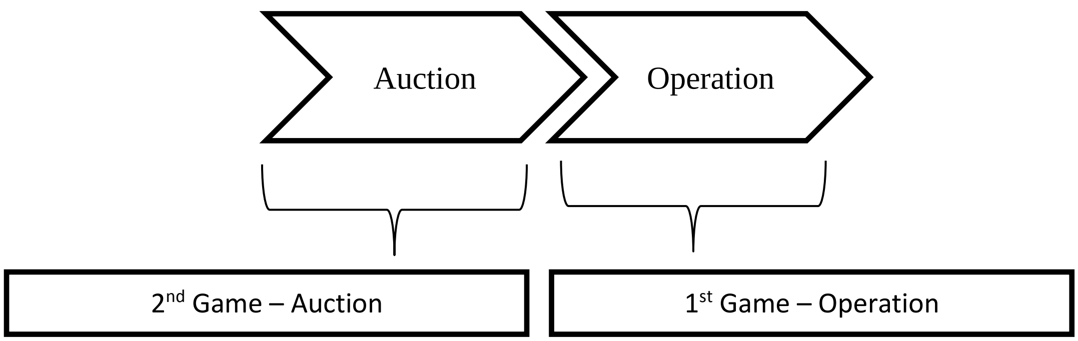
Figure 1. The phases of the airport concession mechanism



Source: The authors

We consider that there are strategic interactions in two of these phases: in the auction, among the bidders, and in the operation, between the concessionaire and the government. Therefore, the problem consists essentially of two games. We'll begin studying the operation game and, following, its effects on the auction game, as presented in Figure 2.

Figure 2. The phases of the airport concession mechanism with strategic interactions



Source: The authors

4. The Operation Game

The integrated analysis of the concession mechanism is made by backwards induction: we first analyze the Operation Game and then, conditional on the solution of the Operation Game, we derive the Auction Game Equilibrium. The Operation Game is modeled following the approach in Bugarin (2006) and Pires and Bugarin (2002) that is inspired in the seminal works by Kreps and Wilson (1982) and Milgrom and Roberts (1982) on signaling and reputation.

4.1. The basic elements of the Operation Game

The Operation Game starts after conclusion of the Concession Auction. The concession is awarded to the winning firm, say firm i, and that firm is expected to invest a certain capital I in order to amass the benefits v_i of the modernized airport.

Whereas the investment I is clearly established in the concession contract and is, thereby, common knowledge, the firm's benefit of investment, v_i , is her private information. This is so due to the fact that different firms may have different managerial abilities, different cost of capital structure, etc. The value v_i is the firm's type and the higher it is, the more efficient is the firm.

Although the firm knows its type, all the government knows is that the value v_i is distributed in the interval $[v, V]$, where $v > 0$ corresponds to the present value of the airport, before any investment is made (in which case, the investment is completely unproductive to that firm), and V is the maximum value the airport can generate if the firm invests the established amount I.

The main choice the firm needs to make in the Operation Game is whether or not to make the investment I. If the firm makes the investment, its net profit is $v_i - I$. On the other hand, if the firm does not invest, then it is subject to paying the fine p if the government decides to enforce the concession contract. Therefore, when the firm does not make the investment I, its net profits are v if the government does not enforce the contract and it is $v - p$ if the government enforces the contract and collects the penalty p.

Note that, if the fine is at least as big and the contracted investment, then the concessionaire will surely make the investment, regardless of her type. In this case, the penalty is so heavy that we will never see noncompliance. This clearly does not reflect the real-world situation. Therefore, we assume here, naturally, that the fine is not as large as the investment requirement: $p < I$.

On the government side, if the firm makes the investment, the government receives the benefit $B > 0$ that corresponds to the social gain from a modernized airport. On the other hand, if no investment is made, then the government receives the basic benefit $b < B$ that corresponds to the social benefit of the original outdated airport.

If the firm does not comply with the investment contract, the government can either enforce the contract and charge the penalty p or revise the concession contract and do not punish the firm. If the government does not punish the firm, the government incurs the popularity cost c_s that corresponds to society's disappointment with the government's lack of attitude. Therefore, his resulting utility is: $b - c_s$. On the other hand, if the government does apply the penalty to the concessionaire, it incurs the cost of confronting that firm, c_f, that corresponds to the pressure the firm can exert on the government, the loss of campaign finance contributions, etc. Therefore, his net utility in that case is: $b + p - c_f$.

Note that a government that cares a lot about his social popularity (high c_s) tends to apply the penalty, whereas the government that strongly cares about the concessionaire support (high c_f) tends not to enforce the contract.

Hereafter, we say that the government is of the "social type", or more simply "strong", if $c_s \geq c_f - p$. Conversely, we say that the government is of the "concessionaire type", or more simply "weak", if $c_s < c_f - p$. The government knows his type, but the concessionaire only know that the government is strong with probability $\mu \in [0,1]$. In order to better distinguish between the two types of government, use upper bar for the costs associated with the social-type government and lower bar for the costs associated with the concessionaire-type government. Therefore:

$$\overline{c}_s \geq \overline{c}_f - p, \qquad \underline{c}_s < \underline{c}_f - p$$

4.2. The extensive form of the Operation Game

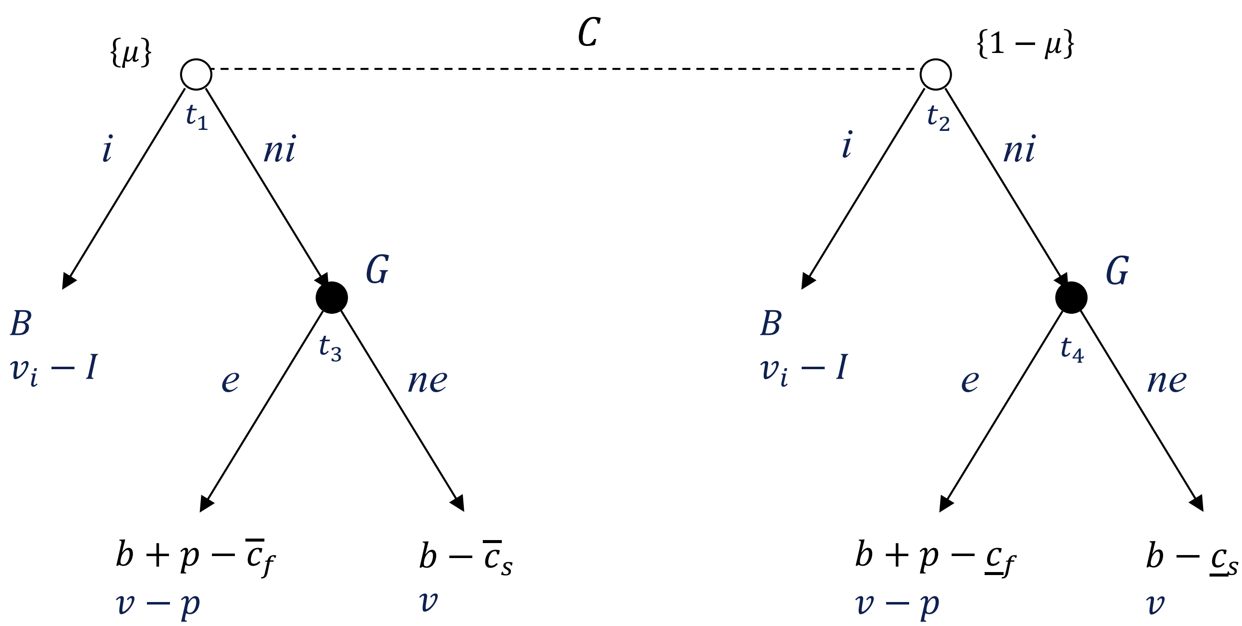
Figure 3 below depicts the extensive form of the incomplete information Operation Game, where G refers to the government, C refers to the concessionaire and N refers to nature.

