The effects of vertical integration on auction outcomes in the EU and US electricity markets.*

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Abstract

With the deregulatory reforms in the electricity industry, stages of production have been split up and are performed – typically – by different companies that compete for inputs and/or customers in decentralized markets. In such markets goods are often sold by auction. As the extant EU and US regulatory frameworks allow integrated electricity holding companies to have ownership of firms active in generation, distribution, and transmission, these holding companies often own both the seller and one of the buyers in such decentralized markets. A holding company that owns both a buyer (called the integrated buyer) and the seller in an auction has distorted bidding incentives. Specifically, the holding company will make the integrated buyer bid more aggressively to increase auction revenue. As a result, the integrated buyer is more likely to win the auction and the good is sold for a higher price. This results in a decreased efficiency of the auction. Moreover, independent companies are less likely to win the auction, and, in any case, pay a higher price.

Keywords: asymmetric auctions, bidding behavior, electricity markets, regulation, vertical integration.

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1. INTRODUCTION

1.1 Liberalization

The electricity supply industries in the US and the EU are being reformed. Production in the electricity supply industry, most notably generation, transmission, and distribution,[1] used to be performed by Vertically Integrated Utilities (VIUs) that often were national or local monopoly producers. Now, these production activities have been separated and are performed – typically – by different companies that compete for inputs and/or customers in decentralized markets.

In many such markets, competition is organized by conducting auctions. In theory, auctions have features that have been judged highly desirable for electricity markets such as non-discrimination (the highest bidder wins regardless its identity), efficiency (the bidder with the highest value makes the highest bid and thus wins), and selling at efficient prices (prices that reflect the scarcity of a good).[2] For example, in the European Union, the rights for generators or suppliers to use capacity on cross-border transmission lines is often allocated by explicit auction.[3] In the US, contracts for electricity supply by generators have been awarded by procurement auctions, such as in New Jersey (Loxley and Salant 2004; Reitzes, 2007) and Illinois (Illinois Commerce Commission 2006; Negrete-Pincetic and Gross 2007).

For the liberalization of the electricity supply industries to be successful, it is essential that such decentralized markets are competitive. However, national markets are frequently dominated by large holding companies, which are often the incumbent VIUs that own companies that are involved in different steps of the electricity production process. As a result, in a market the seller and one of the buyers are sometimes owned by the same holding company; I refer to such a configuration as ownership integration, and to such buyers and sellers as integrated buyers and integrated sellers.

For example, in Illinois and New Jersey, distribution firms award contracts for electricity delivery to generator companies in procurement auctions. Some of these generators are integrated

[1] I focus on the three main production steps of generation, transmission, and distribution: generation is the production of electricity in power plants, transmission is the transport of electricity over long distances, and distribution is the transport of electricity over short distances, mostly to the final consumer.
[2] See for example Consentec (2004).
[3] In 2007 explicit auctions were used to allocate capacity for international transmission lines at 21 border crossings (Commission of the European Communities, 2008, p.30)

buyers; they are owned by a holding company that also owns the seller of the contracts.[4] In the EU, the capacity on cross-border transmission lines (also called interconnectors) is mostly sold by auction to generators (ETSO 2006). In many instances, one of the generators buying capacity is an integrated buyer; it is owned by a holding company that also owns the interconnector. In 2006, for example, in 12 of the 27 EU member states VIUs that were involved in generation and/or distribution also owned the transmission and interconnector networks.[5] A typical pattern in such EU states is that a large dominant electricity generator, in which the state has a majority stake, fully owns the transmission networks (see Commission of the European Communities 10.01.2007).

1.2 Legal unbundling

The holding company could have incentives to instruct the integrated seller to stifle competition by selling only to the integrated buyer. Regulation in EU and US therefore aims to prevent integrated sellers from favoring integrated buyers and thus discriminating against independent entrants. EU laws mandate that the integrated seller must be legally unbundled from the holding company (Directive 2003/54/EC and Regulation 1228/2003). While the seller may still be fully owned by the holding company, the seller must be a legally independent company with an autonomous management, and the holding company is not allowed to give day-to-day instructions to the seller.[6] Legal unbundling intends to prevent the seller from discriminating against independent buyers in favor of the integrated buyer. In this manuscript I assume that legal unbundling is successful, and thus that auctions organized by such an integrated – but legally unbundled – seller are non-discriminatory in the sense that the highest bidder wins, regardless of the identity or affiliation of the buyer. Note that the integrated buyer, the generator, is not regulated and does not have to be legally unbundled; the VIU is thus residual claimant to the profits of the integrated buyer and can exercise control over it.

US laws mandate a comparable form of separation called "functional unbundling" that should

[4] See, for the case of New Jersey, http://bgs-auction.com, and, for the case of Illinois, Illinois Commerce Commission (2006, p.8).

[5] VIUs own transmission networks, including the interconnectors, in the following countries: Austria, Belgium, Bulgaria, Cyprus, Germany, Denmark, Estonia, France, Greece, Hungary, Ireland, and Luxembourg (Commission of the European Communities, 2008, p.38-39).

[6] Recently the European Commission has, in what is referred to as "the third energy package", proposed new laws with stricter requirements on unbundling. However, these laws would also continue to allow VIUs to own generation and network activities, provided the network activities are legally unbundled and operated by an independent System Operator (Commission of the European Communities, 19.9.2007, p.5).

guarantee such non-discriminatory outcomes in auctions (FERC Order 888, 21552). In the procurement auctions in New Jersey and Illinois, for example, distributors selling electricity delivery contracts were not allowed to own generators that participate in the auction (Loxley and Salant 2004; Illinois Commerce Commission 2006; Negrete-Pincetic and Gross 2007). However, distributors were allowed to be part of a holding company that owned both distributors and generators. This liberty did not go wasted; all four distributors in New Jersey and both distributors in Illinois are part of a holding company that also owns a generator that participated in the auction.

While legal or functional unbundling might accomplish the objective that the seller does not discriminate against integrated buyers,[7] I will argue that the ownership of the seller gives the integrated buyer incentives to bid more aggressively in auctions. The rationale is that while the seller is legally unbundled and thus restricted to maximize his own profit (the auction revenue), the buyer can be instructed by the holding company not to maximize the buyer profit, but the total profit of the holding company. To the holding company the price the integrated buyer pays for the good is not a net cost as (a part of) the payment returns to the holding company through its ownership of the seller. The holding company therefore instruct the integrated buyer to adapt its bidding behavior to account for the lower cost of bidding and bid more aggressively.

The holding company orders the integrated buyer to bid more aggressively only when the integrated seller can keep a part of the profit of the auction and send it on to the holding company. This is the case when the holding company is residual claimant of the income of the integrated seller; as, for example, with merchant interconnectors (cross-border transmission lines): The owner can keep the full profits generated by auctions, a scenario allowed by new EU laws.[8] Even when the income of the seller is regulated, under incentive regulation the seller is allowed to keep a part of the increased profit in order to provide incentives for innovation and cost reductions. A type of incentive regulation that has become more commonplace for networks is price cap regulation (Joskow 2006; Vogelsang 2005). Even when the regulator doesn't allow profit retention, it might be possible that the seller is able to use part of the profit in a way that benefits the seller. For example,

[7] However, there is evidence that a legally unbundled seller can discriminate against independent buyers in favor of the integrated seller. For example, the European Commission Competition DG (6.02.2006, p.144-148) reports several concrete examples of legally unbundled transmission and distributor network owners that discriminated against independent generators.

[8] While no merchant line has been built yet, it seems likely they will be built in the future; beginning 2007 the European Commission had received two announcements of plans to build a merchant line (Commission of the European Communities, 2008, part 2, p.117)

regulators in the EU have not been successful in enforcing the prescribed use of auction revenues for transmission lines.[9] Below I assume that the seller can keep a certain proportion of the profits. I refer to this portion as the (effective) ownership share and denote this by the symbol γ.[10]

The main question is if legal unbundling (i.e., when a buyer owns even just a part of the seller) is a sufficient measure to assure a competitive market with non-discriminatory and efficient allocations and prices. This is an important question; if legal unbundling puts independent buyers in a disadvantaged position then this makes it less attractive for new, independent entrants to enter the energy market. This is highly relevant for the national electricity generation markets in the EU, as they are very concentrated.[11] So far the support for legal unbundling as a sufficient measure has been strong in the EU and the US. However, up until now the effect of integrated ownership on bidding behavior and auction outcomes in electricity markets has not been studied. I therefore study in this paper the effect on auction outcomes of a buyer having an ownership share in the seller under legal unbundling. I focus specifically on the question whether auction outcomes in this case are still efficient and non-discriminating.

To answer these questions I model a very simple set-up with two buyers, each with private valuations that are identically, independently, and uniformly distributed.[12] I also assume that the good on sale is indivisible, and not in many divisible units. This simplification allows me to derive explicit solutions that enable an estimation of the size of the effects of ownership integration. The results from this simplified model give a suggestive answer to the effects of unified ownership of buyer and seller in auctions.

The remainder of this paper is organized as follows. In the next sections I first review the relevant literature, focusing on legal separation and toehold auctions, after which I describe the

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[9] While EU regulations state that auction revenues of international transmission lines (interconnections) should be spent on infrastructure projects in full, an energy inquiry by the European Commission that took a sample of 10 transmission owners reported that, over the years 2001-2005, a mere 20% of the auction revenues were spent on such projects (Commission of the European Communities, 2007, p.179).

[10] It is understood that the "ownership share" might be smaller than the stakes a buyer has in the seller due to regulation or profit sharing with other parties.

[11] National markets for generation in the EU are indeed highly concentrated as measured by the Herfindahl-Hirschman Index (HHI). The HHI sums the squares of the market shares in percentages of all relevant firms; its value is thus between 0 and 10.000. In 2006, seven out of 20 EU member states were highly concentrated (HHI between 1800 and 5000), and eight, among which are Belgium and France, were very highly concentrated (HHI above 5000) (Commission of the European Communities, 2008, p.11). Attracting new investment is therefore a major priority.

[12] The buyers might have in addition to their private value a publicly known value component that is identical (common) for all of them. As long this common value component is identical and publicly known, such a value component does not affect the analysis. In section 3.4 I present a setting with perfect information; where the private values of the buyers are publicly known.

setup of my model.

Then I analyze first-price and second-price formats of the main auction model and present the effects of ownership integration. To show the limits and robustness of the effects in my model, I also present models that employ the same setting but under different assumptions on information. I then present empirical data on procurement auctions in Illinois and New Jersey that indicate that one of the effects predicted in the model, discrimination of independent buyers, seems to have been present. In the conclusion I summarize my findings and present suggestions for improvement.

2. LITERATURE

2.1 On legal unbundling

The effects of ownership integration combined with legal separation have been studied in three earlier papers: Cremer, Crémer, and De Donder (2006), Höffler and Kranz (2007), and Reitzes (2008). Höffler and Kranz (2007) claim that legal unbundling can have superior qualities over ownership unbundling. In their model competing generators buy transmission capacity for a fixed, regulated rate from a transmission company to transport their electricity to consumers. The capacity on the transmission network is unlimited in the relevant range. One of the generators, the integrated generator, owns the transmission network. Höffler and Kranz (2007) show that under legal unbundling the integrated generator will produce more output, and that, as a result, the total generation output is weakly higher than under full integration or ownership unbundling. Reitzes (2008) analyzes a setup similar to that of Höffler and Kranz (2007) in the more specific setting of price competition with a large integrated generator and relatively small independent generators. Reitzes (2008) also finds that the integrated generator is more aggressive, and that a profit sharing regulatory scheme for the integrated seller can achieve optimal pricing.

