Abstract

The objective of this paper is to review the classical theoretic results in auction theory and the use of such results to address the resource adequacy problem of the Electricity Supply Industry – ESI, mainly in generation and transmission segments, through optimal design of procurement auctions for electricity services long-term contracts. Furthermore, in view of such literature, we analyze the current design of auctions intended to procure transmission services in Brazil in order to understand whether such design has been producing satisfying results.

The main conclusion from the specialized literature review is that it is possible to tailor an auction suitable to the specific features of the object being auctioned and of the participants bidding for that object. In order to do so, the auctioneer must create incentives for increasing the number and the aggressiveness of participants, as well as chose the type and amount of information available to bidders during the auction.

In the case of Brazilian transmission line auctions, for example, we conclude that after nearly five years and 68 auctions, the current design has been producing satisfactory results in terms of drastically reducing the expected tariffs while avoiding, so far, the risk of winner’s curse.

In the other hand, we identify an apparent incongruence between the optimal theoretic strategy for the Brazilian auction design and the actual strategy used by bidders. We were unable, however, given the limited data available, to determine whether this outcome can be exclusively attributed to the bounded rationality, to the auction design or if part of if can be explained by the participants’ inability to learn from past events.

1. Introduction

Since the mid-1980s, policymakers and regulators of several countries around the world have been engaged in the reform of their Electricity Supply Industry – ESI. The motivation for such reform initiatives vary case by case, but are generally driven by the introduction of market competition in order to stimulate the industry efficiency, to make prices more transparent and to transfer more risks to private investor rather than ratepayers or taxpayers.

Moreover, while ESI restructuring has been increasingly refined for the last 20 years, the role played by risks regarding resource adequacy have claimed special attention in the last years, mainly concerning the debate on whether competitive markets can stimulate adequate investment in new generation and transmission capacity.

In principle, this dilemma could be addressed by a liquid forward market based in long-term contracts for electricity supply or transmissions services which give to the investors the confidence to build a new power plant or a new transmission line based on the expected cash flow and the present net value of the investment.
In the other hand, policy makers need to properly design a contracting mechanism (or an auction) to ensure the public interest – investment adequacy and fair prices.

Thereby, the success of this resource adequacy approach relies mostly on the auction design, which should conciliate bidder attractiveness and fair electricity price. According to Klemperer (1999), there are four basic designs for standard auctions: the English auction (also called the open or oral auction), the Dutch auction, the first-price sealed-bid auction (also known as the pay-as-bid auction) and the second-price sealed-bid auction.

In the English auction, the price is successively raised until only one bidder remains and that bidder wins the object auctioned at the current price when his or her last competitor quits. There is no possibility for one bidder to leave the auction and then, at a higher price, come back in again.

The Dutch auction works exactly in the opposite way: the auctioneer starts at a very high price and then lowers the price continuously. The first bidder who calls out wins the object also at the current price.

In the two sealed-bid auctions, each bidder independently submits a single bid, without seeing others’ bids, and the object is sold to the bidder who makes the highest bid. In the first-price auction, the winner pays exactly the value of his or her own bid (that is, the price is the highest or “first” bid submitted). In the second-price auction, however, the price is the value of the second-highest bid submitted.

These four standard auction models differ from one another basically in terms of the way bids are placed and the amount of information available do bidders during the process. Additionally, the auctioneer may introduce new elements such as reserve prices and entrance fees, manipulate the amount of information available before the auction begins, or combine different auction models to forma a hybrid auction.

However, auction design is not a trivial issue. A good auction needs to be tailored to the specific details of the situation, and must also reflect the specific characteristics of the traded good and the wider economic circumstances. In order to find the appropriate auction design, an auctioneer must answer the following questions:

1. Is the object being auctioned a homogeneous and/or indivisible good?
2. Is the object’s value private, common, or a combination of both?
3. Are bidders symmetric and what is their preference with respects to risk?
4. Is there considerable risk of collusion among bidders?

However, the answers to these questions are often unknown, requiring auctions to be capable of dealing with multiple possibilities and inducing the adoptions of rules that promote the auctioneer’s interest, such as incentives for a larger number of participants and for more aggressive bids.

On section 4 we answer these questions for the Brazilian ESI, and analyze the results of 68 auctions for transmission services long-term contracts in view of the theoretical conclusions about auction design. Before that, we present in section 2 a quick overview of the recent challenges regarding resource adequacy in the

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1 An auction is called standard only if the winner is the one who bids the highest value and if the amount paid or received for the auctioned object is determined only for the submitted bids.
2 Note that for analytical means the Dutch auction and the first-price sealed-bid auction are strategically equivalent, since in both the winner pays exactly his or her own bid without extracting any kind of useful information from others bids until the auction ends.
ESI, and a review of the classical theoretic results in auction theory in section 4. Section 5 draws concluding remarks.