The game starts with the concessionary C deciding either to make the investment I (strategy i) or not to make that investment (strategy ni), without knowing if it is dealing with a strong government (note t_1) or a weak government (node t_2).

If C makes the contracted investment, the game ends with payoffs B for the government and $v_i - I$ for the concessionary firm. This is the best outcome for G. If C does not comply with the concession contract, then G decides whether or not to apply the contracted penalty.

If G is of social type (node t_3) and applies the penalty, the corresponding payoffs are $b + p - \overline{c}_f$ for the government and $v - p$ for the firm. If he does not enforce the contract, the corresponding payoffs are $b - \overline{c}_s$ for the government and v for the firm. An analogous situation occurs in node t_4, where G is weak.

Figure 3. The extensive form of the incomplete-information Operation Game.



Source: The authors

4.3. The solution to the Operation Game.

We derive here the Perfect Bayesian Nash Equilibrium of this game.

First, sequential rationality requires the social-type government to apply the penalty (e) in node t_3, and the concessionaire-type government not to enforce the contract (ne) in node t_4.

Next, again sequential rationality at information set $\{t_1, t_2\}$ requires the concessionaire to choose to invest in the airport concession if $v_i - I \geq v - \mu p$ or, again, if $v_i \geq v - \mu p + I$.

Define $w_\mu = v - \mu p + I$. Then, the (pure strategy) Perfect Bayesian Nash Equilibrium of the Operation Game is:

$$\Big((i, (e, ne)), \mu\Big) \text{ if } v_i \geq w_\mu = v - \mu p + I \qquad (1)$$

$$\left(\left(ni,(\,e,ne)\right),\mu\right) \text{ if } v_i < w_\mu = v - \mu p + I \qquad (2)$$

4.4. Discussion on the Operation Game possible equilibria

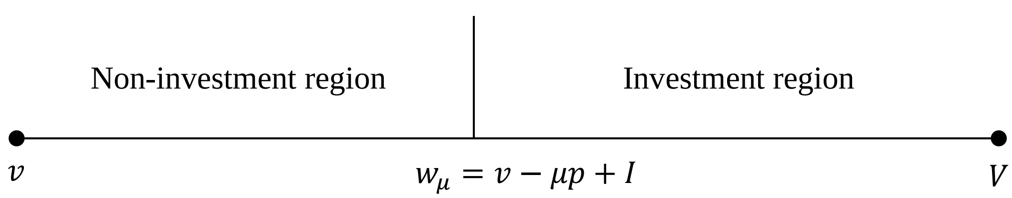
The equilibria found in the previous session show that, given the investment requirement I and the penalty p, the behavior of the concessionaire depends fundamentally on two parameters: the firm's efficiency or ability to derive profits out of the investment, v_i, and the ex-ante reputation of the government, μ.

The higher the value v_i, the more likely condition (1) is satisfied, which means that the more likely the firm will make the expected investment, in order to amass the additional profits that the modernized airport will generate.

In the same direction, the higher the expectation parameter μ, i.e. the higher the reputation of being a social type the government has, the more likely the firm will invest in order to avoid the more likely payment of the penalty if defaulting.

Figure 4 below describes the choice of the concessionaire as a function of the threshold parameter w_μ.

Figure 4. The investment decision of the concessionaire as a function of its value.



Source: The authors

There are several policy conclusions of the Operation Game.

First, it is clear that having a reputation of being a social-type government increases the interval of firm types in which there will be investment. Therefore, if the government could first build a reputation before the concession begins, it would increase the likelihood of a successful concession. This could be done if the government could have shown strength in renegotiation in other sectors that could affect the firm's beliefs, for example, in road concessions or even in subnational debt payment negotiations.

Furthermore, if there are several airport concessions being concluded, and the government has a good reputation (high value for μ) at the outset, even if, in fact, the government is of the concessionaire type, the government may still profit from acting "tough", applying the penalty if a concessionaire does not invest, in order to avoid other concessionaires to update their belief to $\mu = 0$, in which case the noncompliance region increases. By doing so, the government incurs a utility loss in the present negotiation with the concessionaire, but it is compensated with the disciplining effect it will have on the other concessionaries.

For a detailed discussion on the reputational preserving concerns in an environment where the government is playing a larger game with many other firms, please refer to Bugarin (2006), which studies a similar problem in the context of a game of debt payment between a federal government (the lender) and its subnational governments (the borrowers).

5. The Auction Game

5.1. The static complete information Auction Game

For the sake of simplicity, assume there are two competitors, $i = 1,2$ in the auction for selling an airport concession. Each player $i = 1,2$ has two possible values if she wins the concession auction: the value of the airport for her will be $v_i = v$ if she does not make the required investment I, and it will be $v_i \in [v, V]$ if she makes the investment I.

Each player $i = 1,2$ knows his own value, but the other player only knows that her value is distributed in $[v, V]$ according to the probability distribution function $F(v_i)$ and the probability density function $f(v_i)$.

The investment requirement I and the noncompliance penalty p are common knowledge, as well as the government's reputation parameter $\mu \in [0,1]$. Furthermore, we suppose that $v - p > 0$, so that even if there is punishment for sure, the concessionaire firm will still make a profit in the concession phase when she decides not to invest.

The two players play a first price sealed bid auction where players bid the amount that they are willing to pay for the concession. When the players prepare their bids, they are aware of the continuation Operation Game that they will play with the government if they win the auction. Therefore, if a player i has value v_i, makes a bid β_i and wins the auction, it pays to the government the bided value β_i, receives the airport concession and then plays the Concession Game with the government[16].

5.2. The solution of the Auction Game

Let us derive the equilibrium strategies $b_1(.), b_2(.)$ of the players. We look for symmetric equilibria that are non-decreasing in the players' types.

Considering the result of the Operation Game, we can separate a player's type in basically two sets of types, one including the types who will make the investment I in the Operation Game and the other one including those types who will not invest, the noncompliants.

A player i of type v_i will be a noncompliant if $v_i < w_\mu$ and will invest if $v_i \geq w_\mu$. Let us analyze the behavior of a player in each one of these categories separately.

Consider first a noncompliant player i's bid. If he wins, he will have expected profit $v - \mu p$ in the concession period. Therefore, he will never choose a bid higher than that profit. Suppose he makes a lower bid $\beta_i < v - \mu p$. Then his opponent, when he is also a noncompliant type, can make a bid β_{-i}, $\beta_i < \beta_{-i} < v - \mu p$ and win. Therefore, $\beta_i < v - \mu p$ cannot be a best response for player i. Hence, a Bertrand-type analysis implies that noncompliant types will all choose bid $\beta_i = v - \mu p$, regardless of their value $v_i < w_\mu$:

$$b_i(v_i) = v - \mu p, \quad \forall v_i < w_\mu$$

Consider now a compliant player i's bid. For that player, $v_i \geq w_\mu$.