My model resembles that of Höffler and Kranz (2007) and Reitzes (2008); the regulated transmission owner and the integrated generator in their models are the integrated seller and the integrated buyer in my model. The main difference is that in their models the transmission company has an unlimited capacity and thus a vested interest to sell as much capacity as possible. In my model transmission capacity is limited, and thus sold in an auction.[13] Moreover, I analyze the effect of ownership integration on competing independent buyers, something that, remarkably, has not

[13] This makes my model also suitable to analyze the auctioning of other essential inputs, such as electricity contracts in procurement auctions.

been done by Höffler and Kranz (2007) or Reitzes (2008). In this setting, my model leads to conclusions opposite to those of Höffler and Kranz (2007) and Reitzes (2008): Auction outcomes under legal unbundling are worse in terms of competition and efficiency than under ownership unbundling.

Cremer et al. (2006) study the effects of legal unbundling of the buyer: In their model a downstream firm (a buyer) is restricted to maximize its own profit. This is different from my model where the seller is the legally unbundled firm and thus restricted to maximize its own profit (the auction revenue), while the buyer can be instructed by the holding company to behave in ways that do not maximize the buyer profit (but rather the total profit of the holding company).

2.2 On toehold auctions

In the model setup, it will become clear that auctions with an integrated seller and an integrated buyer are mathematically identical with so-called toehold auctions. Toehold auctions have been analyzed mostly in the context of financial takeovers, where two buyers compete to buy a company and one or both buyers already own, by holding shares, a fraction of the company (Bulow, Huang and Klemperer 1999; Burkart 1995; Ettinger 2002). The fraction of the company owned by the potential buyer(s) is called a toehold.

Burkart (1995) analyzed a second-price private value toehold auction with two buyers and finds that the buyer with a toehold bids more aggressively and increasingly so the higher his toehold. Burkart (1995) shows that such aggressive bidding is also likely to occur in auctions with perfect information. Ettinger (2002) compares first-price and second-price private value auctions with symmetrical toeholds and notes that, for strictly positive toeholds, the revenue equivalence theorem doesn't hold. Bulow et al. (1999) analyze common value toehold auctions, where both bidders have a toehold (and at least one bidder a strictly positive toehold) and show that the bidder with a larger toehold has a larger probability of winning the auction. Bulow et al. (1999) also show that the winning price is strongly affected by toeholds.

As Burkart (1995) uses general assumptions, he cannot give estimates of the size of the effects of toeholds on auction outcomes. In addition, he models an auction with only two bidders, while in auctions for transmission capacity often more buyers compete. I therefore model a setup similar to that of Burkart (1995), but assume that values are uniformly distributed which allows me to derive explicit solutions when an arbitrary number of independent buyers take part in the auction. First-price toehold auctions have not been analyzed before at all, and I present a general result for first-price auctions with an integrated buyer that fully owns the integrated seller. Under more restrictive assumptions, I numerically solve such first-price auctions with partial integrated ownership, and show that the revenue equivalence theorem doesn't hold in such auctions. To assess the robustness of the effects to different assumptions, I apply models of Bulow et al. (1999) for unknown common values, Ettinger (2002) for symmetrical ownership shares, and I further elaborate the model of Burkart (1995) for the case of perfect information.

3. THE MODEL[14]

3.1 Assumptions

In the main application of my model, a generator competes to obtain a good, service or contract, such as capacity on an interconnector or a contract for electricity supply, which it needs to perform a profitable transaction. The profitability of the transaction depends thus, amongst others, on the costs of generating electricity. I will assume that the cost of generating electricity differs among buyers.[15] This implies that the buyers value the good on auction differently.

For example, when bidding for transmission capacity on an interconnector, the value of the good for sale is the profit that could be earned by selling electricity abroad. This profit is equal to the difference between the price abroad and the costs of the generator.[16] When generators compete for an electricity supply contract in procurement auctions, the generators actually bid the price they will charge for the electricity supply and the lowest price wins (Loxley and Salant 2004). For the model I transform such a procurement auction, without loss of generality, into an equivalent "discount auction" where a given maximum electricity supply price is set and the generators make bids that represent the discount they will offer on the price. In such a discount auction the highest bidder wins. For a generator the (private) value of the contract is equal to the set electricity supply price minus the (private) cost of electricity generation. For example, a generator with low costs of

[14] See section 8 for a notation overview.

[15] The value of the good to a generator is dependent on the costs of generating electricity. As a generator does not know the cost of his competitors, he treats it as a random variable, drawn from a distribution that, for sake of simplicity, I will assume to be uniform. The random costs drive the dynamics of the bidding behavior. In electricity generation, there is also a common cost component, mainly gas or oil prices. I assume that the size of these common cost components are common knowledge and that they are identical for all generators. As shown in footnote 21, these common cost components are therefore inconsequential for the bidding behavior; this is determined by the unknown private value factors.

[16] In line with the empirical evidence, I assume that, as transmission capacity is fixed and small relative to total demand, buyers cannot influence the final price in distant locations (see e.g. Consentec, 2004).

electricity generation has a high value for the contract, and thus will be willing to bid high discounts in the discount auction, which corresponds to a low price for which the bidder is willing to supply electricity in the procurement auction.

I will assume that a buyer knows his own value, but not the value of the competing buyer. In my model this implies that a buyer does not know his competitor's marginal cost of producing electricity (except for a common, identical cost factor such as gas or oil prices). In older models stemming from the time electricity generator markets were tightly regulated (Green and Newbery 1992; von der Fehr and Harbord 1993), it was usual practice to assume that marginal costs are common knowledge, however, since the electricity industry has become competitive, information on the cost structure of electricity generation has strategic value and is therefore carefully guarded (Léautier 2001, 34). Parisio and Bosco (2006, 8) add: "generators frequently belong to multi-utilities [VIUs] providing similar services often characterized by scope and scale economies (Fraquelli et al., 2004, among others). The cost of generation therefore can vary across firms because firms can exploit production diversities in ways that are not perfectly observable by competitors." In this line of thought, competitors can only make an estimate of each others' marginal costs. However, for completeness I also consider a deterministic configuration, where generators know the costs of electricity generation for competitors.[17]

One of the bidders is an integrated buyer; a holding company fully owns the integrated buyer and (a part of) the integrated seller. I denote with parameter k_1 the proportion of the integrated seller that the holding company owns. I denote with parameter k_2 the proportion of the auction revenue which the integrated seller can retain. For example, when the integrated seller is unregulated, it can keep all of the auction revenue and $k_2 = 1$. When the integrated seller is regulated, it can retain a part of the profit under incentive regulation (and possibly by creative accounting), and thus $0 < k_2 \leq 1$ (Vogelsang 2005). The relevant parameter in the model, which I refer to as the (effective) "ownership share," is the proportion of the auction revenue that is received by the holding company, given by $\gamma = k_1 \cdot k_2$.

Buyers are risk-neutral and have private values that are independently and uniformly distributed

[17] I thank an anonymous referee for this suggestion.

on the interval $[0,1]$. The buyers are thus, at the outset, symmetrical;[18] they have identical, independent value distributions. I assume that the good on sale is sold as one indivisible good.[19] As usual in auctions, the highest bidder wins the good, which reflects that the integrated seller does not favor the integrated buyer and thus the legal separation of the integrated seller is working as intended by the regulators. Given its value realization, the integrated buyer Y chooses its optimal bid b_Y. In line with the literature, I assume that there exists a continuously differentiable, strictly increasing bidding strategy $b_Y[\cdot]$ that maps the integrated buyer's realized value $v_Y \in [0,1]$ onto its bid $b_Y[v_Y]$. The bidding strategy $b_Y[\cdot]$ has an inverse, $y[\cdot]$, such that $y[b_Y[v_Y]] = v_Y$. Analogously, the optimal bid of an independent buyer X, b_X, is determined by its bidding strategy $b_X[\cdot]$ that maps its realized value $v_X \in [0,1]$ onto its bid $b_X[v_X]$. The strategy $b_X[\cdot]$ has an inverse, $x[\cdot]$, such that $x[b_X[v_X]] = v_X$.

3.2 The second-price auction

In a second-price auction where one integrated buyer has an ownership share, the integrated buyer, when it loses, is not indifferent to the price for which the good is sold (see also Burkart 1995). In that case it would like the good to be sold for a price as high as possible. This gives the integrated buyer an incentive to bid more aggressively. As Proposition 1 shows, this effect is relatively strong even when there is more than one independent buyer competing.

Proposition 1: *For any $n \geq 1$, in a second-price auction with n+1 buyers, one integrated buyer who receives a share γ of the auction revenue and n independent buyers, where values are distributed independently and uniformly on [0,1], the independent buyers bid their values, and the integrated buyer bids $b_Y[v] = v + \gamma \frac{1-v}{\gamma+1}$. As a result, with increasing γ for all $n \geq 1$:*

a) *The expected profit of Y, $\pi_Y^{(n)}[\gamma]$, increases,*
b) *The expected auction revenue, $m^{(n)}[\gamma]$, increases,*

[18] This simplification serves to focus the analysis on the effect of an ownership share, and, likely, does not affect the qualitative results. See footnote 22 for an example.

[19] While transmission capacity and electricity supply procurement auctions are usually multi-unit auctions, I restrict my focus to single-unit auctions to simplify the analysis and focus on the effect of integrated ownership.

c) *The expected profit of* X_i, $\pi_{X_i}^{(n)}[\gamma]$, *decreases for all i,*

d) *Efficiency,* $W^{(n)}[\gamma]$, *decreases,*

e) *The profit from optimizing total profits (generator profit and* γ *times auction revenue) increases relative to optimizing the profit of only the generator* $\pi_{Y\,strategic}^{(n)}[\gamma] = \pi_Y^{(n)}[\gamma] - \left(\pi_{X_i}^{(n)}[0] + \gamma m^{(n)}[0]\right)$.

Proof: *See Appendix.*

The intuition for Proposition is as follows. Independent buyers bidding their own bid in a second-price auction is a standard result.[20] The profit function for the integrated buyer Y is given by[21]

1) $$\pi_Y^{(n)}[b_Y, v_Y] = \Pr[Y \text{ wins}] \cdot (v_Y - (1-\gamma) \cdot \mathbf{E[highest\ bid\ from\ n\ buyers\ |\ Y\ wins]})$$
$$+ \gamma \cdot \Pr[Y \text{ has } 2^{\text{nd}} \text{ highest bid}] \cdot \boldsymbol{b_Y}$$
$$+ \gamma \cdot \sum_{i=2}^{n} \Pr[Y \text{ has i}^{\text{th}} \text{ highest bid}] \cdot \mathbf{E[2nd\ highest\ bid\ from\ n-1\ buyers\ |\ Y\ has\ i^{th}\ highest\ bid]}$$
.

The parts in bold in this equation are the expected payments for each case. The first line gives the part of the profit in case Y wins, Y then receives its value v_Y minus the money it must pay that the integrated seller cannot send on to the holding company; this is equal to $1-\gamma$ times the highest expected bid from the *n* competing independent buyers. The expression in the second line gives the part of the auction revenue Y receives in case it has the 2nd highest bid. In this case, Y loses the auction and sets the price to be paid by the winner of the auction; Y thus receives the ownership share γ times its bid b_Y. The expression in the third line gives the expression in case Y has a bid lower than the 2nd highest bid and thus Y loses the auction and does not set the price. When Y has

[20] See, for example, Krishna (2002).

[21] An identical, fixed, commonly known value component *R* in addition to the random private values does not change the bidding behavior of any of the buyers. Imagine that all buyers have an extra identical, fixed, commonly known value component *R* (for example, gas prices fall and lower the cost of generating electricity identically for all generators). In that case the profit function of integrated buyer Y, $\tilde{\pi}[b_Y, v_Y]$ is different from the profit function in equation 1; the value of Y, and the bids of all buyers – who bid their value – are higher by *R*. Because *R* is a constant it can be taken out of the expectations operator and as a result $\tilde{\pi}[b_Y, v_Y] = \pi[b_Y, v_Y] + \gamma R$, which implies that $\frac{d\tilde{\pi}[b_Y, v_Y]}{db_Y} = \frac{d\pi[b_Y, v_Y]}{db_Y}$.

the i^{th} highest bid (with $2 \le i \le n$), the expected payment by the winner is the 2nd highest bid from the (n-i) bidders that have a higher bid than Y. The total expected profit for Y in this case is thus its ownership share γ times the summation of the probability of Y having the i^{th} highest bid times the expected 2nd highest bid from the (n-i) bidders.