2. The electricity supply industry and the resource adequacy problem

Since the mid-1980s, policymakers and regulators in a number of countries around the world have engaged in market reform: liberalization, restructuring and privatization of the ESI.

The typical structure adopted for the ESI reform has the following basic elements (Woo et al., 2003):
1. The unbundling of the four distinct functions of the ESI: generation, transmission, local distribution, and retail services;
2. Deregulation of those functions where competitive markets can be introduced, typically wholesale generation and retail services;
3. Transmission and distribution services that remain regulated and are made available to all users under mandatory open access;
4. The creation of physical and financial markets for electricity trading; and
5. The creation of an independent system operator (ISO) to operate the transmission system (i.e., generation dispatch and reliability maintenance).

The motivations for such reform initiatives vary from case to case, but are generally driven by the desire to introduce competition in the hope of making the industry more efficient, making prices more transparent and transferring more risks to private investor rather than ratepayers or taxpayers (Correia et al., 2008). Therefore, competition among suppliers should create the conditions for ensuring that investments in electricity generation and transmission will be made prudently and that assets will be managed carefully and responsibly.

However, electricity has special characteristics which distinguish it from other industrial goods. First, electricity is a critical service to maintain civilized everyday life, and any disruption may cause serious damages. Second, while it is a service, in the sense that consumption and production occur simultaneously, these two stages usually take place in separate and distant locations, creating transportation issues. Third, energy sources (e.g. water, coal, natural gas, etc.) have extremely limited storage flexibility. Finally, considerable time as well as huge amounts of investment is necessary to construct new facilities for production, transmission and distribution.

As a result, supply curve of electricity is very steep in the vicinity of generation or transmission capability limit. Therefore, sustained price run-ups and volatility are inevitable in tight supply situations, which imply high political costs once electricity is indispensable to voters’ everyday life. In this sense, it is necessary to take measures to avoid sustained price run-ups, even if the industry is deregulated. The most secure measure is to have appropriate supply capability to meet demand growth. However, if one waits until the price signal induces investment, it will be too late to avoid price spike and volatility (Lee, 2004).

While ESI restructuring has been increasingly refined for the last 20 years, in recent years the role played by risks regarding resource adequacy have claimed special attention, mainly concerning the debate on whether competitive markets can stimulate adequate investment in new generation and transmission capacity.

This dilemma could be addressed by:
1. The absence of any kind of price spike mitigation;
2. A mandatory reserve requirement to serve end-use consumers; and
3. A liquid forward market based in long-term bilateral contracts.

However, while electricity prices are usually very volatile, consumer’s capability to answer to prices signals is extremely limited, which means that consumers have little ability to defend themselves when a dominant supplier engages in the exercise of market power (Adib and Hurlbut, 2008). Until demand response matures, market monitors and price spike mitigation have a crucial role to play.

Another alternative would be a mandatory requirement for power producers to maintain a target reserve margin (ranging, for example, between 10% and 25%) to ensure a given level of reliability and resource adequacy. This approach requires a mix of resources specifically designed to serve fluctuating demand and to meet future load growth, which entails strong interference in the market, including customer’s choice, to impose extra and often unnecessary cost on consumers.

Thus, the reliability of the electricity service rests better on long-term bilateral contracts which give investors the capability to foresee, with a reasonable certainty, the project’s expected cash flow and net present value. Thereby, it means that policy makers need to properly design a contracting mechanism to ensure the public interest – investment adequacy and fair prices.

The Brazilian approach to address the resource adequacy problem has been based on long term contracts resulting from specific procurement auctions for electricity supply and transmission service. Auctions are used precisely because investors, consumers and regulators are unsure about the value of a long-term contract to build and operate some specific electricity utility. Thereby, the success of this resource adequacy approach relies mostly on the auction design which should conciliate bidder attractiveness and fair electricity price. However, auction design is not a trivial issue. A good auction needs to be tailored to the specific details of the situation, and must also reflect the specific characteristics of the traded good and the wider economic circumstances.

3. Auction theory overview

Auction theory is important for both theoretical and practical reasons. First, auctions may be understood as a simple set of rules that create a well-defined competitive environment which has, as a main feature, the ability to lead quickly to the price revelation of a given good, though its value may be initially unknown. Such attributes demonstrate that auctions are a very valuable testing-ground for economic theory and understanding auctions may help develop the understanding of the process of price formation under imperfect competition – especially oligopolistic pricing and competition under incomplete information.

Second, an increasing volume of economic transactions is conducted through auctions. Not only individuals sell and buy art, houses and cars, but also firms trade inputs and final goods and Governments negotiate treasury bills, foreign exchange, mineral rights or public concessions.