Suppose first that $v_i = w_\mu$. Then, if she chooses a bid $\beta_i < v - \mu p$, then she will surely loose. On the other hand, if she chooses a bid $\beta_i > v - \mu p$, her utility when she wins will be $v_i - \beta_i = (v - \mu p) - \beta_i < 0$. Therefore, her best response is to set $b_i(w_\mu) = v - \mu p$.

Suppose next that $v_i > w_\mu$. Then, she will choose a bit higher than $v - \mu p$ and win for sure if her opponent is a noncompliant or of type $v_i = w_\mu$, which occurs with probability $F(w_\mu)$. Therefore, if she chooses bid $\beta_i > v - \mu p$, her expected utility is:

$$(v_i - I - \beta_i)F(w_\mu) + \frac{v_i - I - \beta_i}{2}\text{Prob}[\beta_i = b_{-i}(v_{-i})] + (v_i - I - \beta_i)\text{Prob}[\beta_i > b_{-i}(v_{-i}) > v - \mu p]$$

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[16] In practice, β_i may be the present value of the stream of payments the concessionaire makes along the concession period.

Therefore, the best response of a compliant player of type $v_i > w_\mu$ is the solution β_i to the following maximization problem:

$$\max_{\beta_i}(v_i - I - \beta_i)F(w_\mu) + \frac{v_i - I - \beta_i}{2}\text{Prob}[\beta_i = b_{-i}(v_{-i})] + (v_i - I - \beta_i)\text{Prob}[\beta_i > b_{-i}(v_{-i}) > v - \mu p]$$

Let us look for a Bayesian Nash equilibrium (b_1, b_2) where the strategy of the compliant-type player is strictly increasing, i.e., for $v_i, v_i' > w_\mu$, $v_i > v_i' \Rightarrow \beta_i(v_i) > \beta_i(v_i')$, $i = 1{,}2$.

Then, b_{-i} is strictly increasing on $[w_\mu, V]$ and, thereby, invertible and, given β_i:

$\text{Prob}[\beta_i = b_{-i}(v_{-i})] = 0$ and,

$\text{Prob}[\beta_i > b_{-i}(v_{-i}) > v - \mu p] = \text{Prob}[b_{-i}^{-1}(\beta_i) > v_{-i} > b_{-i}^{-1}(v - \mu p)] =$
$\int_{w_\mu}^{b_{-i}^{-1}(\beta_i)} f(v_{-i})dv_{-i} = F\left(b_{-i}^{-1}(\beta_i)\right) - F(w_\mu)$

Therefore, her maximization problem can be reduced to:

$$\max_{\beta_i}(v_i - I - \beta_i)F(w_\mu) + (v_i - I - \beta_i)\left[F\left(b_{-i}^{-1}(\beta_i)\right) - F(w_\mu)\right]$$

Or, more simply,

$$\max_{\beta_i}(v_i - I - \beta_i)\, F\left(b_{-i}^{-1}(\beta_i)\right)$$

Assuming that the objective function is strictly concave, we can find the solution to this maximization problem calculating its first order condition (FOC).

$$\frac{d}{d\beta_i}(v_i - I - \beta_i)\, F\left(b_{-i}^{-1}(\beta_i)\right) = -F\left(b_{-i}^{-1}(\beta_i)\right) + (v_i - I - \beta_i) f\left(b_{-i}^{-1}(\beta_i)\right)(b_{-i}^{-1})'(\beta_i) = 0$$

In a symmetric equilibrium, all bidders choose the same bid function, i.e., $b_1(v) = b_2(v)$. Denote by $b(v)$ that common bid function.

Note that the solution β_i to the player's problem is the that player's bid, therefore, $\beta_i = b(v_i)$ and, since b is invertible (for $v_i > w_\mu$), we have $v_i = b^{-1}(\beta_i)$. Therefore, the above FOC can be rewritten as:

$$-F(v_i) + (v_i - I - \beta_i) f(v_i)(b^{-1})'(\beta_i) = 0$$

Now recall that if b is an invertible, differentiable function, then its inverse is also differentiable and $(b^{-1})'(\beta_i) = [b'(v_i)]^{-1}$. Hence, the FOC can still be written as:

$$F(v_i)b'(v_i) + b(v_i)f(v_i) = (v_i - I)f(v_i)$$

Therefore, from the Fundamental Theorem of Calculus, for every $w \in (w_\mu, v_i]$,

$$b(v_i)\,F(v_i) - b(w)\,F(w) = \int_w^{v_i} (y - I)f(y)dy$$

Now, by continuity, since $b(w_\mu) = v - \mu p$, we can write:

$$b(v_i) = (v - \mu p)\frac{F(w_\mu)}{F(v_i)} + \frac{1}{F(v_i)}\int_{w_\mu}^{v_i} (y - I)f(y)dy$$

In summary, the solution to the auction game can de written as:

$$b(v_i) = \begin{cases} v - \mu p & \text{if} \quad v_i \leq w_\mu = v - \mu p + I \\ (v - \mu p)\dfrac{F(w_\mu)}{F(v_i)} + \dfrac{1}{F(v_i)}\displaystyle\int_{w_\mu}^{v_i} (y - I)f(y)dy & \text{if} \quad v_i > w_\mu = v - \mu p + I \end{cases} \qquad (3)$$

Note that this will indeed be the solution to the auction game only if, when we replace $b^{-1}(\beta_i)$ in the original maximization problem, we find a strictly concave function. This can be checked once the ex-ante distribution function is made explicit.

Next section analyzes the role of the expected reputation of strength of the government on the behavior of the bidding firms.

5.3. The role of the government’s reputation

Consider now the effect of the expectation bidders have on the likelihood they are dealing with a social type government, i.e., a strong government that will not hesitate to apply the contract sanctions in case of noncompliance. This is measured by means of the parameter $\mu \in (0,1)$. The higher the value of μ, the higher the probability a noncompliant concessionaire will have to pay the fine p.

Note first that $w_\mu = v - \mu p + I$ decreases with μ, i.e., the noncompliance region decreases. This happens because the opportunity cost of compliance increases: when a firm decides not to comply it will pay a higher expected cost.

Next, if $v_i \leq w_\mu$, then $b(v_i) = v - \mu p$, which decreases with μ, i.e., the higher μ, the lower the bid a noncompliant concessionaire will set. This happens because the expected cost of noncompliance increases and, therefore, the noncompliant revises downwards his bid in order to compensate that expected cost.

