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Essays on the unbundling of electricity networks in the EU and the USA: Theory and Empirics

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Abstract

This Ph.D. thesis focuses on a central question about regulation in the EU and US electricity markets: the effects of vertical integration of generation and transmission and distribution networks. I focus on the forms of vertical integration where the generation and network firms are partly separated, such as in a legal or organizational form. Such form of separation is called unbundling. In the first 2 papers, I develop theoretical models to analyze the economic effects of vertical integration under legal unbundling (firms are legally separated entities and have the same owner) relative to ownership unbundling (firms are legally separated entities and have different owners). Both papers have policy implications for the regulation of the EU and US electricity markets, and make new contributions to auction theory, especially toehold auctions. In the first paper I consider the legal unbundling of the network activities; in the second paper I consider the legal unbundling of both the network activities *and* the generation activity. In both papers I find theoretical evidence that, in terms of efficiency, legal unbundling gives results inferior to ownership unbundling. Furthermore, I find solutions for several cases of toehold auctions that have not been solved before and that I believe to be interesting. In the third paper, I study the factors that have driven the choice and speed of implementation of different forms of unbundling. I find tentative evidence that questionable (corrupt?) practices may have played a role in selecting less stringent unbundling regimes.

Contents

Introduction

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. VIUs exist in the form of holding companies that still own many of the generation facilities and all, or almost all, of the transmission infrastructure. 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 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

[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)

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.[4] 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).

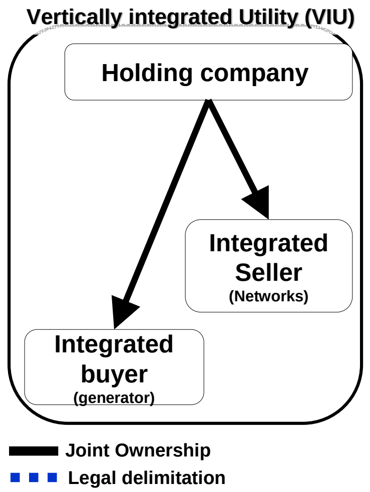
The holding company could have incentives to instruct the integrated seller to stifle competition by selling only to the integrated buyer. Regulation in EU and US therefore aims to prevent integrated sellers from favoring integrated buyers and thus discriminating against independent entrants. EU laws 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.[5] Legal unbundling intends to prevent the seller from discriminating against independent buyers in favor of the integrated buyer. I refer to this requirement as “partial legal unbundling”. In this dissertation I also consider a more stringent requirement which I refer to as “complete legal unbundling”; legally separating network activities and generation activities from one another *and* from the holding company. Figure 1 illustrates partial and complete legal unbundling of the holding companies.

Figure 1: Unbundling schemes for the VIU.

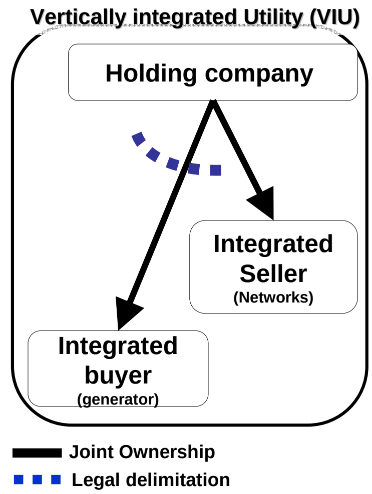
1a: Full integration 1b: Partial legal unbundling 1c: Complete legal unbundling

[4] 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).

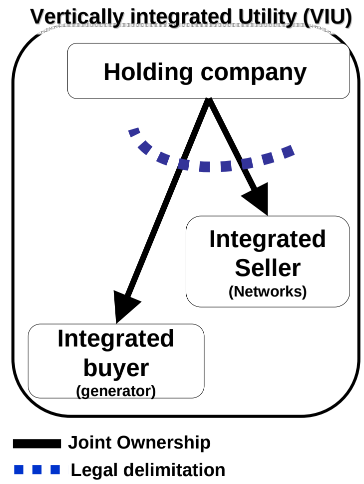
[5] Recently the European Commission has, in what is referred to as “the third energy package”, proposed new laws with stricter requirements on unbundling. However, these laws would also continue to allow VIUs to own generation and network activities, provided the network activities are legally unbundled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



Full integration of the (integrated) seller and (integrated) buyer.