There is a powerful theoretical result, first demonstrated by Vickrey (1961), known as the Revenue Equivalence Theorem – RET, that shows that in any form of standard auction the expected payment function of a bidder does not depend on the particular auction form and the expected revenue in any auction is the same. This theorem is a benchmark of the auction theory – all others results in the area constitute a departure from the RET and can be measured against it – and its result holds when all the following assumptions are ensured:
1. **Private value & independence**— each bidder knows the value of the object to himself at the moment of the bid and the bidders’ private information values are not correlated;

2. **Rationality** – all bidders seek to maximize their expected profits;

3. **Risk neutrality** – Bidders are indifferent between a sure chance of gain or loss and an unsure chance of the same amount of gain or loss;

4. **Absence of budget constraints** – all bidders have enough budget to pay up to their respective values;

5. **Symmetry** – all bidders draw their value according to the same distribution function \( F(.) \);

6. **Competition** – the absence of collusion among bidders.

The general proof of the RET is due to Riley and Samuelson (1981), which showed that all auctions forms at which the bidder with the highest value wins yield the same expected revenue to the seller. Moreover, the equilibrium-bid functions under RET assumptions are strictly increasing and symmetric and the expected revenue must equal:

\[
 n\int_r^{\overline{v}} \left( vF'(v) + F(v) - 1 \right) F(v)^{n-1} dv,
\]

where: \( n \) is the number of potential bidders; \( v_i, i = 1, \ldots, n \) is the valuation that bidder \( i \) assigns to the auctioned object; \( F(v) \) is the common independent and identical distribution of the reservation values which is strictly increasing and differentiable over the interval \([v, \overline{v}]\); and \( r \) is the reservation value below which is unprofitable to submit bid.

Intuitively, such result may be understood as a consequence of a compensatory balance between the dominant bidding strategy and the price definition rule. In a second-price auction, for example, each bidder knows that his or her own bid is the unique criterion to determine his or her winning chances, but has no effect over the expected price in a victory scenario. Thereby, the dominant strategy is to bid his or her real object valuation.

In contrast, in a first-price auction equilibrium behavior could not be to bid an amount equal to the real object valuation, since it would guarantee only a payoff of zero. Thus, bidders face a simple trade-off: an increase in the bid will increase the probability of winning while, at the same time, will reduce the gains from winning. Consequently, the dominant strategy is to bid an amount equal to the expected bid of the second higher valuation bidder.

We will now into review the main theoretical results for how the revenue equivalence principle is affected in terms of optimality and efficiency when different assumptions are relaxed.

First we relax the assumption of private values by allowing for the possibility that bidders have only partial information regarding the value. The other bidder, for instance, may have exclusive information concerning geological or environmental risk that would, if known to a particular bidder, affect the valuation he or she assigns to the project of power plant or transmission net auctioned.

The resulting information structure is called *interdependent value* and each bidder has some private information concerning the value of the object (or project). Bidder \( i \)'s private information is summarized as
the realization of the random variable $X_i \in [0, w_i]$, called $i$’s signal. The value of the object to bidder $i$, $V_i$, can then be expressed as a function of all bidders’ signal and we will write

$$V_i = v_i(X_1, X_2, ..., X_N),$$

where the function $v_i$ is bidder $i$’s valuation and is assumed to be nondecreasing in all its variables and twice continuously differentiable. In addition, it is assumed that $v_i$ is strictly increasing in $X_i$.

The interdependence of values complicates the decision problem of a bidder. In particular, since the exact value of the object is ex ante unknown and depends also on other bidders’ signals, an initial estimate of this value may need to be revised as a result of events that take place during or after the auction. In an extreme case, the announcement that a particular bidder has won with a bid much higher than the other bids may lead to a decrease in his or her own estimated value. In this sense, winning brings “bad news”. A failure to foresee this effect and take it fully into account when formulating bidding strategies will result in what has been called the winners’ curse – the possibility that the winner pay more than the real value, which will be know only ex post.

Besides its effect over bidders’ strategy, interdependent values alone do not affect the RET. With interdependence and affiliated values, however, the RET no longer holds. Affiliation means that the bidders’ information are positively correlated – that is, if a subset of the $X_i$’s are all large, then it is more likely that the remaining $X_j$’s are also large.

Thus assuming interdependent values and affiliation, the difference between auction forms derives from the fact that in an English auction active bidders get to know the prices at which the bidders who have dropped out have done so. This allows the active bidders to make inferences about the information that the inactive bidders had and in this way to update their estimates of the true value. A sealed-bid or a Dutch auction, by its very nature, makes no such information available.

According to Krishna (2002), all the four auctions types mentioned have symmetric and increasing equilibria, which means that the winner will be the one with the highest final value, even when he or she did not have the highest initial signal, ensuring the efficiency of all alternatives.