Consider now a compliant firm, for which $b(v_i) = (v - \mu p)\frac{F(w_\mu)}{F(v_i)} + \frac{1}{F(v_i)}\int_{w_\mu}^{v_i}(y - I)f(y)dy$, and let $G(y)$ be a primitive of $(y - I)f(y)$. Then, $b(v_i)$ can be rewritten as:

$$b(v_i) = (v - \mu p)\frac{F(w_\mu)}{F(v_i)} + \frac{1}{F(v_i)}\left[G(v_i) - G(w_\mu)\right]$$

Note that $\frac{dw_\mu}{d\mu} = -p$. Hence, the derivative of $b(v_i) = b(v_i;\mu)$ with respect to μ is:

$$\frac{db(v_i;\mu)}{d\mu} = -p\frac{F(w_\mu)}{F(v_i)} + (v - \mu p)\frac{f(w_\mu)}{F(v_i)}(-p) - \frac{1}{F(v_i)}G'(w_\mu)(-p)$$

$$\frac{db(v_i;\mu)}{d\mu} = -p\frac{F(w_\mu)}{F(v_i)} + (v - \mu p)\frac{f(w_\mu)}{F(v_i)}(-p) - \frac{1}{F(v_i)}(v - \mu p + I - I)f(w_\mu)(-p)$$

$$\frac{db(v_i;\mu)}{d\mu} = -p\frac{F(w_\mu)}{F(v_i)} < 0$$

Therefore, the complaints reduce theirs bids as well, when μ increases. This is a consequence of the fact that there are less noncompliant types and these noncompliants choose lower bids.

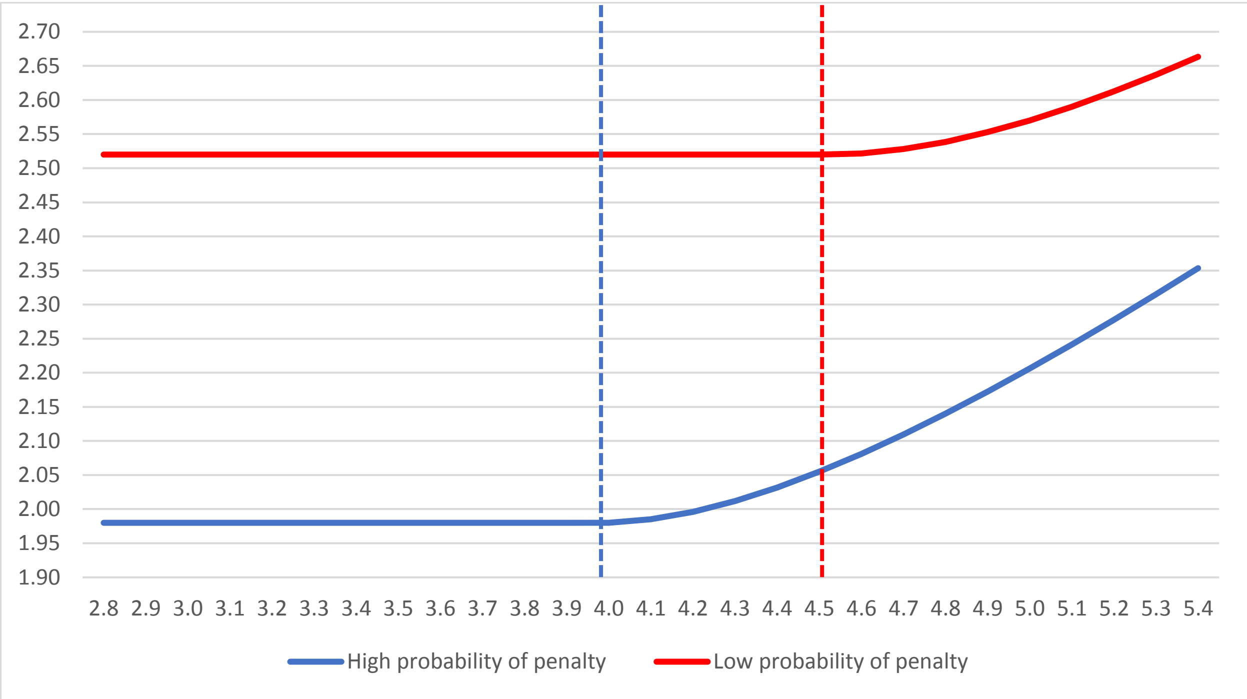
In summary, the better the government reputation of being a social, strong type, the lower the bids and the lower the noncompliance region. Conversely, the less likely the government is strong, the more aggressive bids will show up in the auction phase, but the more likely the concessionary will make the investments that are required in the concession contract.

6. The paradox of concessions: The better they appear, the worse they may be

The results presented in the previous section show clearly the tragic expected long-term implementation of concessions that require important investment on the part of the concessionaire. Indeed, when we observe higher than expected competition with high bids and a high selling price for a concession, this is exactly the situation one should also expect that the likelihood of noncompliance with the required investments is the lowest.

Therefore, an initially successful concession contract is a red light suggesting the government should follow carefully the investment schedule of the concessionaire, as that firm may more likely have decided not to invest already at the outset, when it participated in the auction.

Figure 5. The equilibrium bid functions for different levels of punishment probability: a simulation. $[\boldsymbol{v}, \boldsymbol{V}] = [\mathbf{2.7}, \mathbf{5.3}], \boldsymbol{I} = \mathbf{2}, \boldsymbol{p} = \mathbf{0.9}, \boldsymbol{\mu_{low}} = \mathbf{0.2}, \boldsymbol{\mu_{high}} = \mathbf{0.8}$.



Note: The red line corresponds to the bids in the low punishment probability $\mu_{low} = 0.2$ environment and the blue line corresponds to the bids in the high punishment probability $\mu_{high} = 0.8$ environment.
Source: The authors.

Figure 5 presents two simulations for the auction-operation sequential games. For this simulation we assumed that the players' types are uniformly distributed between 2.7 and 5.3 billion reals (the Brazilian currency[17]); the required investment is $I = 2$ billion reals and the penalty fine is $p = 0.9$ billion reals. We considered two values for the probability of the government type being strong; the blue line corresponds to the high probability

[17] Currently, one US dollar corresponds to approximately 4 Brazilian reals. We tried to use data extracted from one actual airport concession auction that took place in Brazil.

$\mu_{high} = 0.8$ whereas the red line corresponds to the low probability $\mu_{low} = 0.2$. With these parameters, the noncompliance threshold values are 3.98 for the case of high punishment probability and 4.52 for the case of low punishment probability. The simulation makes it clear that the worse the ex-ante reputation of the government, the higher the bids in equilibrium and the more successful the auction will appear.