Having more independent buyers participating in the auction has opposing effects on the bidding function of the integrated buyer Y. On the one hand, having more buyers lowers the risk for the integrated buyer Y to win the auction with a bid higher than his value (the first line in the equation), and thus gives Y an incentive to bid more aggressive. On the other hand, having more independent buyers lowers the probability that Y will be setting the price by having the 2nd highest bid (the second line in the equation), and thus gives Y an incentive to bid less aggressive. Interestingly, for values being independent and uniformly distributed on [0,1] the two opposite effects cancel out, and the integrated buyer Y chooses an identical bidding function for any number of competing independent buyers: $b_Y[v_Y] = v_Y + \gamma \frac{1-v_Y}{\gamma+1}$. Figure 1 illustrates the bidding by the integrated buyer and the independent buyers.[22]

Figure 1: The bidding function of integrated buyer Y in second-price auctions.

As a result of its aggressive bidding, the auction revenue increases (Prop. 1a). Notably, for an auction with two buyers (thus with one competing independent buyer) and $\gamma = 1$, the auction revenue is equal to $\frac{11}{24}$,[23] which is different from the auction revenue in a first-price auction shown below. Also, the total profit of the integrated buyer (the profit of its generation activity plus its share of the auction revenue) is higher (Prop. 1b). The profit of each independent buyer X_i is now lower, X_i is less likely to win, and if it wins, it pays a higher price (Prop. 1c). The auction is now inefficient because there are some cases where Y wins without having the highest value. The more aggressively Y bids, the more often this happens, and thus efficiency decreases further (Prop. 1d).

[22] The assumption of symmetry likely does not affect the qualitative results. For example, assume that the integrated buyer Y is a stronger bidder in the sense that its private value v_Y is distributed uniformly over $[0,2]$. If $v_Y \in [1,2]$, Y would win the auction by bidding any bid larger than 1, and if $v_Y \in [0,1]$, bid the bidding function above. The analyses above then apply whenever $v_Y \in [0,1]$.

[23] This result can be obtained for $n = \gamma = 1$ by using the formula in the proof of Proposition 1b on page 31 in the Appendix.

The last expression (Prop. 1e) shows that the strength of the incentive for Y to bid more aggressively increases in its ownership share γ.[24] The strength of this incentive, which I call the "strategic profit", is the difference in profits between using a strategy of maximizing total profits (generator profits and γ times auction revenue) and of using a strategy (which I call the naïve strategy) of maximizing the profit of only the generator. The strategic profit is thus given by $\pi_{Y\,strategic}^{(n)}[\gamma] = \pi_Y^{(n)}[\gamma] - \left(\pi_Y^{(n)}[0] + \gamma m^{(n)}[0]\right)$. The first expression is its profit when maximizing total profits and the second part is his profit when maximizing only the profit of the generator.

Figure 2: Outcomes in second-price auctions with one independent buyer.

Figure 2 shows the effect of ownership share on auction outcomes when the integrated buyer competes with one independent buyer. There is a considerable efficiency loss,[25] up to 6.25%. The gain for the Vertically Integrated Utility (VIU), given by the strategic profit[26] is also considerable; a VIU can, by bidding more aggressively, increase its profit by up to 16.7%. The price of the good is strongly affected; it can increase by up to 37.5%. However, this might also be considered a positive effect in the case of transmission line capacity auctions; Joskow and Tirole (2005) claim that, due to the "lumpiness" of transmission investment, auction revenues are too low to incite the building of an efficient amount of merchant transmission capacity. The increase in profits for the transmission owner could thus at least somewhat alleviate this problem. Also in procurement auctions this could be seen as a positive effect, as then the price paid reflects the discount generators are giving to the distributor that buys electricity. An increase in the price means that the generator gives a larger discount than without ownership integration; electricity is thus eventually supplied to the distributor at a lower price.

However, the strong discrimination against independent generators favoring the VIU is a negative effect. As can be seen in Figure 2 ownership integration decreases the expected profit of

[24] This is an important indicator for external validity of the model; experimental evidence has shown that the strength of incentives is important for theoretical predictions to show in real settings (Hertwig and Ortmann, 2001, Smith and Walker, 1993).

[25] The efficiency loss percentage is calculated as $\frac{W[0]-W[\gamma]}{W[0]}$, which is equal to $\frac{25\gamma^2}{(1+\gamma)^2}$.

[26] The strategic profit percentage is calculated as $\frac{\pi_{Y\,Strategic}}{\pi_{Y\,Naïve}}$.

the integrated buyer by up to 75%. Also at low levels of ownership integration discrimination is considerable; even with an ownership share of only 10%, the independent generator has a profit that is lower by 17%. This violates one of the key principles which the EU intends to apply to the electricity markets: creating fair competition in electricity generation. Moreover, the fact that ownership integration creates strong discrimination against independent generators might discourage investment into generation by independent investors, especially since generators, in order to recover significant fixed cost, need to make positive profits on their electricity deliveries (see, for example, Soft 2002).[27] In lowering the profits of independent generators, ownership integration – most likely – lowers the number of independent generators in the market which are able to recover their fixed costs. The dynamic costs of such a suboptimally low level of competition are not determined here but are likely to be considerable.

Figure 3: Outcomes in second-price auctions with several independent buyers.

Figure 3 shows that when the number of competing independent buyers goes to infinity all effects disappear, but that with more realistic numbers in the electricity market, effects are strong. The discrimination effect of integrated ownership is remarkably strong. Graph (a) shows the loss in expected probability of winning for each competing independent buyer, which can be as high as 50%. Not only do independent buyers win less often, but when they win, they make less profit, as shown in Graph (b). With one competing buyer, the loss in profit can be as high as 75%. With two competing independent buyers, each of them has a decrease in profits of up to 62.5%. Even with as many as three competing independent bidders, a rather generous assumption as the markets for electricity generation are rather concentrated in the EU,[28] each has a decrease in profits of up to 52%. Even for a low ownership share the discrimination effect is rather strong; for example when $\gamma = 0.15$, each independent buyer experiences a decrease in expected profits of 10% with three

[27] The fewer the number of independent buyers, the higher is the profit for each of them. Generally, for $n+1$ independent buyers with uniformly distributed values, the expected profit for each buyer is equal to $\frac{1}{(n+1)(n+2)}$ (see, for example, Krishna, 2002). If buyers in the auction receive a profit higher than what is needed for fixed cost recovery, new buyers start entering the auction, which decreases the profit of each buyer in the auction. New buyers keep entering until the profit is just enough for cost recovery. If the profit is too low an outflow of buyers occurs, leaving the market more concentrated.

[28] For example, in a survey by the European Commission, the average share in total generation of the largest generator in 2006 was 61% for the 18 countries that reported (Eurostat).

competing independent buyers, and up to 24% with one competing independent buyer.

Graph (c) shows the loss in efficiency, which represents a considerable social loss. Remembering that strategic profit is the extra profit over naïve profit derived from ownership, Graph (d) shows the strength of incentives for Y to bid more aggressively as given by the strategic profit as a percentage of the naïve profit. The incentive is considerable for reasonable values of the ownership share and the number of competing independent buyers; when the ownership share is above 0.5, and there are no more than 2 independent buyers, then Y can increase its profit by 5.6% or more.

3.3 The first price auction

In this section, I will analyze the effect of ownership integration in first price auctions.[29] When Y fully owns the integrated seller in first price auctions, a general result can be established. Remarkably, Proposition 2 shows that Y bids as if taking part in a second-price auction.

Proposition 2: *When the values of X and Y, v_X and v_Y, are independently distributed without any further restrictions on the possible distribution, then when the integrated buyer Y fully owns the seller such that $\gamma = 1$, Y bids its own value in a first-price auction.*

Proof: *When $\gamma = 1$, Y receives the full amount of any bid paid. Therefore Y does not have to take bidding costs into account and, regardless of his bid, earns at least $\min[v_Y, b_X]$. Now an argument similar to that for truthful bidding in second-price auctions applies. Suppose Y has value v_Y. If Y makes a bid lower than his value $b_Y < v_Y$, then with a positive probability X wins with a bid b_X, which is higher than the bid of Y but lower than the value of Y, $b_Y < b_X < v_Y$. In this case Y can guarantee itself a higher profit at no costs by bidding his value, $b_Y = v_Y$. A similar argument establishes that Y will not make a bid higher than his value. Hence, Y bids $b_Y = v_Y$ and earns* $\max[v_Y, b_X]$.

To further analyze the bidding functions of X and Y, I assume that the values of X and Y, v_X, v_Y, are independently and uniformly distributed on [0,1]. In first-price auctions, the expected

[29] In a first price auction the highest buyer wins and pays his own bid.

profit of Y is given by:

1) $\pi_Y\left[b_Y\right]=\Pr[\text{Y wins}]\cdot E[v_Y-(1-\gamma)b_Y \mid b_Y>b_X]+\gamma\left(\Pr[X\text{ wins}]\right)\cdot E[b_X \mid b_Y<b_X]$

The first part in Equation 1 is the probability that Y wins times its expected profit in that case; this profit is equal to the value of the good on auction minus its bid plus the part of the bid it "pays to itself" through its ownership of the seller, altogether $v_Y-(1-\gamma)b_Y$. The second part is the probability that Y loses times its expected profit in that case; this profit is equal to the ownership share times the payment by X, γb_X. Y wins the auction with bid b_Y when the bid of X is lower, $b_X[v_X]<b_Y$. Applying the inverse bidding function $x[\cdot]\equiv b_X^{-1}[\cdot]$ on both sides of the equation gives $v_X<x[b_Y]$. Y thus wins for value realizations of X with $v_X<x[b_Y]$. Equation 1 can then be written as

2) $\pi_Y[b_Y]=\int_0^{x[b_Y]}(v_Y-(1-\gamma)b_Y)dz+\gamma\int_{x[b_Y]}^{1}b_X[z]dz$.

Solving the first integral and substituting $v_X\equiv x[b_Y]$ in the second integral and integrating by parts results in

3) $\pi_Y[b_Y]=x[b_Y]\left(v_Y-\left(1-\gamma\right)b_Y\right)+\gamma\left(\bar{b}-b_Y\cdot x[b_Y]-\int_{b_Y}^{\bar{b}}x[q]dq\right)$,

where $\bar{b}$ is the maximum bid.

To determine the first order condition for profit maximization for Y, differentiate equation (3) with respect to b_Y, set it equal to zero and substitute $y[b_Y]\equiv b_Y^{-1}[b_Y]$ for v_Y:

4) $(y[b_Y]-b_Y)x'[b_Y]=(1-\gamma)x[b_Y]$.

The profit maximization problem for X is identical to that for Y with the ownership share set to zero, i.e. $\gamma=0$, therefore the first order condition for profit maximization for X is:

5) $(x[b_Y]-b_Y)\cdot y'[b_Y]=y[b_Y]$.

When $\gamma=0$, the problem is symmetrical for X and Y and both have bidding function $b[v]=\frac{1}{2}v$.

Under full ownership, when $\gamma = 1$, Y bids his value, and thus, using (5), X bids following $b_X[v] = \frac{1}{2}v$. The more aggressive bidding by Y has several interesting effects on price, competition, profits and efficiency. Proposition 3 summarizes the main effects.