However, regarding to the expected revenue, Krishna (2002) also shows that the English auction should outperforms the second-price auction, which in turn, out-performs the first-price and the Dutch auction. Such revenue ranking is a consequence of the different auctions’ forms capability to dissipate the exclusivity of bidders’ information and to mitigate the winners’ curse risk. Therefore, the release of public information in any of the four formats should lead to higher revenues and to a lower difference between the expected revenues.

Now we restore the private value assumption and relax the hypothesis that bidders are risk neutral. Riley and Samuelson (1981) approached this subject in a classical paper and proved that the introduction of risk aversion does not affect the biding strategy dominance in a second-price or in an English auction. However, in a first-price or Dutch auction, the authors demonstrated that the bidders become more aggressive and make uniformly higher bids. Consequently, the auctioneer enjoys greater expected revenue under first-price auction than under second-price or English auctions.
The intuition behind these results is that with risk aversion the marginal increment in profit associated with a successful, slightly lower bid is weighted less heavily than the possible utility loss if, as a result of lowering the bid, the bidder is no longer the winner. This leads risk-averse bidders always to attempt lower bids than risk-neutral bidders. Therefore, in a first-price auction there is a positive probability that a risk-averse bidder with lower reservation value than a risk-neutral bidder will win the auction, that is, under risk-averse assumption there is no guarantee that the auctioned object will be efficiently allocated.

Now we restore the risk neutral hypothesis and relax the assumption that bidders are symmetric ex ante in the sense that their preference parameters are drawn from the same joint probability distributions $F_i()$, thus if two bidders are asymmetric they will have different beliefs about the remaining bidders’ preferences. Once more, we reference the classic literature to illustrate the results. Maskin and Riley (2000) showed that under different assumptions about the nature of the asymmetry, the first-price auction may produce higher expected revenue than the English and the second-price auctions.

To illustrate their conclusions, Maskin and Riley presented three examples of an auction with two bidders competing for a single object. They assumed that bidder $i$’s valuation $V_i$ is private while the other bidder’s is a random variable $\bar{V}_i$ with support interval $[\beta_i, \alpha_i]$ and $F_i()$. Asymmetry was represented by the assumption that one bidder may be described as “strong” (s) and the other as “weak” (w), which means that $F_s()$ first-order stochastically dominates $F_w()$. Finally, the other RET assumptions still hold.

In their first example, Maskin and Riley supposed the weak bidder valuation is distributed uniformly on the interval $[0,1]$ and that the strong bidder valuation on the interval $[2,3]$. That is, the strong bidder distribution $F_s()$ is shifted to the right. Hence, the authors concluded that, when the strong bidder’s distribution is such that, with high probability, his or her valuation is much higher than that of the weak bidder, the first-price auction will tend to generate more revenue than the English or the second-price auctions.

In their second example, Maskin and Riley supposed that the weak bidder’s valuation is distributed uniformly on $[0, \frac{1}{1+z}]$ and the strong bidder valuation on $[0, \frac{1}{1-z}]$ for $z \in [0,1]$. That is, the strong bidder has the same distribution as the weak bidder, only “stretched out” over a wider interval. Under such assumption, the authors proved that expected revenue is strictly greater for the first-price auction than the English and second-price auctions when $z > 0$.

In their last example, Maskin and Riley supposed that both bidders have degenerate distributions in which all probability mass is confined to the points 0 and 2. The strong bidder has all probabilities concentrated on 2 and the weak bidder has half probability on 0 and half on 2 – the probabilities that weak bidder has valuation 0 or valuation 2 are $\frac{1}{2}$ each. The remarkable conclusion of this example is that if the strong bidder does not get a positive payoff from bidding so high that she or he is assured of winning and does have a positive expected payoff from bidding very low, then there is an incentive to “low ball” that works against the first-price auction. Thus the English or second-price auctions out-perform the expected revenue from the first-price and the Dutch auctions.

Maskin and Riley noted that low-balling strategy is feasible only when preferences are affected by strong idiosyncrasy, as could be expected in art markets, and the demand is extremely thin. In contrast, if we find at least two bidders in serious competition, a low-balling strategy will no longer be viable. Thus the authors

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3 Restoring private values assumption, the English and the second-price auctions are strategically equivalent again.
pointed that we should expected the first-price auction to generate higher revenue than English or second-price auction.

Regarding efficiency in asymmetric auctions, Krishna (2002) noted that it is a weakly dominant strategy for a bidder to bid his or her reservation value in a second-price or in an English auction, so the winner bidder is also the one with the highest value and such auction form is always ex post efficient under assumption of private values. In contrast, asymmetries allow inefficient allocations in a first-price or in a Dutch auction since there is a positive probability that the bidder with the lowest reservation value wins the auction.