In this specific simulation, the probability of having a winning concessionaire that will not make the required investments is:

$$F\left[w_{\mu_{low}}\right]^2 = \left[\frac{w_{\mu_{low}} - v}{V - v}\right]^2 = 49\% \quad \text{for } \mu = \mu_{low}$$

$$F\left[w_{\mu_{high}}\right]^2 = \left[\frac{w_{\mu_{high}} - v}{V - v}\right]^2 = 24\% \quad \text{for } \mu = \mu_{high}$$

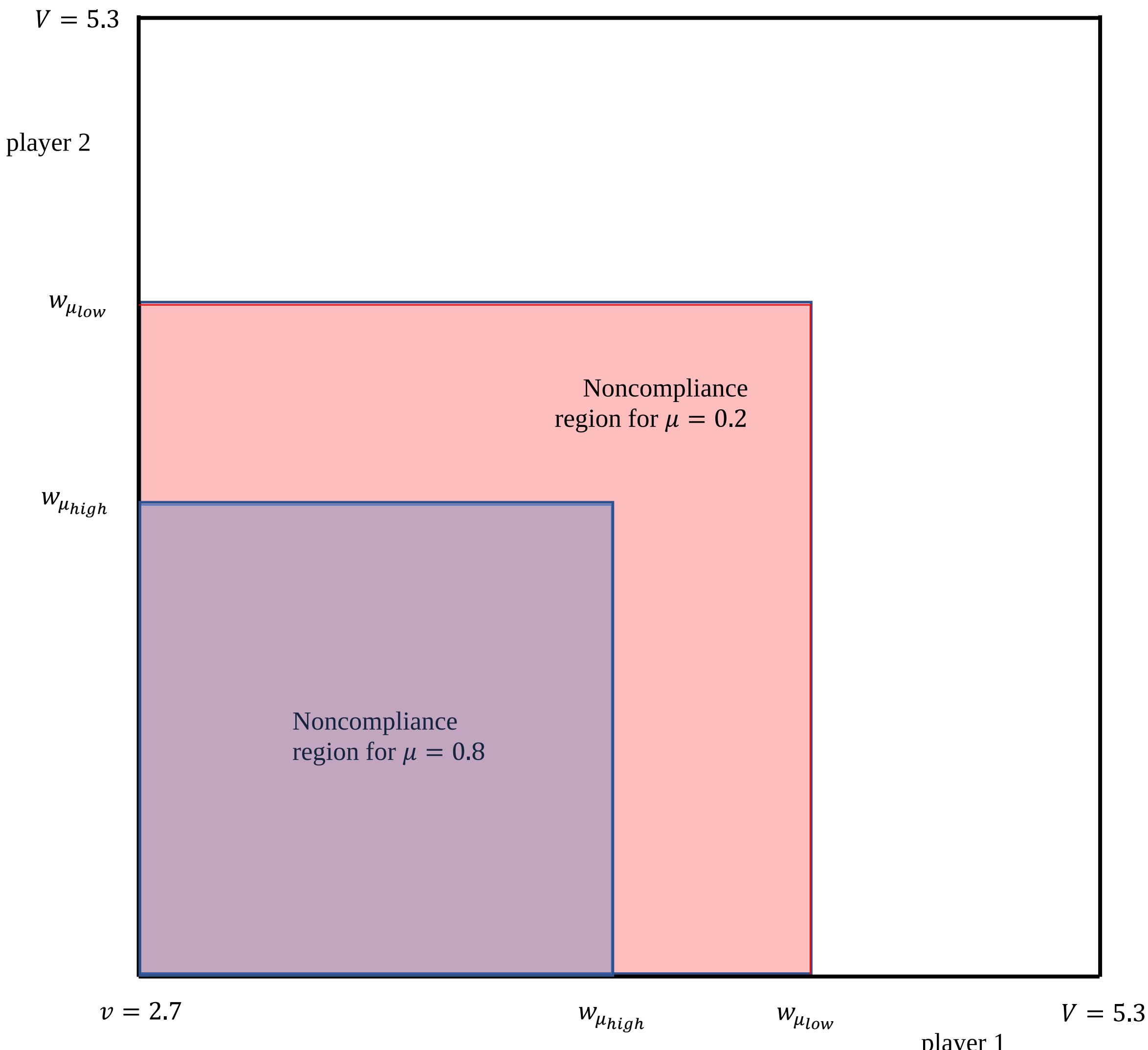
Figure 6 presents the regions of noncompliance in equilibrium for the above simulation.

This is the unfortunate consequence of a weak institutional environment where a firm may be able to break a contract and not being punished for it. Note that the present model focusses on the type of the government, arguing that a social (strong) type government cares more about the lack of popularity that will come from not punishing a noncompliant firm, whereas the concessionaire (weak) type government cares more about losing the support of the concessionaire. In addition to the government itself, there may be other constraints to the punishment of a noncompliant firm. In Brazil, the Judiciary is the utmost source of such institutional weakness. Indeed, the Brazilian Supreme Court has a historical record of protecting individuals or firms that do not act according the law.[18]

In the present model, these additional institutional issues can be modeled by introducing an addition parameter, say $\delta \in [0,1]$ in the expected punishment when the government decides to apply the penalty that is specified in the concession contract. In that case, the government still has to bear the cost of losing the firm's support, c_f, in the concession game, but the penalty will only be applied with probability δ because, for example, the firm will use all institution mechanisms available in order to avoid having to pay that penalty, such as appealing all the way to the Brazilian Supreme Court.

Figure 6. The region of values of the players where, in equilibrium, the winning concessionaire firm will not comply with the investment requirement: a simulation. $\boldsymbol{[v, V] = [2.7, 5.3], I = 2, p = 0.9, \mu_{low} = 0.2, \mu_{high} = 0.8}$.

[18] The Brazilian Supreme Court's most recent case is the ruling, on November 8, 2019, that all types of criminals will not be put in prison until all possible appeals have been resolved which, considering that there are four instances of appeal in the country's institutional framework, and all types of appeals for each decision taken in each instance, makes it virtually impossible for a rich criminal to be put in jail.



Source: The authors.

The consequence is that, in the Operation Game, the payoff when the firm does not comply, and the government decides to apply the fine increases from $v - p$ to $v - \delta p$. This, in turn, makes the government less likely to be strong, because the benefit of punishing the noncompliant concessionaire reduces to $c_s \geq c_f - \delta p$, which is less likely to happen. Thus, the parameter μ most reduce and the threshold $w_\mu = v - \delta\mu p + I$ increases. Therefore, we will observe: i) still higher bids in the auction phase; and ii) higher noncompliance in the concession phase.[19]

[19] The detailed calculations mimic the ones presented here and can be provided by the authors upon demand.

7. The Bonification Mechanism

The main motivation for the government to offer the concession of public enterprises in developing countries is the government's lack of investment capabilities. Therefore, one of the main goals of any concession mechanism in such countries is to create the conditions for the concessionaire to decide to comply with the investment requirements. However, an important characteristic of many developing countries is the lack of credibility of the government and, in general, of the countries' institutions. This suggests that the firms in a concession auction may most likely believe the likelihood of the government really being able to apply the due penalties are low, which implies that the likelihood of the concessionaries not investing are high precisely in the countries that are the most in need of private investment.

One way to deal with this adverse incentive of the institutional and reputation environment in developing countries is getting rid of the need for the government to have to decide whether or not to enforce the noncompliance penalties. This to be done while preserving the incentives for the concessionaire to invest. The present session proposes an alternative mechanism aiming precisely at aligning the investment incentives of the firm while, at the same time, freeing the government of having to decide whether or not to punish the firm.

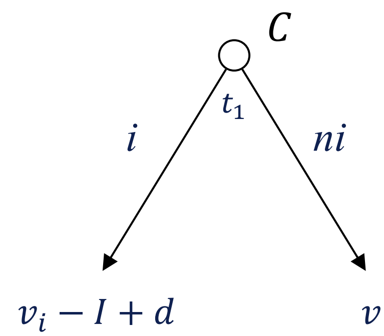
Suppose that in the operation game, rather than punishing a noncompliant firm, the government awards a reduction in the concessionaire payments if she did make the expected investment. This is especially implementable because the concession fees' payment is typically spread over a long period of time after the auction determines who is the concessionaire firm. Furthermore, the firm has to pay regular license fees as well. The deduction can be made from the entire due payment in case of proper investment. We call that mechanism the "Bonification Mechanism" and denote it BM and, for the sake of comparison, we call the original mechanism the "Traditional Mechanism" and denote it by TM.