Proposition 3: *In a first-price auction with one competing independent buyer X an integrated buyer Y who has full ownership, $\gamma = 1$, bids its value, while the independent buyer bids $b_X[v_X] = \frac{1}{2}v_X$. As a result of the more aggressive bidding of Y,*

a) *The expected profit of Y, $\pi_Y[\gamma]$,increases,*
b) *The expected auction revenue, $m\,[\gamma]$, increases,*
c) *The expected profit of X_i, $\pi_{X_i}[\gamma]$, decreases,*
d) *Efficiency, $W\,[\gamma]$, decreases.*
e) *The strategic profit – the extra profit that can be earned by bidding more aggressively – increases.*

Proof: *See appendix.*

Quantitatively, with Y bidding its value, its profit is equal to the auction revenue. Furthermore, the auction revenue increases by 62.5% from $\frac{1}{3}$ to $\frac{13}{24}$, the profit of X falls by 50% from $\frac{1}{6}$ to $\frac{1}{12}$, efficiency falls by 4.2% from $\frac{2}{3}$ to $\frac{15}{24}$, and the strategic profit increases from 0 to $\frac{1}{24}$. Interestingly, the auction revenue when Y has full ownership is different in a first-price auction than in a second-price auction.

Corollary 1: *Revenue equivalence between first and second-price auctions does not hold.*
Proof: *Using the above bidding function the auction revenue is calculated to be equal to $\frac{13}{24}$ in the case of full ownership. In section 3.2, p.12, I found that the auction revenue in a second-price auction with two buyers is equal to $\frac{11}{24}$ for the case of full ownership.*

Outcomes for $\gamma : 0 < \gamma < 1$ lie in between the extremes of no ownership, $\gamma = 0$, and full ownership, $\gamma = 1$. Equations (4) and (5) can be solved numerically for $x[b_Y]$ and $y[b_Y]$ for

$\gamma : 0 < \gamma < 1$.[30] Figure 3 shows numerical approximations of the bidding functions for $0 < \gamma < 1$.[31]

Figure 4: the bidding functions for independent buyer X and integrated buyer Y in first-price auctions.

The bidding functions in Figure 4 demonstrate that an increased ownership share in the seller results in the integrated buyer Y bidding more aggressively. Y maximizes profits given by $\Pr[Y \text{ wins} \mid b_Y] \cdot (v_Y - (1-\gamma)b_Y) + \Pr[X \text{ wins} \mid b_Y] \cdot (\gamma b_X)$. A positive ownership share, $\gamma > 0$, increases the gain of winning, $v_Y - (1-\gamma)b_Y$. This gives Y the incentive to sacrifice a part of this gain by bidding stronger and increasing its probability of winning. This incentive is partly countered by the income Y earns when it loses; the ownership share times the bid of X, γb_X. All in all, Y bids stronger. The stronger bidding by Y lowers the profits of X, $\Pr[X\ wins \mid b_Y] \cdot (v_X - b_X)$, by lowering the probability of X winning the auction. This gives X the incentive to sacrifice a part of its earnings by bidding stronger and increasing its probability of winning.

3.4 Alternate models

In this section I analyze two alternative cases that might be relevant in electricity markets. The cases are very similar to the setup I analyzed before but make different assumptions concerning information. In the first case I assume that there is perfect information; generators know the value of their competitor. In the second case I assume that generators do not have private values for the good on auction, but rather a common value which they do not know precisely; they only have an estimate of this value available. This case can be modeled as a common value auction.

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[30] To my best knowledge there exists no explicit analytical solution for the bidding function in first-price auctions with $\gamma : 0 < \gamma < 1$. Proposition 4 in the Appendix lays out the necessary restrictions that the bidding strategies must fulfill.

[31] Note that there is a discontinuity at $\gamma = 1$. If and only if $\gamma = 1$, then bidding $b_Y = v_Y$ is a weakly dominant strategy for Y. Suppose $\gamma = 1 - \delta$ (for small $\delta > 0$), then if X sticks with its strategy $b_X = \frac{1}{2} v_X$, Y would never bid more than $\frac{1}{2} + \varepsilon$ (for small $\varepsilon > 0$). At $v_Y = \frac{1}{2} + \varepsilon$ there would be a mass point which in turn would create an incentive for X to overbid it whenever its value is larger ($v_X > \frac{1}{2} + \varepsilon$). Therefore, once $\gamma < 1$, bidding $b_Y = v_Y$ cannot be an equilibrium strategy for Y. For an equilibrium in pure strategies to exists at all, the bidding functions of X and Y must have the same bid for $v_Y = v_X = 1$. This is the case in the strategies shown in Figure 3; there are no mass points, and the density of Y's bids is continuous, excluding the possibility for X to improve its profits by deviating from its strategy.

3.4.1 Perfect information

While I assumed that generators have private information about their values (allowing for a common value factor that is publicly known), it is useful to look at an idealized situation where generators can estimate the exact value of their competitor without error. Burkart (1995) analyzes such a setup for second-price auctions and notes that the integrated generator mostly still overbids. This analysis is also valid for sealed-bid first-price auctions. Remarkably, in this case there is no inefficiency and the independent buyer has a fair chance to win the auction, but it is possible that all his profits are appropriated by the integrated buyer.

The intuition for this result is as follows: To guarantee the existence of Nash-equilibria, assume that if both buyers make the same bid, then the auction is won by the buyer with the highest value (and in case of equal values the winner is chosen at random). When the price for transmission is equal to p, then buyer Y with ownership share γ and value v_Y receives $v_Y - (1-\gamma)p = v_Y - p + \gamma p$ on winning, and γp on loosing. From the relationship $p < v_Y \Leftrightarrow v_Y - p + \gamma p > \gamma p$, it follows that when the price is lower (higher) than its value, Y prefers to win (lose) the auction and receive $v_Y - p + \gamma p$ (γp). Thus when $v_X < v_Y$, Y and X bid $b_X = b_Y = p$ for $p \in [v_X, v_Y]$, and Y wins and earns $\pi_Y = v_Y - (1-\gamma)p$, while X loses. In case $v_X > v_Y$ Y and X bid $b_X = b_Y = p$ for $p \in [v_Y, v_X]$. Y loses and earns $\pi_Y = \gamma p$, while X wins and earns $\pi_X = v_X - p$.

There is a continuum of Nash equilibria in all of which the buyer with the highest value wins the auction; all Nash equilibria are thus efficient. As the buyer with the highest value wins the auction, both buyers have equal probability to win the auction, 50% each, which indicates that there is no discrimination against the independent buyer concerning winning the auction. The profits of the independent and integrated buyers cannot be determined without further assumptions.

However, a sealed-bid second-price auction with a trembling-hand refinement criterion for equilibria or common English auctions have a unique equilibrium (Burkart 1995), as the independent buyer bids its value in these auctions. The integrated buyer will then always match the bid of the independent buyer, and thus, when its value is the highest, win and earn $\pi_Y = v_Y - (1-\gamma)v_X$, and when its value is the lowest, lose and earn $\pi_Y = \gamma v_X$.[32] The integrated buyer thus makes the highest profit possible in these auctions; the independent buyer, on the other

[32] Its expected profit is thus equal to $\frac{1}{6} + \frac{1}{2}\gamma$ in auctions with one competing independent buyer.

hand, makes *zero* profits.

The case of perfect information can therefore lead to an outcome of perfect discrimination, where the integrated buyer appropriates all surpluses from the independent buyer. This shows that while some of the negative effects of integrated ownership – such as inefficiency – disappear, it is possible that the independent buyer is prevented from making a profit higher than zero, which is a form of discrimination far stronger than in the previous models.

3.4.2 Unknown common values

While my model allowed for an identical common value component in the valuations of the bidders, I assumed that this component is common knowledge to both buyers, thus preventing this component to affect bidding strategies; these are determined by the unknown private value. A setup without a private value factor and where the size of the common value component is unknown to both buyers can be modeled as a common value auction.[33] Bulow et al. (1999) model such common value auctions where both buyers own a share of the seller. Both buyers have the same value for the good on auction, but the exact value of the good is only known with certainty after a buyer has won the auction. Both buyers have private information (called a signal) that allows them to make an estimate of the value of the good. Using the results of Bulow et al. (1999) for the case where only one buyer, the integrated buyer, has an ownership share, and under additional assumptions similar to the ones I use in my model, signals are uniformly distributed on the interval [0,1] and the common value component is equal to the average of the signals, effects similar to the ones in my model can be determined.

While efficiency is not an issue in such a common value auction by definition (the good has the same value for each buyer), ownership integration has, like in my model, a strong discrimination effect against the independent buyer and an upward effect on prices. Under the above mentioned additional assumptions the probability of winning of the independent buyer is $\frac{1-\gamma}{2-\gamma}$ in first-price, and

[33] Such an analysis might be relevant for the electricity markets. For example, generators that have the same costs in producing electricity might both need transmission capacity to sell electricity in a distant location. The exact price the generators will receive in the distant location is not certain, and each generator makes an estimate of this price given his private information. The value of transmission capacity to the distant location is then the same for both generators, but each has a different estimate of this value. Common values might also play a role in procurement auctions. Negrete-Pincetic and Gross (2007) argue that in Illinois in 2006 there was uncertainty over the value of the contracts on sale. If in addition generators had more or less the same cost of producing electricity, then the auction could be modeled by a common value auction as done in Bulow et al. (1999).

zero in second-price auctions. The discrimination effect is stronger in such common value auctions; the probability of winning for the independent buyer – and thus his expected profit – in second-price auctions is *zero*, even if the integrated buyer has only a small ownership share. In first-price auctions both go to zero as the ownership share of Y goes to one. The expected price of the good on auction when the integrated buyer has a strictly positive – but possibly very small – ownership share cannot be compared with the price when the integrated buyer has no ownership share; in the latter case such a common value auction has a multiplicity of equilibria (Bulow et al. 1999). However, it can be determined that the expected price is increasing in the ownership share of the integrated buyer.[34]

The model of Bulow et al. (1999) shows that integrated ownership, as in my model, causes strong discrimination against the independent buyer, while the effect on expected price cannot be determined due to indeterminacy of the model when the integrated buyer has no ownership share.

4. PROCUREMENT AUCTIONS IN NEW JERSEY AND ILLINOIS.

The procurement auctions held in New Jersey from 2002 untill 2008 and in Illinois in 2006 are examples of cases where distributors and generators figured as integrated buyers and sellers. In 2002, New Jersey organized its first procurement auction where distribution companies sold one-year forward contracts to ensure the electricity needs of their default service customers for a period of one year (Loxley and Salant 2004).[35] The contracts were sold in procurement auctions as fixed percentages of load, called tranches. All four distribution companies selling contracts, Public Service Electric and Gas Company (PSE&G), Jersey Central Power & Light Company (JCP&L), Atlantic City Electricity Company (ACE) and Rockland Electric Company (RECO), were integrated sellers; they were owned by holding companies that also owned generation companies. In the procurement auction in Illinois in 2006 electricity supply contracts, like those in New Jersey, were sold in tranches (Negrete-Pincetic and Gross 2007). Both distributors involved**,** Ameren and ComEd, were integrated sellers, as they were owned by holding companies that also owned

[34] The expected auction revenue in second-price auctions is equal to $m[\gamma] = \gamma \frac{2\gamma+1}{4\gamma+4}$ (Bulow et al., 1999). Using the functions in Bulow et al. (1999) with the additional assumptions mentioned above the expected auction revenue in first-price auctions can be shown to be equal to $m[\gamma] = \frac{1}{4}\left(1 + \frac{4}{3-2\gamma} - \frac{1}{3-\gamma} - \frac{2}{2-\gamma} + \frac{2\,\mathrm{Gamma}[\frac{2-\gamma}{1-\gamma}]^2}{\mathrm{Gamma}[3+\frac{1}{1-\gamma}]\mathrm{Gamma}[\frac{1}{1-\gamma}]}\right)$.