If we have affiliated values, the effects of asymmetries can be even more dramatic. If one bidder has a small advantage, for example, a slightly higher private value component in a setting that is close to common-value, that specific bidder may be a little more aggressive. This will make the opponent more cautious about the risk of winner’s curse, since winning against a more aggressive competitor is the worse new in a common-value auction, thus she will be a little less aggressive. So the first bidder’s winner’s curse odd is ameliorated and he or she can bid a little more aggressively still, and so on (Klemperer, 1999).

Therefore, since the winner of an almost-common-value open auction may often have the lower reservation value (the sum of private and common values elements), in this context the English auction may be inefficient and very unprofitable generating expected revenue even lower than a second-price auction. In contrast, in a first-price auction a small change to the symmetric value distribution model results in a small change to the symmetric equilibrium. So the first-price auction is almost optimal for a revenue-maximizing auctioneer.

We relax now the assumption of fair competition by supposing that a set of bidders may have a pre-auction collusive agreement to try to designate the winner and divide the gain by making appropriate side-payments. Krishna (2002) shows that collusion may be easier to sustain in a second price or an English auction than in a first-price auction, since, cartel agreement in a first-price auction is not self-enforcing and, hence, there is incentive for bidders to cheat the cartel.

So far, we have assumed implicitly that the auctioneer agrees to negotiate the object whatever price comes out the auction process. In many auctions, however, the auctioneer reserves the right to not sell the object if the price determined in the auction is lower than some threshold amount, say \( r > 0 \). Such a price is called reserve price.

Suppose that the auctioneer attaches a value \( x_0 \in [0, w] \), this means that if the object is left unsold, the auctioneer would drive a values \( x_0 \) from its use. Then the overall expected payoff of the auctioneer from setting a reserve price \( r \geq x_0 \) is:

\[
\Pi_0 = N \times E[m^S(X, r)] + F(r)^w x_0, \tag{3}
\]

where \( E[m^S(X, r)] \) is the expected payment by a bidder with value \( x \) in a standard auction \( S \) with reserve price \( r \).

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^{4} Bidders with common-value are an extreme and special case of affiliated value and means that all bidders’ reservation values are identical functions.
Since, if \( x_0 > 0 \) the derivative of \( \Pi_0 \) at \( r = x_0 \) is positive and if \( x_0 = 0 \) the derivative of \( \Pi_0 \) at \( r = 0 \) is 0, then the auctioneer may offset the potential loss of not selling the object by the expected gain if \( x_0 > r > \max x_j, j \neq i \). Thus a revenue maximizing auction should always set a reserve price that exceeds his or her value.

Additionally, it is interesting to consider the effects of the number of bidders in the expected revenue. Bulow and Klemperer (1996) show that when bidders are symmetric and value private, and also in a wide class of common-value settings, an English auction with no reserve price and \( N+1 \) bidders is more profitable than any standard auction with \( N \) of these bidders. Krishna (2002) considers auctions where bidders with private values are uncertain about how many rivals they are competing with. The general result shows that the RET still holds even if there is uncertainty about the number of bidders and the equilibrium bidding strategy in a first price auction is a weighted average of the equilibrium bids in auctions when the number of bidders is known to all bidders.

Consider now a situation in which a set of \( K \) identical objects are sold to \( N > K \) bidders using a sequence of auctions, specifically, consider that one of the objects is auctioned and that the winning bid and the final price (when the auctioneer is not using a first-price format) are announced before the second auction starts and so on.

When we restrict attention to the case that bidders are risk neutral, have private value and each one has interest only on a single unit of the object, Krishna (2002) shows first that there is an option value associated with not winning the current auction – the expected payoff arising from the possibility of winning some future auction. Consequently, in both first-price and English sequential auctions, the expected price of the next auction is the same as the closing price of the last one, which is known as a martingale equilibrium price path. This occurs because the equilibrium price path is affected by the interaction between the decreasing availability of supply relative to current demand and the fact that the remaining bidders have smaller valuations than the winners of the previous auction. Precisely, the equilibrium when those two vectors exactly offset each other is a martingale.

The martingale property of prices with symmetric independent private values was first derived by Milgron and Weber (1982). They also studied sequential auctions with interdependent and affiliated values and, under these latter assumptions, the equilibrium price path is no longer a martingale. Remarkably, they expect that prices have a tendency to drift upward because each price announcement carries now valuable information over object real value.

These results, however, were all derived under the restrictive assumption that all bidders have interest in only a single unit. Once a particular bidder has won the first unit his behavior and interest are different from those of the remaining bidders. In other words, even if bidders are symmetric \( \text{ex ante} \) multiunit demand introduces asymmetries in sequential auctions, such effect is even more dramatic when the auctioned objects are not identical, especially when the objects are complementary to each other.