7.1. The new Operation "Game"

Let d be a discount or deduction in the price the concessionaire has to pay – which is the auction winning bid – that can be reduced from the firm's concession payments to the government, in case the convened investments are concluded in the expected time. Then, the original concession game becomes a simple decision problem for the firm. If she does not make the expected investments, then she will pay the full original concession price. On the other hand, if she does make the investment, she will receive the additional discount d.

Figure 7 below presents the corresponding concessionaire decision problem.

Figure 7. The concessionaire's decision problem in the Bonification Mechanism



Source: The authors

Therefore, the concessionaire will decide to invest if and only if:

$$v_i \geq v - d + I$$

Note that the discount d in the present mechanism plays exactly the same role as the expected punishment μp in the original mechanism. However, now it does not depend on the type of the government. This is an objective, crystal clear, legal rule that is to be applied if and only if the investment has been made regardless of how strong or weak the government may be. Furthermore, as d is a parameter of the mechanism, it can be chosen by the government strategically according to its interest, as we will see next.

7.2. The new Auction Game

Consider now the new auction game induced by this mechanism and define $w_d = v - d + I$.

We can again separate the set of types of a player into two subsets. If $v_i < w_d$, then if player i wins, she will find not to her interest making the investment in spite of the benefit she would receive if she did invest: the investment is too expensive to her compared to the discount benefit. We call this type of player a "noninvestor" in analogy to the noncompliant type in the other model.

On the other hand, if $v_i \geq w_d$, then if that player wins, she will find in her interest to make the investment and receive the corresponding discount. We call this type of player an "investor".

A calculation analogous to the one developed in section 6 allows us to determine the symmetric Bayesian Nash equilibrium $(b(.), b(.))$ of this game as:[20]

$$b(v_i) = \begin{cases} v & \text{if} \quad v_i \leq w_d = v - d + I \\ v\dfrac{F(w_d)}{F(v_i)} + \dfrac{1}{F(v_i)}\displaystyle\int_{w_d}^{v_i}(y - I + d)f(y)dy & \text{if} \quad v_i > w_d = v - d + I \end{cases} \quad (4)$$

Therefore, the threshold that separates the noninvestors and the investors is the cutoff point $w_d = v - d + I$.

7.3. Comparison of mechanisms when $d = \mu p$

In order to better compare the two mechanisms, let us start assuming that the government sets the discount to $d = \mu p$. Then, $w_d = w_\mu$ and the cutoff point that separates noninvestors from investors in the bonification mechanism is the same as the cutoff point that separates noncompliants from compliants in the traditional concession mechanism.

In that case noninvestment region and, therefore, the probability of the concessionaire not investing remains the same as in the traditional concession mechanism. However, the two mechanisms are not equivalent. Indeed, comparing expression (3) with expression (3) it is straightforward to check that all bids, including those corresponding to the types in the noninvestment region, increase by precisely the amount d. In other words, the expected revenue of the government increases by that amount d. Therefore, the expected revenue of the government increases by d.

Therefore, in terms of expected revenue, the bonification mechanism is clearly superior to the tradition concession mechanism, as long as the government chooses the discount benefit to equal the expected penalty that the noncompliant concessionaire pays in the traditional mechanism.

However, the government wishes to maximize the entire his payoffs including the social benefit of investment and the net financial return of the concession. Recall G receives social benefit B when the investment is completed and $b < B$ when it is not made. Since

[20] The calculations' details can be made available upon demand to the authors.

when $d = \mu p$ the noncompliant types in the TM are precisely the noninvestors in the BM, the expected social benefit is the same under both mechanisms. Furthermore, the additional payment of the investors in the BM, d, is actually discounted by that precise amount d, so that the investors pay the exact same net amount as the investors in the TM. Finally, the noncompliants in the TG make the lower bid $v - \mu p$, but they also pay the expected fine μp when the G realizes it has not made the required investment. Thus, the expected net payments of the noncompliants is precisely that same amount v that the payments of the noninvestors in the BM.

Hence, in ex ante terms, i.e., before the government learns his own type, both mechanisms are completely equivalents. If, however, the government knows his type at the moment the selling mechanism is decided upon, the strong government knows that he will be able to enforce the full penalty payment p in case of noncompliance in the TM, in which case, he prefers that mechanism. Conversely, if the government knows that he is of a weak type, he prefers the BM, since he will not be able enforce the penalty payment in case of noncompliance in the TM.

7.4. Comparison of mechanisms when $d \neq \mu p$

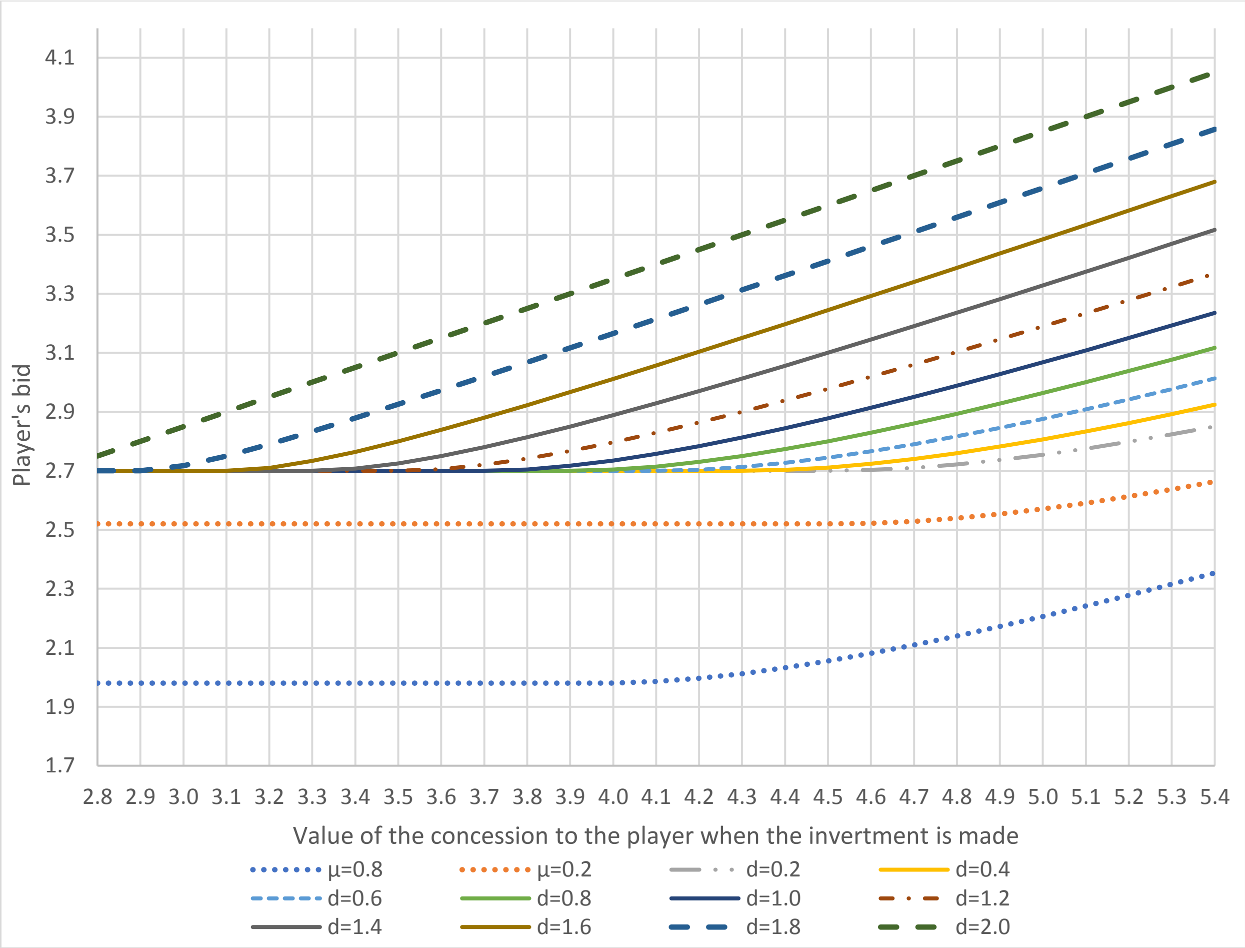
As discussed previously, whereas in the traditional mechanism the parameter μ (the government's reputation of being strong) is exogenous and, thereby, cannot be controlled by the government, in the bonification mechanism the parameter d can be set strategically by the mechanism designer.