[35] See also http://bgs-auction.com.

generators that were bidding in the auction. Table 1 gives an overview of the distributors and their integrated generators in New Jersey and Illinois.

Table 1: Distributors and their integrated generators in New Jersey and Illinois

The auctions in New Jersey and Illinois were multi-unit, and therefore more complicated than the auctions I modeled in this paper.[36] However, it seems likely that the logic of the theoretical models in this paper carries over to more complicated settings. This would imply that generators are more likely to win auctions when the seller and the buyer are owned by the same holding company (they have the same affiliation), then when the seller and buyer are owned by different holding companies. In the auctions in New Jersey and Illinois, an integrated generator might thus be able to acquire more tranches from its “own” integrated distributor.

The raw data suggest that this might be the case. Table 2 shows the percentages of tranches won by the generator integrated with ACE (Connective) in the auctions over 2002-2008, for the different products. As my model suggests, the average percentage of tranches Connective won from ACE is higher than those won from other distributors. In addition, Connective, from 2004 on, only acquired tranches from its integrated distributor ACE, which suggests that Connective learned over time about the strategic advantage it has in auctions for ACE tranches.

Table 2: Tranches won by the generator integrated to ACE (Connective)

To test if bidders with affiliation did indeed have an advantage in the New Jersey auctions, I compare the (unweighted) average proportion of tranches won in auctions over 2002 till 2006 amongst the four integrated generators. If affiliation has no effect, then an integrated generator should win, on average, equal proportions from the different distributors. If affiliation brings an advantage, then the average proportion of tranches won should be higher for a generator when the distributor has the same affiliation than when the distributor has a different affiliation. For example, a generator integrated to ACE should have a higher proportion of contracts won to supply ACE than to supply JCP&L, PSE&G, or RECO.

[36] Detailed descriptions of the auctions can be found in Negrete-Pincetic and Gross (2007) for the Illinois auctions, and in Loxley and Salant (2004) and on http://bgs-auction.com for the New Jersey auctions.

Table 3: Results of the New Jersey BGS auctions over 2002-2006

In Table 3, column 1, I have shown the average percentages of the load won in the New Jersey auctions from 2002 till 2008 by the generators with the same affiliation as one of the distributors. Numbers in bold are the percentages won when the generator and the seller had the same affiliation. In column 2, I have depicted the averages of the percentages won of the three distributors that have a different affiliation than the generator in the row. For example, the generator affiliated with ACE, won over the auctions from 2002 till 2008 an average of 8.1% of the tranches of ACE, which is higher than the average percentage of tranches it won from any of the other distributors (JCP&L, PSE&G and RECO). Table 3 shows that percentages a generator wins from a distributor with the same affiliation (the bold numbers in the first column) are higher than the average percentages from a distributor with another affiliation (the second column). The percentage of tranches won by the generator affiliated with RECO is significant.[37]

Table 4: Results of the Illinois auctions in 2006

Table 4 shows the average percentages of the tranches won in the Illinois auctions by the generators with the same affiliation as one of the distributors. Numbers in bold are the percentages won when the generator and the seller had the same affiliation. As in New Jersey, the average percentage of tranches won from a distributor is higher when the generator has the same affiliation.

For a more rigorous test, I estimated, separately for Illinois and New Jersey, the regression $Won = \alpha + \beta_1 \cdot Integrated + \beta_2 \cdot Year + \varepsilon$. The variable *Won* is the proportion of tranches won by the integrated generators, as the dependent variable. The indicator variable *Integrated* takes value 1 (0) if the proportion won by the generator was with an integrated (non-integrated) distributor. As the auctions in New Jersey took place from 2002 till 2008, I also included the variable *Year*, indicating the year the auction took place**.** The last term, ε, gives the error, which I assume to have an i.i.d. normal distribution. The theory presented in this paper suggests that an integrated buyer will bid

[37] I compared the average of tranches of RECO won by the generator affiliated with RECO (Consolidated Edison Energy, Inc.) with the average of tranches this generator won from the other distributors using a t-test with pooled variance. I did the same test for the other generators, but most of them had low significance (around 0.2 ~ 0.3).

more aggressively in an auction and thus have a higher probability of winning the auction; the variable *Integrated* should thus have a positive effect on the proportion won. Table 5 shows that in regressions with the proportion won as a dependent variable, the coefficient on *Integrated* is indeed positive and significant both in Illinois and in New Jersey.[38]

Table 5: Percentage of tranches won in auctions regressed on *Integrated.*

My analysis in the procurement auctions in Illinois and New Jersey shows that generators obtained higher shares of contracts for supply from the distributor with the same affiliation than from a distributor with a different affiliation. This conforms to the intuitions developed in the theoretical models in this paper. However, an alternative explanation would be that there are other advantages for a generator to supply to an integrated distributor. For example, a generator might receive information from its distributor which enables it to better forecast the needed supply and thus save costs. In addition, for the theoretical models in this paper to apply, it must be the case that the distributor at least partly benefits from the auction revenues and that a part of the benefit is passed on to the owner, the holding company. A more extensive study could control for such alternative explanations.

5. CONCLUSION

My analyses suggest that the integrated ownership of a buyer and seller has negative effects on auction outcomes when values are private. A holding company that owns both a buyer (the integrated buyer) and (a share of) the seller has incentives to make the integrated buyer bid more aggressively. Consequently, the profit of the integrated buyer increases at the expense of an independent buyer, thus curbing competition and causing efficiency losses. The aggressive bidding also drives up the price of the good on auction. This price effect can be interpreted as positive: In transmission auctions the price of capacity, which is generally underpriced, is closer to its social value, and in procurement auctions the price of electricity is lower. Additional analysis shows that different but similar effects arise under perfect information; when the buyers' valuations for the good are common knowledge, the allocations that result from the auction are no longer inefficient,

[38] As a robustness test I included several sets of dummy variables in the regression. I included dummies for different products (contracts for different duration and pricing), for years, and for generators, but the significance of the variable *Affiliated* was hardly influenced. See Table A in the Appendix for the regression models including the dummies.

but the independent buyer can in some settings be prevented from making any profits at all. The independent buyer is also strongly discriminated against when buyers have an unknown common value component and no private valuation.

The results are relevant for EU electricity markets as transmission capacity on international lines are often sold by explicit auction mechanisms. Moreover, the EU allows the building of merchant transmission lines where the owner can keep the auction revenues in full. As the analysis in this paper shows, this might result in discrimination against independent generators under legal unbundling. Such discrimination, while undesirable in itself, also makes new entry less attractive. This is a serious concern as national electricity generation markets in the EU are very concentrated and thus new entrants are needed to make any liberalization reforms successful. Furthermore, the holding company owning the integrated seller is advantaged, and because the holding company is often the (former monopoly) incumbent, this further consolidates its already dominant position in the electricity supply industry.

The results are also relevant for the US electricity market as contracts for electricity supply are sometimes sold in procurement auctions. Distributors selling in such auctions are owned by companies that also own generators that participate in the auction. As my analysis shows, such auctions are likely not fair – integrated generators have a higher probability to win auctions. Indeed, my empirical analysis shows that integrated generators obtained significantly more contracts from integrated distributors than from other ones. This might affect efficiency negatively and discourage new entrants. However, a positive static effect is that the aggressive bidding of integrated generators makes the electricity cheaper for distributors, from which consumers are likely to benefit.

There are a few possible solutions to remedy the negative results found in this analysis. Firstly, regulators could aim their efforts at preventing that auction revenues benefit the VIU that owns distribution or transmission networks. If successful, this would reduce the effective ownership share to zero and thus take away the basis for the advantaged position of the integrated generator. Enforcing ownership unbundling would effectively achieve this goal. Alternatively, given the strong resistance against ownership unbundling both in the EU and the US, regulators could try to achieve this goal by means of strict regulation without ownership unbundling, for example by using rate of return regulation for transmission and distribution networks. However, rate of return regulation has long been known to lead to welfare losses (Averch and Johnson 1962). As the electricity industry is being liberalized it is becoming more and more attractive to use a form of incentive regulation that gives a network owner incentives to run the network efficiently and to add new capacity (Vogelsang 2002, 2005; Joskow 2006). Moreover, preventing transmission owners from benefiting from the auction revenue goes against the EU policy of allowing the merchant (for-profit) building of new transmission lines. In addition, there is evidence that network owners are sometimes able to use the auction revenues in other ways than prescribed by regulators (Commission of the European Communities 2007, 179).

Secondly, a possible remedy is to mandate the VIU to legally separate not only the seller, but also the integrated buyer. This is the form of legal unbundling that Cremer et al. (2006) consider, and for which Höffler and Kranz (2007) coined the term "reverse unbundling". By implementing the same sort of legal unbundling for the integrated buyer, the holding company is no longer able to give the integrated buyer day-to-day instructions. Also, the integrated buyer is not allowed to take revenues of the integrated seller or the holding company into account; it is usual that in a legally unbundled firm managers are not allowed to receive bonuses contingent on results of the holding company.[39] I take up this question in Van Koten (2008), and show that auction outcomes are still negatively affected on the same dimensions as in this paper, although slightly less pronounced. Legal unbundling of the integrated buyer is therefore not a sufficient measure.

Thirdly, an independent generator could be awarded or sold an ownership share such that both generators end up with equal shares. Ettinger (2002) has analyzed such a setup and finds that in this case there is no discrimination and no efficiency loss. Moreover, the increase in price, which can be a positive effect, is stronger. Giving equal shares thus provides a solution but requires the regulator to have the authority to mandate the VIU to sell shares in the transmission line to new independent generators. Moreover, implementation of such a measure brings up many practical questions, such as on what legal basis should regulators be allowed to take away ownership shares from the incumbent and for what compensation? And should ownership shares only be given to participating buyers or also to *potentially* participating buyers? Giving buyers symmetrical shares could therefore be complicated in practice.

The solution most in line with economic logic suggested by the models in this paper is to mandate ownership unbundling for distribution and transmission networks: When buyers have no ownership shares in sellers, auctions are efficient and non-discriminatory.

[39] For example, managers in legal unbundled transmission companies are not allowed to receive bonuses contingent on results of the holding company (Directive 2003/54/EC, article 10, section 2b, and Commission of the European Communities, 16.01.2004, p.8).

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7. APPENDIX

Proposition 1: *For any $n \geq 1$, in a second-price auction with n+1 buyers, one integrated buyer who receives a share γ of the auction revenue and n independent buyers, where values are distributed independently and uniformly on [0,1], the independent buyers bid their value, and the integrated buyer bids $b_Y[v_Y] = v_Y + \gamma \frac{1-v_Y}{\gamma+1}$. As a result, with increasing γ for all $n \geq 1$:*

a) *The expected profit of Y, $\pi_Y^{(n)}[\gamma]$,increases,*

b) *The expected auction revenue, $m^{(n)}[\gamma]$, increases,*

c) *The expected profit of X_i, $\pi_{X_i}^{(n)}[\gamma]$, decreases,*

d) *Efficiency, $W^{(n)}[\gamma]$, decreases.*

e) *The profit of optimizing total profits (generator profits and γ times auction revenue) increases relative to optimizing the profit of only the generator..*

Proof: *Independent buyers bidding their own bid in a second-price auction is a standard result.*[40] *The profit function for the integrated buyer Y is given by*

$$\pi_Y^{(n)}[b_Y, v_Y] = \Pr[Y \text{ wins}] \cdot (v_Y - (1-\gamma) \cdot \mathbf{E[highest\ bid\ from\ n\ buyers\ |\ Y\ wins])}$$

$$+\gamma \cdot \Pr[Y \text{ has } 2^{\text{nd}} \text{ highest bid}] \cdot \boldsymbol{b_Y}$$

$$+\gamma \cdot \sum_{i=2}^{n} \Pr[Y \text{ has i}^{\text{th}} \text{ highest bid}] \cdot \mathbf{E[2nd\ highest\ bid\ from\ n\text{-}i\ buyers\ |\ Y\ has\ i^{th}\ highest\ bid]}$$

.