However, if the auctioned objects are not identical, nor substitute, nor complementary, a sequence of auction in a short interval of time – the same day, for example – has the only effect of making it easier for bidders to engage in cooperative strategies such as collusion or cartel. Under such conjuncture the auction should be done simultaneously.
4. Brazilian Hydroelectric Plants auctions

As we saw in section 2, some of the power industry’s special characteristics make it risky to rely only on price signals to ensure adequate investment and to avoid price run-up and volatility. A possible solution is move competition from spot markets to long-term contracts for projects in electricity generation and transmission, but, because the exact value of these contracts is unknown, the auction design to be used is a main issue and should be tailored to conciliate bidder attractiveness and fair prices.

Currently there are four different auctions types taking place in the Brazilian ESI. The first type is for procuring the energy from existing power plants that, since there are no more uncertainties about the cost of investment, can be treated as divisible goods of purely common value. The auction in this case has a mixed design, with two stages. The first stage is a reverse English auction with a reservation price, while the second stage is a first-price auction. Transition from the first to the second stage occurs when the total supply of the remaining projects is slightly higher than the demand reported by consumers.

The second type of procurement is for “availability” contracts for new thermoelectric projects, as well as projects with alternative sources such as small hydroelectric plants, biomass and wind power. Few entrance barriers have been identified for these projects, given their relatively small budgets, making supply usually higher than demand. For that reason, Brazilian regulators treat such object as a common value one in a quasi-competitive market, allowing for the same auction design as for existing projects discussed above.

The third type of procurement regards the contracting of new large hydroelectric plants that require a concession or authorization for the use of a public good (river flow)\(^5\). Such auctions differ from the above in the following sense:

1. High uncertainty about the true cost of investment, especially as a result of multiple engineering possibilities in each one of them.
2. The existence of significant entrance barriers given the high costs and long maturity period of each project, increasing the possibility of collusion among competitors;

As a result, these auctions have the opposite design, that is, they begin with a first-price stage being followed by an English auction stage. This second stage occurs only if there is at least one sealed-bid within a certain range from the first-price bid, given by \((b^* + \gamma (b^*))\), where \(b^*\) is the first-price and \(\gamma\) is a small chosen parameter, usually fixed at \((5\% \times b^*)\). The auctioneer also establishes a reservation price in order to minimize the cost of collusion.

The last type of procurement in Brazil is for contracting transmission services from new facilities, with very similar characteristics to those of large hydroelectric plants. Thus, the same auction design is adopted.

_Auction Design Analysis_

In this paper, we focus on the last type of auction, the two-stage, first-price plus English auction with reservation price for the procurement of large power or transmission projects.

\(^5\) These are basically Public-Private Partnerships where investors build, operate and transfer (BOT) a plant after a 35 year period.
The first step in order to understand whether the Brazilian design is appropriate is to verify the basic features of the object being auctioned. When we negotiate long-term contracts, consumers are looking for electricity and transmission services which are relatively simple and homogenous goods or services. However, investors see the problem from a different point of view since such contracts are attached to unique engineering projects with a very specific investment cost and expected net present value.

Thereby, we can assume that the contracts to be auctioned are nonidentical, not homogeneous and, since they may have complementariness, they have both private and common value elements. The weight of each element depends on engineering features and commercial externalities – projects with many engineering risk or environmental uncertainty tend to have more common value weight and projects which have strong scale or scope economies or may have strong effect on market share tend to have more private value weight.

The second step is to answer the question about the bidders’ characteristics: Are the bidders symmetric and/or risk neutral? Specifically in respect to transmission line projects, the pool of potential participants is composed essentially by asymmetric agents, who may, however, group up in “clusters of symmetry” according to their profile: state enterprises, construction companies, institutional investors (funds) etc. Therefore, although the possibility exists for there being an auction with basically symmetric bidders, the odds are that most auctions will have asymmetric bidders. And the same may be expected in terms of risk-preference, that is, there could be agents averse or neutral to risk.

The last step is to ascertain the risk of collusion among bidders. Although large generation and transmission projects are indivisible goods during an auction, there are ways for participants to share the rent from these contracts after the auction is over, by including former competitors as partners or as service providers for the project. Additionally, in the case of sequential auctions, entrepreneurs may agree on sharing the different projects among themselves, eschewing competition. Thus, we the risk of there being collusion agreements between bidders must not be underestimated.

As a result, we may assume that procurement auctions for long-term contracts for projects in electricity generation or electricity transmission are bound by the following assumptions:

1. Interdependent value and affiliation;
2. Rationality;
3. Varying preferences in respect to risk;
4. Absence of budget constraints;
5. Random strategy possibilities – with higher probability of having asymmetric bidders;
6. Imperfect competition – there is the possibility of tacit collusion among bidders.