Since $w_d = v - d + I$ is a decreasing function in d, the higher the deduction offered for the investment, the lower the noninvestment region. Moreover, from expression (4), it can easily be checked that the investors' bid functions are strictly increasing in d. More precisely, it can be shown that:[21]

$$\frac{\partial b(v_i)}{\partial d} = \frac{F(v_i) - F(w_d)}{F(v_i)} \in (0,1), \forall v_i \in (w_d, V] \qquad (5)$$

Figure 8. The equilibrium bid functions for different levels of punishment probability in the Traditional Mechanism and for different deduction parameters in the Bonification Mechanism: a simulation. $[\boldsymbol{v}, \boldsymbol{V}] = [\mathbf{2.7}, \mathbf{5.3}], \boldsymbol{I} = \mathbf{2}, \boldsymbol{p} = \mathbf{0.9}, \boldsymbol{\mu_{low}} = \mathbf{0.2}, \boldsymbol{\mu_{high}} = \mathbf{0.8},\ \boldsymbol{d} \in \{\mathbf{0.2}\boldsymbol{j}, \boldsymbol{j} = \mathbf{1}, \dots, \mathbf{10}\}$.

[21] Calculations available upon request to the authors.



Source: Authors' calculations.

Figure 8 adds to the strategies of the TM simulated in Figure 6, the equilibrium strategies for the BM for different values of the deduction parameter d, ranging from 0,1 to its maximal value $d = I$. The figure shows clearly the strong positive effect on the bids, that increase strongly with d, but most importantly, on the reduction of the noninvestment area, that corresponds to about two-thirds of the type interval for the TM with $\mu = 0.2$ and is reduced to about half of that interval with $d = 0.6$ in the BM and to about 25% of the interval with $d = 1.4$ and to investment for all types if there is total discount of the investment, i.e., $d = 2$. Note that the threshold for investment is virtually the same for $\mu = 0.2$ in the TM and for $d = 2$ in the BM (about 4.5) because $\mu p = 1.8$ which is almost very close to $d = 2$. Had we plotted the corresponding bid strategies for $d = 1.8$, the threshold would be exactly identical. The equivalence between these the two mechanisms when $\mu p = d$ will become still clearer in the next figure.

Then, if the government is mainly concerned with reducing the noninvestment area and increasing the auction equilibrium bids, it should actually set d to its maximum possible value, i.e. $d = I$.

However, as condition (5) makes it clear, a one dollar increase in the discount d yields an increase inferior to one dollar in the investor's bit. Therefore, one must include the opportunity cost for the government of discounting the amount d from the bids when there is investment.

Therefore, the net return of a winning bid must deduct the amount the government will not receive when there is investment in the BM. Similarly, when there is noncompliance in the TM one should add to the return to the government the expected penalty payment μp. Finally, in order to really being able to compare the two mechanisms, one must include the value to the government of having the investment done, the parameters B, and the analogous value of having the airport functioning without the investment, the parameter b.

Figure 9 replicates Figure 8 but now it shows the net utility of the government when each bid function is the winning function of the auction. Therefore, it takes into account the complete extent of the concession mechanism, including the payment after the auction, the penalties (for the TM), the discounts (for the BM) and the social benefits of the investing or not in the airport (B and b, respectively). In the corresponding simulation we set $B = V$, the maximum possible value of the firm's profits when there is investment and $b = v$ the corresponding minimal value when there is no investment at all.[22]

The graph shows clearly first the equivalence between TM and the BM when $\mu p = d$. Indeed, the ex post utility of the government is essentially the same for $\mu = 0.2$ with the TM and for $d = 0.2$ for the BM. Note, however, that the TM involves the complex issue of signal extraction (to determine μ) and may be further jeopardized by institutional instability such as the ones related to an judicial instability, whereas rules are clearer in the BM.