The parts in bold in this equation are the expected payments for each case. Writing out $\pi_Y^{(n)}[b_Y, v_Y]$, *filling in the probabilities and expected values, taking into account that values are uniformly distributed on the interval [0,1,] and that independent buyers bid their own value, results in the following expression:*

$$\pi_Y^{(n)}[b_Y, v_Y] = b_Y^n \left(v_Y - (1-\gamma)\frac{1}{b_Y^n}\int_0^{b_Y} nz^{n-1} zdz \right)$$

$$+ j\left(nb_Y^{n-1}(1-b_Y)b_Y\right)$$

$$+ j\sum\nolimits_{i=2}^{n}\left(\frac{n!}{(n-i)!i!} b_Y^{n-i}(1-b_Y)^i \int_{b_Y}^{1} \frac{i(i-1)(1-z)(z-b_Y)^{i-2}}{(1-b_Y)^i} zdz\right).$$

In the first line, the probability of Y winning with bid b is equal to b_Y^n *and the expected price is equal to* $\frac{1}{b_Y^n}\int_0^{b_Y} nz^{n-1}zdz$ *, where* nz^{n-1} *is the probability distribution function of the highest value of the n independent buyers. In the second line, the probability of Y having the 2nd highest bid is equal to* $nb_Y^{n-1}(1-b_Y)$*, and the payment by the winner of the auction is the bid b of Y. In the third line, the probability of Y having the ith highest bid (*$2 \le i \le n$*) is equal to* $\frac{n!}{(n-i)!i!} b_Y^{n-i}(1-b_Y)^i$*, and the expected 2nd highest bid of n-i buyers is equal to* $\int_{b_Y}^{1} \frac{i(i-1)(1-z)(z-b_Y)^{i-2}}{(1-b_Y)^i} zdz$ *, where* $i(i-1)(1-z)(z-b_Y)^{i-2}$ *is the probability distribution function of the 2nd highest value of n-i independent buyers. Solving the integrals in the first and third line, and collecting the elements*

[40] See, for example, Krishna, 2002.

multiplied with the ownership share γ gives the following expression:

1) $\pi_Y^{(n)}[b_Y, v_Y] = b_Y^n v_Y - \frac{n}{n+1} b_Y^{n+1} + \gamma\left(\frac{n}{n+1} b_Y^{n+1} + nb^{n-1}(1-b_Y)b_Y + \frac{n-1}{n+1}(1-(n+1)b_Y^n + nb_Y^{n+1}\right),$

where $\frac{n}{n+1} b_Y^{n+1}$ *is the expected price Y must pay when it wins and* $\frac{n-1}{n+1}(1-(n+1)b_Y^n + nb_Y^{n+1}$ *is the s expected payment when Y has a bid lower than the 2nd highest bid (the third line in the above equation). Differentiating the equation with respect to b, setting it equal to zero, and solving for b results in a bidding function given by* $b[v_Y] = v_Y + \gamma \frac{(1-v_Y)}{\gamma+1}$*. Differentiating* $\pi_Y^{(n)}[b_Y, v_Y]$ *twice and substituting* b_Y *with* $b[v_Y] = v_Y + \gamma \frac{(1-v_Y)}{\gamma+1}$ *gives* $\frac{d^2\pi_Y^{(n)}[b_Y, v_Y]}{(db_Y)^2} = -(1+\gamma)n\left(\frac{j+v_Y}{j+1}\right)^{n-1} < 0$*, which establishes that the found bidding function is a global optimum. The inverse bidding function* $y[\cdot]$ *such that* $y[b[v_Y]] = v_Y$ *is given by* $y[b_Y] = (1+\gamma)b_Y - \gamma$ *.*

As a result, with increasing γ*, for all* $n \geq 1$*:*

a) The expected profit of Y, $\pi_Y^{(n)}[\gamma]$ ***,increases.*** *The expected profit of Y,* $\pi_Y^{(n)}[\gamma] = \frac{1}{(n+1)(n+2)}\left\{1+\gamma\left(n^2+n+\gamma-\gamma(\frac{\gamma}{1+\gamma})^n\right)\right\}$*, can be found by substituting* b_Y *with the optimal bidding function* $b_Y[v_Y] = v_Y + \gamma \frac{1-v_Y}{\gamma+1}$ *in equation 1 above, and integrating over the value realizations of Y from 0 to 1:* $\pi_Y^{(n)}[\gamma] = \int_0^1 \frac{(z+\gamma)^{n+1}}{(n+1)(1+\gamma)^n} + \gamma \frac{n-1}{n+1} dz$ *.*

b) The expected auction revenue, $m^{(n)}[\gamma] = \frac{1}{(n+1)(n+2)(1+\gamma)^{n+1}}\left\{(1+\gamma)^{n+1}\left(n^2+n+2\gamma\right) - \gamma^{n+1}\left(n+2\gamma+2\right)\right\}$***, increases.*** *The expected payment by Y,* $m_Y^{(n)}[\gamma]$*, is in the same fashion equal to the bolded portion of the first line of equation (1) (the case that Y wins the auction, in other words, equal to equation (1) with* $v_Y = 0$ *and* $\gamma = 0$*). This expression is equal to*

$$m_Y^{(n)}[\gamma] = \int_0^1\left(\frac{n}{n+1} b_Y^{\,n+1}\right) dv_Y = \frac{n}{(n+1)(n+2)(1+\gamma)^{n+1}}\left((1+\gamma)^{n+2} - \gamma^{n+2}\right).$$

The expected payment by all independent buyers together is equal to the second and third line of equation (1) (in other words, equal to equation (1) with $v_Y = 0$ *and* $\gamma = 1$*). The expected payment by a independent buyer i (*$1 \le i \le n$*),* $m_{X_i}^{(n)}[\gamma]$*, is thus equal to this expression divided by the number of independent buyers, n,* $m_X^{(n)}[\gamma] = \frac{1}{n}\int_0^1 \left(n{b_Y}^{n-1}(1-b_Y)b_Y + \frac{n-1}{n+1}(1-(n+1){b_Y}^n + n{b_Y}^{n+1} \right) dv_Y$.

The expected auction revenue, $m^{(n)}[\gamma]$*,is equal to these expected payments added for all participants, thus* $m^{(n)}[\gamma] = n \cdot m_X^{(n)}[\gamma] + m_Y^{(n)}[\gamma]$*, which is equal to*

$m^{(n)}[\gamma] = \frac{1}{(n+1)(n+2)(1+\gamma)^{n+1}} \left\{ (1+\gamma)^{n+1} \left(n^2 + n + 2\gamma \right) - \gamma^{n+1} \left(n + 2\gamma + 2 \right) \right\}$.

c) The expected profit of X_i **,** $\pi_{X_i}^{(n)}[\gamma] = \frac{1}{n(n+1)(n+2)(1+\gamma)^{n+1}} \left\{ (1+\gamma)^{n+1} \left(n - 2\gamma \right) + \gamma^{n+1} \left(n + 2\gamma + 2 \right) \right\}$,

decreases. *The expected profit of* X_i *is equal to its expected value minus its expected payment, thus* $\pi_{X_i}^{(n)}[\gamma] = v_{X_i}^{(n)}[\gamma] - m_{X_i}^{(n)}[\gamma]$*. The expectation of the value an independent buyer* X_i *assigns to the good when it wins,* $v_{X_i}^{(n)}[\gamma]$*, is equal to the probability of winning times the expected value conditional on winning. The probability of* X_i *winning requires the remaining n-1 independent buyers to have a lower value (the first element in the integral below), and the integrated buyer Y to have a lower bid (the second element in the integral below). Thus:*

$v_{X_i}^{(n)}[\gamma] = \Pr[X_i \text{ wins}] \cdot E[v \mid X_i \text{ wins}] = \int_{\frac{j}{j+1}}^1 {v_Y}^{n-1} \cdot y[v_Y] \cdot v_Y dv_Y$.

Note that the integration runs from $\frac{\gamma}{1+\gamma}$ *to 1, as the value of* X_i *must be higher than the lowest bid of Y, given by* $\frac{\gamma}{1+\gamma}$*. The expected payment of* X_i *,* $m_{X_i}^{(n)}[\gamma]$*, was derived in (b). The expected profit of* X_i *, is then equal to* $\pi_{X_i}^{(n)}[\gamma] = v_{X_i}^{(n)}[\gamma] - m_{X_i}^{(n)}[\gamma]$.

d) Efficiency, $W^{(n)}[\gamma]$***, decreases.*** *Efficiency,* $W^{(n)}[\gamma] = \frac{n+\gamma+1}{(n+1)(n+2)} \left\{ n + 1 + \gamma \left(n - 1 + (\frac{\gamma}{1+\gamma})^n \right) \right\}$*, can be calculated by summing over profits and auction revenues:*

$W^{(n)}[\gamma] = \pi_Y^{(n)}[\gamma] + (1-\gamma) m^{(n)}[\gamma] + \sum_{i=1}^{n} \pi_{X_i}^{(n)}[\gamma]$*. This expression is decreasing in* γ *.*

e) The profit of optimizing total profits (generator profits and γ times auction revenue) increases relative to optimizing the profit of only the generator. *The difference between profits when maximizing total profits minus that when maximizing the profit of only the generator is what I call the strategic profit and is given by* $\pi^{(n)}_{Y\,strategic}[\gamma] = \pi^{(n)}_Y[\gamma] - \left(\pi^{(n)}_Y[0] + \gamma m^{(n)}[0]\right)$. *The first part in the expression is the profit when maximizing total profits, as* $\pi^{(n)}_Y[\gamma]$ *includes the ownership share times the auction revenue. The second part is the profit when maximizing only the profit of the generator. In that case , the auction revenue is given by* $m^{(n)}[0]$, *and the profit of Y, which I call the naïve profit, is given by* $\pi^{(n)}_Y[0] + \gamma m^{(n)}[0]$. *Using (a) and (b) for substituting into the strategic profit it can be shown to be increasing in* γ.

Proposition 3: *In a first-price auction with one competing independent buyer X and an integrated buyer Y who has full ownership,* $\gamma = 1$ *,who bids its value, while the independent buyer bids* $b_X = \frac{1}{2} v_X$. *As a result of the more aggressive bidding of Y,*

a) The expected profit of Y, $\pi_Y[\gamma]$ *,increases,*

b) The expected auction revenue, $m\,[\gamma]$, *increases,*

c) The expected profit of X_i, $\pi_{X_i}[\gamma]$, *decreases,*

d) Efficiency, $W\,[\gamma]$, *decreases.*

e) The profit of optimizing total profits (generator profits and γ *times auction revenue) increases relative to optimizing the profit of only the generator.*

Proof: *Proposition 2 established that Y bids its own value,* $b_Y[v_Y] = v_Y$, *and the independent buyer bids* $b_X[v_Y] = \frac{1}{2} v_Y$. *The inverse bidding functions are thus* $b_Y^{-1}[b_Y] = b_Y$ *and* $b_X^{-1}[b_X] = 2b_X$.