Under such conditions, according to the theoretical results assumed in section 3, auctions for long-term transmission contracts should be first-price sealed, with public reserve price and high information disclosure by the auctioneer. A sealed bid has a double effect: it stimulates betrayals among bidders and increases the number of potential participants by creating better chances for weaker bidders to play aggressively and win the auction.
As for the option for the first price, it is based on the assumption that bidders are likely to have asymmetric strategies, and as such it should maximize the consumer benefit. On the other hand, a first-price design makes strategies more complex and increases the risk of winner’s curse. This, in turn, makes information access an essential issue, and the auctioneer must produce and disclose as much information as possible.

Finally, the reserve price works as a signal for bidders about the value attributed by the auctioneer to the object on auction and, moreover, it gives extra protection to consumers in the event of successful collusion strategies.

Thus, considering such auction design (as is the case of transmission services contract auctions), we expect high bid differences for the first objects being auctioned. As the sequential auction proceeds, we would expect bids to increase in average (smaller discounts in respect to the reserve prices) and to converge among themselves, once bidders start to extract information from their competitors strategies.

Brazilian auctions

Perhaps the most important feature in Brazilian generation and transmission services contract auctions is the policy toward information disclosure. In the months prior to the auction, the auctioneer prepares and makes available a number of documents and studies about the projects, including:

1. Copies of concession contracts and service provision contracts to be signed by winners after the auction. These documents include precise information about capacity and delivery rules for generation projects, and tension level, connection points and the number of substations for transmission projects.
2. Detailed technical information about the mandatory features of each project, as well those features for which investors have the freedom to change according to their own studies.
3. The programmed schedule of works, along with an estimated budget for the projects’ main items, which was used to define the reserve price for the auction. The reserve price itself is made public thirty days prior to the auction.
4. Geographic and geological maps and studies pertinent to the project.

All the information listed above is made available thru the internet, major newspaper and during public meeting and workshops aimed at clearing doubts from potential investors. The auctioneer’s strategy is to minimize information asymmetry among players, as well as risk and uncertainties about each project. In so doing, he/she helps to counterbalance the inability of bidders of obtaining relevant information from each other during the auction due to the sealed-bid design. Bidders can only learn any new information in case the auction moves on to the second stage, or when final prices are revealed.

In comparison to the recommended design by the classical literature discussed above, the design for procuring long-term contracts for large energy generation and transmission projects in Brazil differs mainly in respect to the existence of the second, English-auction stage after the first-price sealed-bid stage is over. An interesting question to ask, then, is what sort of implications this combination of auction types may lead to?

One possible answer is that it could be useful in case where bidders have little idiosyncrasy and are sufficiently aware of the common value weight of the project, which would lead them to make close bids,

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6Notice that the dominant strategy in a first-price auction is to bid an amount equal to the expected value of the second best bid.
allowing for the occurrence of the second stage and thus removing any over-protection against winner’s curse.

However, the occurrence of the second stage may result mainly from accidentally close bids, either due to coincidence or to the interaction of different assumptions. For example, close first bids may result from the fact that while one bidder has more information, the other has a different, more aggressive strategy, due to idiosyncratic issues. In this particular case, we might expect a very small price decrease in the event of a second stage. In any case, if the range given by \((b^* + \gamma (b^*))\) is small enough not to affect strategy behavior due to risk preferences in sealed auction, the expected consumer revenue resultant from the Brazilian auction is at least the same expect in a common first-price auction.

Analyzing the empirical results for such double-stage, sequential auction for the procurement of an object with part common part private value, with bidders possibly asymmetric and with there being high likelihood of collusion may help us understand …

**Auction results for transmission lines**

In order to test the consistency and adequateness of the Brazilian auction design for large projects, we analyzed data from 68 auctions for the procurement of transmission lines, from 10 different dates between 2003 and 2008. In this same period, there were also auctions for 15 hydroelectric plants\(^7\), but since part of the information from non-winners were never made public, these auctions are not considered in the present analysis, sufficing to say that all of them ended in the first stage, that is, the price difference between the first price and the second were higher than the minimum required for continuing the auction.

The first significant pattern to report in respect to the transmission line auctions is that the reserve price doesn’t seem to be a restrictive parameter for bidders’ strategies. From the 68 auctions recorded, none ended without at least one bidder interested in the object, and only in six of them did the first price come close (less than 10% discount) to the reserve price. Three of these occurred on the same day, that is, as part of a sequential set of auctions, being that in the third one, curiously, only one of 14 participants actually placed a bid, winning with a 0.5% discount from the reserve price. This could indicate either strong idiosyncrasy for this player or a successful attempt for collusion.

The average discount between first and reserve price was 35%, an impressive mark, which can be attributed either to an overshoot of the reserve price by the auctioneer or to aggressive behavior by competitors, given their acute idiosyncrasy. In support for the latter theory, we register that 78% of all auctions ended in the first stage, that is, the first price was at least 5% smaller than the second price, and, in those cases, the average difference between first and second prices was 21.7%.