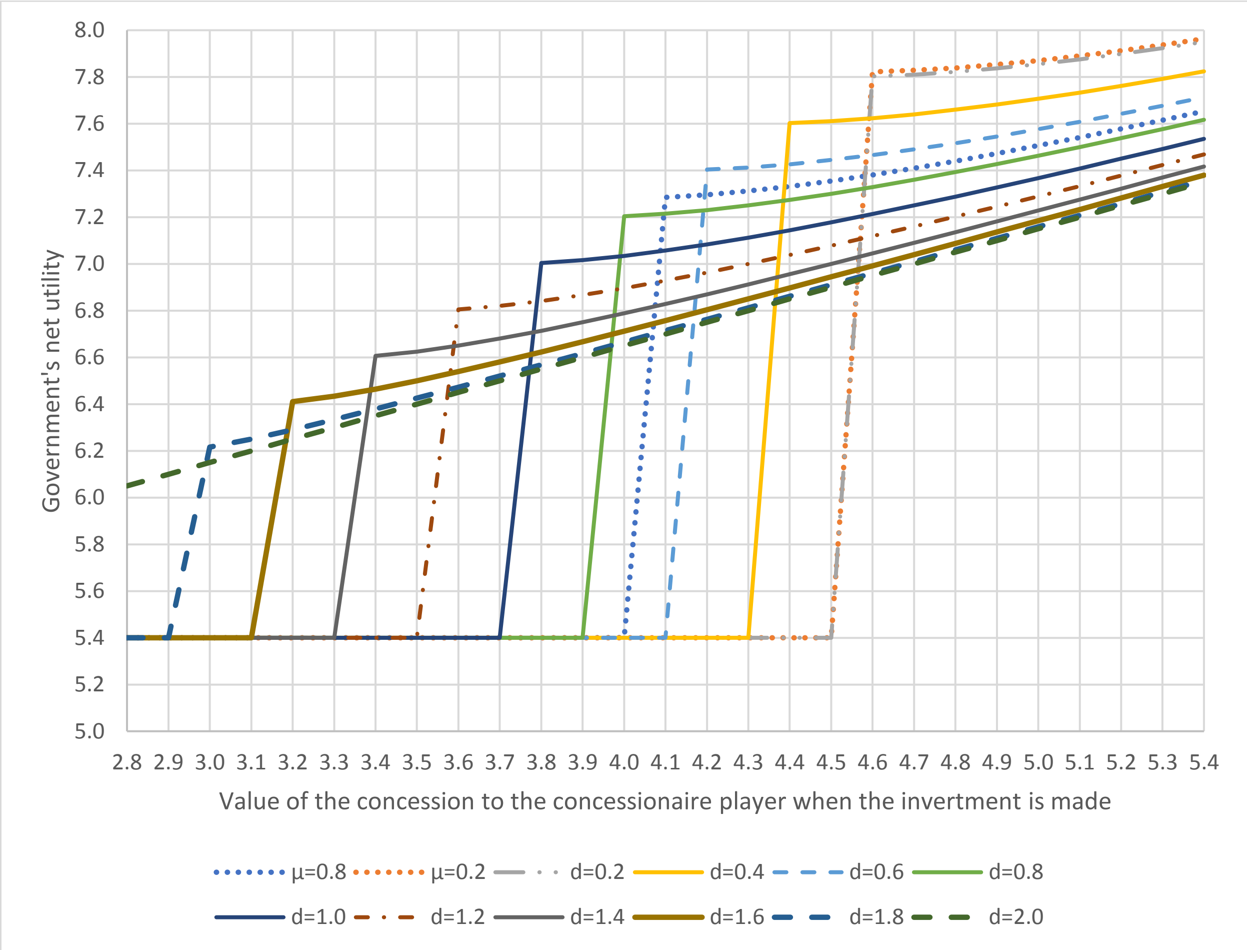
In addition, the graphs in Figure 9 highlight two important points for the comparison of the TM and the BM and about the choice of the deduction level.

First, the BM mechanism allows a more significant reduction of the noninvestment area. Indeed, with the TM even when the government has a very high reputation of $\mu = 0.8$, i.e., there is an 80% probability that the penalty will be enforced in case of noncompliance, about half of the types ($v_i < 4.2$) will still not invest. The BM, on the other hand, allows

[22] Note that the chosen parameters are conservative, as the returns are likely to be much higher when we consider the additional benefit to consumers.

the government to fine tune the noninvestment region, all the way to emptying it (all concessionaires will invest) by properly adjusting the deduction parameter ($d = 2 = I$).[23]

Figure 9. The net utility of the government associated to the equilibrium bid functions for different levels of punishment probability in the Traditional Mechanism and for different deduction parameters in the Bonification Mechanism: a simulation. $[v, V] = [2.7, 5.3], I = 2, p = 0.9, B = V, b = v, \mu_{low} = 0.2, \mu_{high} = 0.8, d \in \{0.2j, j = 1, \dots, 10\}$.



Source: Authors' calculations.

[23] It is true that the TM can also induce a higher compliance area by increasing the penalty p. However, there are two limitations to the amount of penalty that could be chosen. First, the concessionaire may argue, ex post, and in Court, that the penalty is economically abusive; this means that, in fact, the parameter μ, when also interpreted as to include the institutions, may be a decreasing function of the penalty p, which blocks the ability of the Government to increase μp significantly. Second, if the government is able to impose very high expected penalties, depending on the parameters of the problem, some firms may find it ex ante optimal not to participate in the concession auction at all, which may reduce competition.

Second, Figure 6 highlights the trade-offs between the choice of different deduction values in the BM. Indeed, the higher d, the lower the probability of noninvestment; however, the higher d the lower the ex post payment when there is investment. In other words, the higher d, the higher the set of types of firms that will invest, generating higher ex post utility to the government; however, the higher d, the lower the ex post return of an investing firm. Therefore, the optimal choice of d will depend on the actual parameters of the model and will be an intermediate value between 0 and I, and will still involve some level of noninvestment. The determination of the explicit general solution to the optimal level of deduction in the BM is left here as a suggestion for future research.

8. Conclusion

This paper used the recent history of airport concessions in Brazil as a motivation to analyze, on a theoretic point of view, the concession mechanism as two sequential integrated strategic interactions. The first one is the auction game where several companies compete for the concession. The second is the operation game, where the strategic interaction occurs between the concessionaire, who decides whether or not to make the investments required in the concession contract and the government, who decides whether or not apply the contract penalties if the concessionaire defaults.

The equilibrium behavior of the involved agents was found by solving the two games in reverse order. First, the operation game is solved, showing that the lower the credibility of government, i.e., the lower the likelihood that the government will effectively apply the contract penalties for default, the higher the probability that the concessionaire will not make the agreed upon investments. Second, the lower that credibility, the higher the equilibrium bids in the concession auction.

These results identify a phenomenon that we called the “paradox of concession” that says that the more successful the initial auction may look, with higher bids in equilibrium, the more likely it is that the concessionaire will not comply with the required investment, that are the main motivation for the concession itself.

In order to cope with this adverse equilibrium, the paper proposes an alternative mechanism, the Bonification Mechanism that replaces the penalty for default (that may not be enforced) with an ex post deduction in the concession fee in case the investment is indeed realized. This makes the deduction as objective part of the contract, not subject to the decision of the government and, thereby, not affected by the government’s reputation.

The use of the Bonification Mechanism, in addition to making the contract more objective and judicially secure, increases overall bids in the auction and can be fine-tuned in order to reduce the probability of noncompliance according to the government’s interests.

This is the main original contribution or this paper. This paper is a first attempt to carefully model the incentives that arise in the concession mechanism for airports that need significant investments, in an integrated framework that links the operation phase to the initial auction. The basic model, naturally, does not include several additional features of the real-world interaction, especially in the operation game. For example, although in the real-world contracts the investment are well specified in terms of their outcomes, such as building a new terminal with a specified capacity by a certain date, the noncompliance may be partial in the sense that a smaller terminal is built or the terminal is not completed on time. a more general model would consider the possibility of partial compliance in the traditional mechanism. Note that, in the BM this is note really an issue as the deduction would only take place once the investment is completed as required in the contract.

Another simple extension would be to explicitly include in the operation game the role of institutions in addition to the role of the government, as discussed in the text, to better disentangle these two factor, and being able to characterize the role of weak institutions on the likelihood the government will be of a strong type. The main insight here is that the cost of confronting firm for the government remain the same, but the financial return, in terms of expected revenue from enforcing the penalty, reduces. Therefore, the government is less likely to apply the penalty in weak institutions' countries.

A more significant extension would consider the possibility of the firm herself not knowing exactly her true value of the concession. The model would follow without much change if the concessionaire took her expected value into consideration in the auction phase. However, depending on the timing of real value discovery, the concessionaire may start making the investments and later find out that she is a low-value type and, therefore, stop the investment after having initiated them, or even go bankrupt.

The extension of the original model in order to include these additional frictions is left here as a suggestion for further research.

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