a) The expected profit of Y, $\pi_Y[\gamma]$***,increases.*** *In the case of no ownership, it is equal to* $\pi_Y[\gamma = 0] = \frac{1}{6}$. *In the case of full ownership,*

$$\pi_Y[\gamma = 1] = \int_0^{\frac{1}{2}} p^{Y\,wins}\left(b_Y\left[v_Y\right]\right) dv_Y + \int_{\frac{1}{2}}^1 p^{Y\,wins} \cdot \left(b_Y\left[v_Y\right]\right) dv_Y + \left(\int_0^1 p^{X\,wins}\left(b_X\left[v_Y\right]\right) dv_Y\right)$$

$$= \int_0^{\frac{1}{2}} 2v_Y \left(v_Y\right) dv_Y + \int_{\frac{1}{2}}^1 1\cdot\left(v_Y\right) dv_Y + \left(\int_0^1 \tfrac{1}{2} v_Y \left(\tfrac{1}{2} v_Y\right) dv_Y\right)$$

$$= \left[\tfrac{2}{3} {v_Y}^3\right]_0^{\frac{1}{2}} + \left[\tfrac{1}{2} {v_Y}^2\right]_{\frac{1}{2}}^1 + \left(\left[\tfrac{1}{12} {v_Y}^3\right]_0^1\right)$$

$$= \tfrac{13}{24}.$$

Where the probability of Y winning with value v_Y *is given by*

$p^{Y\,wins}[v_Y] = {b_X}^{-1} \circ b_Y[v_Y] = 2\cdot v_Y$ *when* $v_Y \le \frac{1}{2}$

$p^{Y\,wins}[v_Y] = 1$ *when* $v_Y > \frac{1}{2}$

Once Y has a value higher than $\frac{1}{2}$ *it can be sure of winning as the highest bid of X is* $b_X[1] = \frac{1}{2}$. *The probability of X winning with value* v_X *is given by* $p^{X\,wins}[v_X] = {b_Y}^{-1} \circ b_X[v_X] = \frac{1}{2} v_X$.

b) The expected auction revenue, $m^{(n)}[\gamma]$***, increases. As Y pays all its realized value, auction revenue is equal to profit of Y plus*** $m[\gamma = 1] = \pi_Y[\gamma = 1] = \frac{13}{24}$.

c) The expected profit of X_i***,*** $\pi_{X_i}^{(n)}[\gamma]$***, decreases.*** *In the case of no ownership the expected profit of X is given by* $\pi_X[\gamma = 0] = \frac{1}{6}$. *With full ownership, the profit is equal to*

$$\pi_X[\gamma = 1] = \left(\int_0^1 P^{X\,WINS}\left(v_X - b_X\left[v_X\right]\right) dv_X\right)$$

$$= \int_0^1 \tfrac{1}{2} v_x \left(\tfrac{1}{2} v_x\right) dv_x = \tfrac{1}{12}.$$

d) Efficiency, $W^{(n)}[\gamma]$***, decreases.*** *In the case of no ownership efficiency is equal to the expected value of the highest out of two signals which is equal to* $W\left[\gamma = 0\right] = \frac{2}{3}$. *In the case of full ownership, by* $W\left[\gamma = 1\right] = \frac{5}{8}$. *The efficiency is equal to the profits of X and Y together, that is, the full auction revenue is accounted for in the profit of Y, and thus* $W\left[\gamma\right] = \pi_X\left[\gamma\right] + \pi_Y\left[\gamma\right] = \frac{13}{24} + \frac{1}{12} = \frac{5}{8}$.

e) The profit of optimizing total profits (generator profits and γ ***times auction revenue) increases***

relative to optimizing the profit of only the generator $\pi^{(n)}_{Y\,strategic}[\gamma]=\pi^{(n)}_{Y}[\gamma]-\left(\pi^{(n)}_{X_i}[0]+\gamma m^{(n)}[0]\right)$***.*** *In the case of no ownership the strategic profit is by definition equal to* $\pi_{Y\,Strategic}\left[\gamma=0\right]=0$*, and, in the case of full ownership, by* $\pi_{Y\,Strategic}\left[\gamma=1\right]=\frac{1}{24}$*. Total profits of Y are equal to* $\pi_{Y}[\gamma=1]=\frac{13}{24}$*,and the naïve profit is equal to* $\overline{\pi}_{Y\,Naïve}\left[\gamma\right]=\pi^{Y}\left[0\right]+\gamma m\left[0\right]=\frac{1}{6}+\frac{1}{3}=\frac{1}{2}$*,thus the difference is equal to* $\pi_{Y\,Strategic}\left[\gamma=1\right]=\pi^{Y}\left[\gamma=1\right]-\overline{\pi}_{Y\,Naïve}\left[\gamma=1\right]=\frac{13}{24}-\frac{1}{2}=\frac{1}{24}$.

Proposition 4: *Given a value of the ownership share,* $\gamma:0<\gamma<1$*, the inverse bidding functions* $x[b]$ *and* $y[b]$ *and the maximum bid* $\overline{b}$ *for all bids* b *can be found by solving the following set of equations:*

4) $(y[b]-b)\cdot x'[b]=(1-\gamma)x[b]$*;*

5) $(x[b]-b)\cdot y'[b]=y[b]$*;*

6) $x[\overline{b}]=y[\overline{b}]=1$*;*

7) $\overline{b}=\frac{1}{2}\left(1+\gamma\int_0^{\overline{b}}x[\beta]d\beta\right)$.

Proof: *Equation (4) and (5) are the first order conditions on p. 16. Equation (6) states that a buyer only makes the maximum bid* $\overline{b}$ *when it has the highest possible value, which is one. This follows from the fact that it is a Nash-equilibrium to bid equal or lower than the highest bid. Equation (7) puts a restriction on the maximum bid that can be derived from the fact that a buyer with value 0 bids 0,* $x[0]=y[0]=0$*, and the first order conditions (4) and (5). Rewriting (4) and (5) gives*

$$x'[b]\cdot(y[b]-b)=(1-\gamma)\cdot x[b]\Leftrightarrow$$

8) $(x'[b]-1)\cdot(y[b]-b)=(1-\gamma)\cdot x[b]-y[b]+b$,

$$y'[b]\cdot(x[b]-b)=y[b]\Leftrightarrow$$

9) $(y'[b]-1)\cdot(x[b]-b)=y[b]-x[b]+b$.

Summing up 8) and 9) gives;

$$(x'[b]-1)\cdot(y[b]-b)+(y'[b]-1)\cdot(x[b]-b)=2b-\gamma x[b]\Leftrightarrow$$

10) $\frac{\partial}{\partial b}(x[b]-b)\cdot(y[b]-ab)=2b-\gamma x[b]$.

Integrating equation (10) over 0 to the maximum bid $\bar{b}$ gives

$$(1-\bar{b})\cdot(1-\bar{b}) = \bar{b}^2 - \gamma\int_0^{\bar{b}} x[b] \Leftrightarrow$$

7) $\bar{b} = \frac{1}{2}\left(1+\gamma\int_0^{\bar{b}} x[b]\right).$

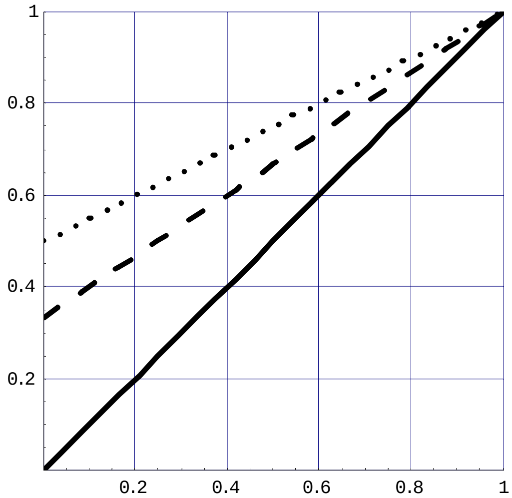
8. NOTATION

γ	$\gamma \in [0,1]$ is the ownership share that the integrated buyer holds in the seller. The integrated buyer therefore receives the portion γ of the revenue of the seller.
b_i	$b_i \in [0,\bar{b}] \subseteq [0,1]$, with $i \in [X,Y]$, is the officially stated bid offered by a buyer. $\bar{b} \in [0,1]$ is the maximum bid in the auction.
$b_Y[v_Y]$	The optimal bid of the integrated buyer Y given its realized value $v_Y \in [0,1]$. This strategy $b_Y[\cdot]$ has the inverse $y[\cdot]$ (such that $y[b_Y[v_Y]] = v_Y$).
$b_X[v_X]$	$b_X[v_X]$ is the optimal bid of the independent buyer X given its realized value $v_X \in [0,1]$. This strategy $b_X[v_X]$ has the inverse $x[\cdot]$ (such that $x[b_X[v_X]] = v_X$).
$m[\gamma]$	$m[\gamma] = m_Y[\gamma] + m_X[\gamma]$ is the ex-ante expected revenue of the seller when the ownership share is γ, where $m_Y[\gamma]$ ($m_X[\gamma]$) is the ex-ante expected payment of buyer Y (X) when the ownership share of Y is γ.
v_i	$v_i \in [0,1]$, with $i \in [X,Y]$, is the value of the good on auction for buyer *i*. It is a random variable independently and uniformly distributed on $[0,1]$.
$W[\gamma]$	The expected efficiency.
$\pi^Y[\gamma]$	The expected compound profit of the integrated buyer Y.
$\bar{\pi}_{Y\,Naïve}[\gamma]$	The naïve compound profit of the integrated buyer, $\bar{\pi}_{Y\,Naïve}[\gamma] = \pi_Y[0] + \gamma m[0]$, is the compound profit when the integrated buyer has an ownership share of γ, but bids as if the ownership share is zero (it maximizes its buyer profit ignoring the effect on the auction revenue).
$\pi_{Y\,Strategic}[\gamma]$	The strategic profit, $\pi_{Y\,Strategic}[\gamma] = \pi_Y[\gamma] - \bar{\pi}_{Y\,Naïve}[\gamma]$, is the extra profit that can

be made when the integrated buyer Y maximizes the compound profit (buyer *plus* its ownership share times the auction revenue) instead of the naïve profit (only buyer profit).

FIGURES AND TABLES

Figure 1: The bidding function of integrated buyer Y in second-price auctions.

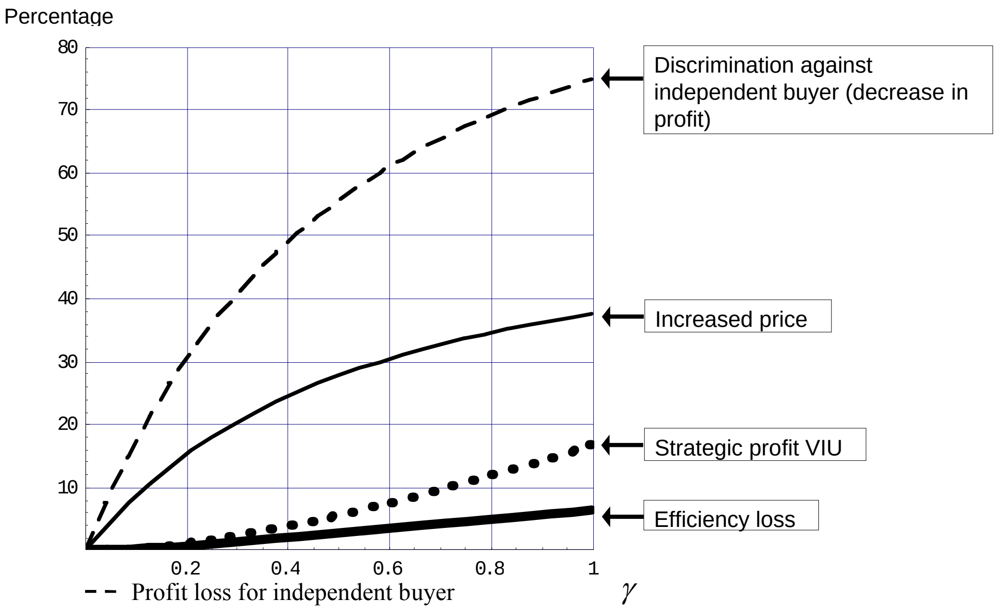


... bidding function of Y when $\gamma = 1$

--- bidding function of Y when $\gamma = 0.5$

— bidding function of Y when $\gamma = 0$

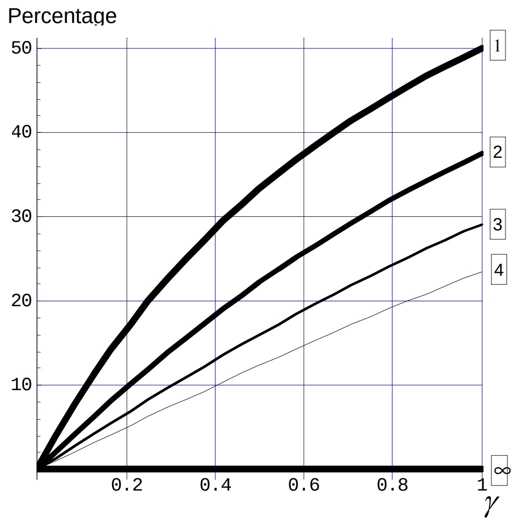
Figure 2: Outcomes in second-price auctions with one independent buyer.