The consistent frequency of auction results with a large difference between the first and the second prices is possibly the most dazzling outcome from the Brazilian transmission auctions, since it indicates that the bidders aren’t having success in following the theoretical best strategy in first-price auctions. Such outcome may be partially explained by the hypothesis that the costs and the difficulties to estimate the expect value of the second best bid are so high that the bidders are unable to follow this strategy. However, it is hard to

\(^7\) In December 16 2005, 13 hydroelectric plants were auctioned sequentially, but only 7 projects won energy supply contracts, in December 10 2007 and in May 19 2008 two more hydroelectric plants were auctioned. The total amount of energy contracted in these auctions was 29,691 TWh year.
justify the fact that the information released between sequential auctions seems to have no effect over bidder strategy.

The differences between first and second prices apparently aren’t affected by the position of the auction on the day or on the historical record of all auctions. In other words, bid differences aren’t converging as more auctions occur, a fact that challenges the predictions coming from theory. One possible explanation is that participants aren’t learning with new information, which could be evidence that rationality isn’t such a strong assumption after all. By rationality, we mean here that players don’t seem to be fully studying their strategic options, a reasonable explanation given the recent introduction of such mechanisms in the Brazilian power industry (about 5 years).

In regard to the English-auction style second stage, which occurred 22% of the time, the average difference between the end price from this stage and the closing first price of the previous sealed-bid stage was 4%, showing that, in many cases, there is an important common value element and that the second stage allows bidders to review their personal valuation and to remove some protection against winner’s curse. Every time the second stage occurred there was price reduction, which is a good sign. The total amount gained by the auctioneer during second stages represents 0.6% of the sum of all 68 reserve prices, justifying, at least from the auctioneers point of view, the existence of this arrangement.

So far there has been no indication of the occurrence of winner’s curse. By that we mean that no winner has contested the result of any of the 68 auctions or denied the right to sign contracts after the auction was over. Naturally, part of this is the effect of a noncompliance clause in the auctions’ regulating norms which requires the payment of 1% of the expected investment for winning projects that ratify their contracts. Nevertheless, it seems as though the excessive preoccupation with collusion has not caused any anomaly in the ending results.

**Conclusion**

The level of information disclosure during auctions is a choice that may be taken by the policy makers or the regulator in cases in which there might be social and/or economic benefits. These cases occur whenever bidders have partial information with respect to the auctioned goods, meaning that private values assumption doesn’t hold. In the evaluated auctions, information disclosure during the auctions was restricted to (i) the values of reservation price, (ii) the number of bidders, (iii) the bids and the final price, only after the first round ends, and (iv) the number of active bidders and the current prices during the open second round.

Such information policy is compatible with auctions characterized by asymmetric bidders, risk aversion and possible collusion, but it constrains the learning possibilities in the first round which rises the exposure to the winner’s curse. To mitigate such exposure, and also to increase the auctions attractiveness, the Brazilian auctioneer discloses the large possible amount of information before the auctions, manly: (i) Detailed technical information about the mandatory features of each project, as well those features for which investors have the freedom to change according to their own studies, (ii) the programmed schedule of works, along with an estimated budget for the projects’ main items, which was used to define the reserve price for the auction, (iii) copies of concession contracts and service provision contracts to be signed by winners after the auction, and (iv) geographic and geological maps and studies pertinent to the project.
Moreover, according to the results of the 68 transmission auctions occurred since 2003, one can realize that risk neutrality assumption doesn’t hold because, as the expected results from Riley and Samuelson (1981), in a first-price auction (as in the case of the first round of the transmission line auctions), bidders become more aggressive and make uniformly higher bids. This fact has been observed in most of the occurred auctions, which presented a decreasing price cut as the number of remaining auctions where diminishing.

In the case of Brazilian transmission line auctions, for example, we conclude that after nearly five years and 68 auctions, the current design has been producing satisfactory results in terms of drastically reducing the expected tariffs while avoiding, so far, the risk of winner’s curse. We were unable, however, given the limited available data, to determine whether this success can be exclusively attributed to the auction design or if part of if can be explained by the participants’ inability to learn from past events.

Finally we identify an apparent incongruence between the optimal theoretic strategy for first-price auctions and the actual strategy used by bidders in the Brazilian auctions. Such result suggests that bidders have their rationality bounded by incomplete information, time scarcity to make decisions and lack of resources to follow the optimal strategy. Therefore the bidders have sought for satisfactory solutions rather than for the optimal one. We were unable, however, given the limited data available, to determine whether this outcome can be exclusively attributed to the bounded rationality, to the auction design or if part of if can be explained by the participants’ inability to learn from past events.

References