- - Profit loss for independent buyer
— Percentage increase in price paid
• • • Strategic (extra) VIU profit as a percentage of "naïve" total profits
▬ Loss of efficiency as a percentage of total efficiency without ownership integration.

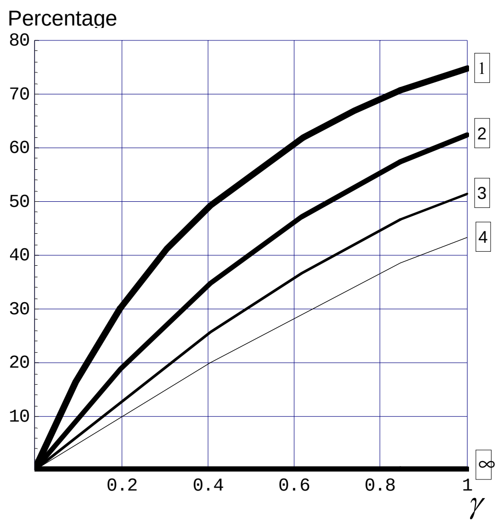
Figure 3: Outcomes in second-price auctions with 1, 2, 3, 4, and ∞ independent buyers.

a) Discrimination winning



The relative increase in winning probability for Y

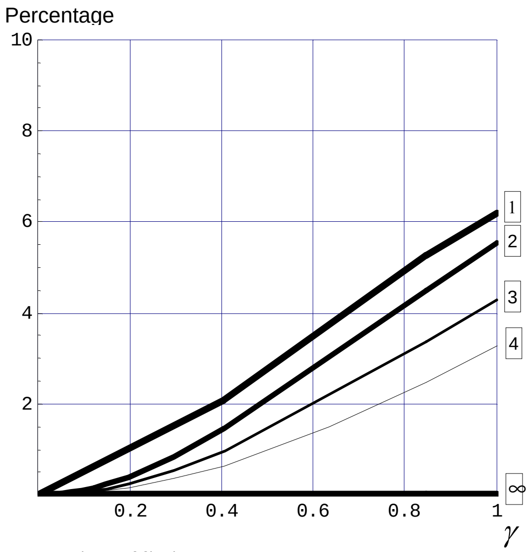
b) Discrimination profit



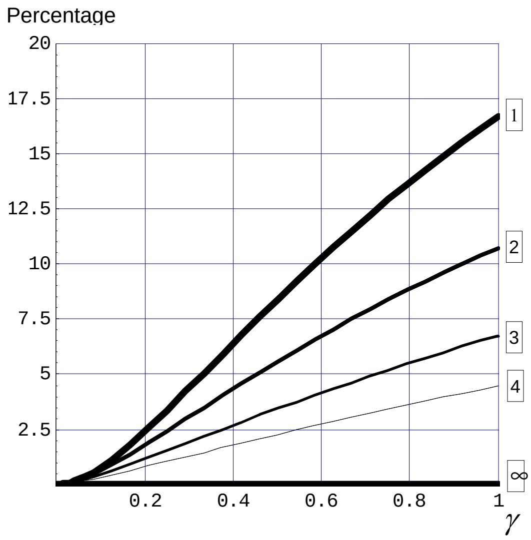
The relative loss in profit for each competing independent buyer

c) Inefficiency

d) Incentive for aggressive bidding

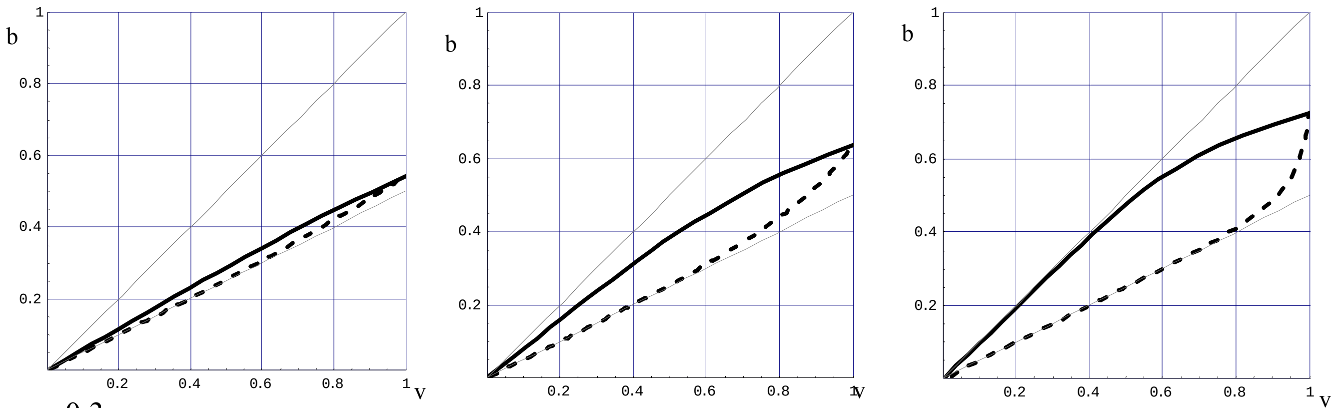


Loss in efficiency



Strength of incentives for Y to bid more aggressively as given by the strategic profit as a percentage of the naïve profit.

Figure 4: the bidding functions for independent buyer X and integrated buyer Y in first-price auctions.



$\gamma = 0.3$ $\bar{b} \approx 0.542$

$\gamma = 0.75$ $\bar{b} \approx 0.637$

$\gamma = 0.97$ $\bar{b} \approx 0.725$

— bidding function Y

- - bidding function X

— bidding functions X and Y when $\gamma = 1$

Table 1: Distributors and their integrated generators in New Jersey and Illinois

Distribution company	Generation company affiliated with the distribution company
New Jersey BGS auctions 2002-2008	
ACE	Conectiv Energy Supply, Inc.
JCP&L	FirstEnergy Solutions Corp
PSE&G	PSEG Energy Resources & Trade LLC
RECO	Consolidated Edison Energy, Inc.
Illinois electricity auctions	

Ameren	Ameren Energy Marketing Company
ComEd	Exelon Generation Cross-ownership., LLC

Table 2: Tranches won by the generator affiliated with ACE (Connective)

		Distribution company			
Year	Product	PSE&G	JCP&L	**ACE**	RECO
2002	No differentiation	0%	0%	**0%**	25%
2003	34-month	0%	36%	**29%**	100%
	10-month	5%	17%	**0%**	0%
2004	BSG-FP, 3-year	4%	0%	**14%**	0%
	BSG-FP, 1-year	0%	0%	**0%**	0%
	BSG-CIEP	0%	0%	**0%**	0%
2005	BGS-FP	0%	0%	**13%**	0%
	BSG-CIEP	0%	0%	**0%**	0%
2006	BSG-FP	0%	0%	**14%**	0%
	BSG-CIEP	0%	0%	**0%**	0%
2007	BGS-FP	0%	0%	**14%**	0%
	BSG-CIEP	0%	0%	**0%**	0%
2008	BSG-FP	0%	0%	**38%**	0%
	BSG-CIEP	0%	0%	**0%**	0%
Unweighted average 2002-2008		1%	4%	**9%**	8%

Table 3: Results of the New Jersey BGS auctions over 2002-2006

	1. Percentages of tranches won per distributor, averaged over all product groups and auctions from 2002 till 2006				2. Average percentage of tranches won at different distributors
	ACE	JCP&L	PSE&G	RECO	
Generator affiliated with					
ACE (Connective Energy Supply)	**8.1%**	3.5%	0.6%	8.3%	4.1%
JCP&L (First Energy Solutions Corp)	2.7%	**2.4%**	2.5%	0.0%	1.7%
PSE&G (PSEG Energy Resources & Trade)	9.8%	14.9%	**21.8%**	20.0%	14.9%
RECO (Consolidated Edison Energy)	1.9%	9.7%	1.7%	**16.7%****	4.4%

** Significant at the 5% confidence level

Table 4: Results of the Illinois auctions in 2006

	1. Percentages of tranches won per distributor, averaged over all product groups	
	Ameren	ComEd
Generator affiliated with		
Ameren (Ameren Energy Marketing Company)	**26.9%*****	0.0%
ComEd (Exelon Generation CO)	12.3	**29.4%**

*** Significant at the 1% confidence level

Table 5: Percentage of tranches won in auctions regressed on *Integrated*.

	Illinois	**New Jersey**
Integrated	0.22** (.10)	0.05* (0.03)

Year	-	0.003 (0.006)
N	20	236
R^2	0.21	0.03

** Significant at the 5% confidence level
* Significant at the 10% confidence level
() Standard errors

Table A1

Won	Illinois			New Jersey BGS		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Integrated	**0.22** (.10)**	**0.22* (0.11)**	**0.22* (0.11)**	**0.05* (0.03)**	**0.05* (0.03)**	**0.05** (0.03)**
Dummies For products		Product 2 -0.01 (0.24) Product 3 0.20 (0.24) Product 4 0.47* (0.24) Product 5 0.08 (0.24) Product 6 0.20 (0.24) Product 7 0.20 (0.24) Product 8 0.04 (0.24) Product 9 0.26 (0.24) Product 10 0.20 (0.24)	Product 2 -0.01 (0.25) Product 3 0.20 (0.25) Product 4 0.47* (0.25) Product 5 .08 (0.25) Product 6 0.20 (0.25) Product 7 0.20 (0.25) Product 8 0.04 (0.25) Product 9 0.26 (0.25) Product 10 0.20 (0.25)		Product 2 0.12* (0.06) Product 3 0.05 (0.06) Product 4 0.09 (0.07) Product 5 (dropped) Product 6 0.02 (0.06) Product 7 0.03 (0.06) Product 8 (dropped)	Product 2 0.12 (0.06) Product 3 0.05 (0.06) Product 4 0.09 (0.07) Product 5 (dropped) Product 6 0.02 (0.06) Product 7 0.03 (0.06) Product 8 (dropped)
For generators[41]			ComEd .07 (0.11)			JCPL -0.03 (0.03) PSEG 0.13*** (0.03) RECO 0.02 (0.03)
For years				Year 2003 0.05 (0.05) Year 2004 .04 (0.05) Year 2005 0.02 (0.06) Year 2006 0.05 (0.06) Year 2007 0.08 (0.06 Year 2008 0.03 (0.06)	Year 2003 -0.00 (0.06) Year 2004 0.02 (0.06) Year 2005 -0.05 (0.09) Year 2006 -0.02 (0.09) Year 2007 0.01 (0.09) Year 2008 -0.03 (0.09)	Year 2003 -0.00 (0.06) Year 2004 0.02 (0.06) Year 2005 -0.05 (0.08) Year 2006 -0.02 (0.08) Year 2007 0.01 (0.08) Year 2008 -0.03 (0.08)
N	20	20	20	236	236	236
R^2	0.21	0.53	0.56	0.03	0.05	0.16

** Significant at the 5% confidence level

[41] I use the name of the affiliated distributor in place of the generator, so for example, the generator affiliated to ComEd is Exelon. Ownership is listed in Table 1.

* Significant at the 10% confidence level
() Standard errors