Partial legal unbundling: legal separation of the integrated seller (first paper).



Complete legal unbundling: legal separation of both integrated seller and integrated buyer (second paper).

In the first two papers I address whether legal unbundling can be an effective means to guarantee non-discrimination of new independent entrants in generation. I compare the outcomes under legal unbundling with those under ownership unbundling (ownership unbundling requires firms not only to be legally separated entities, but also to have different owners).

I find that a holding company that owns both a buyer and (a share of) the seller has incentives to make the integrated buyer bid more aggressively. Under partial legal unbundling the holding company can give its integrated buyer direct instructions to bid more aggressively. I analyze this case in the first paper and find that, as a consequence of the aggressive bidding, the profit of the integrated buyer increases at the expense of independent buyers, thus curbing competition and causing efficiency losses. The aggressive bidding also drives up the price of the good on auction.

Under full legal unbundling the holding company cannot directly order its buyers to bid more aggressively, as the buyer is a legally independent entity and the holding company is not allowed to give day-to-day instructions. However, the way legal unbundling has been implemented in the EU energy laws, a holding company is allowed to set periodically performance goals and bonus schemes. In the second paper I show that the firm could draw a bonus scheme that gives the manager of the legally unbundled buyer firm a fraction of a combination of the profit and the revenue. Such a scheme is not illegal as it does not refer to activities outside of the buyer firm. However, the proportion of revenues in the bonus scheme gives the manager incentives to bid more aggressively. Like in the first paper, the aggressive bidding brings about an increase in the profit of the integrated buyer at the expense of independent buyers, thus curbing competition and causing efficiency losses. While the outcome is similar to the one in the first paper, it is quantitatively smaller by about 50%.

In the 3rd paper, written together with Andreas Ortmann, we study empirically the factors that have driven the choice and speed of implementation of different forms of unbundling. In this paper we incorporate all forms of unbundling, so apart from ownership and legal unbundling, we also consider (listed from more to less drastically unbundled): management and account unbundling, and unified ownership (no unbundling). We find tentative evidence that questionable practices may have played a role in selecting less stringent unbundling regimes.

Paper 1: The effects of vertical integration on auction outcomes in the EU and US electricity markets.*

Silvester van Koten**

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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.*

JEL classification code*: L43, L51, L94, L98, R39.*

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* I am grateful to Levent Çelik, Libor Dušek, Dirk Engelmann, Dennis Hesseling, Peter Katuščák, Jan Kmenta, Thomas-Olivier Léautier, Jesse Rothenberg, Avner Shaked, Sergey Slobodyan, the participants of the EEA-ESEM 2008 conference in Milano, and two anonymous referees of the Journal of Regulatory Economics for their helpful comments. Special thanks to Andreas Ortmann. I thank the REFGOV Integrated project funded by the 6th European research framework programme, CIT3-513420, for financial support.

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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,[6] 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).[7] 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.[8] 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

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[6] 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.

[7] See for example Consentec (2004).

[8] 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)

generators are integrated buyers; they are owned by a holding company that also owns the seller of the contracts.[9] 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.[10] 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.[11] 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.

[9] See, for the case of New Jersey, http://bgs-auction.com, and, for the case of Illinois, Illinois Commerce Commission (2006, p.8).
[10] 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).
[11] 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).

US laws mandate a comparable form of separation called "functional unbundling" that should 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,[12] 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.[13] 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

[12] 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.
[13] 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)

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, regulators in the EU have not been successful in enforcing the prescribed use of auction revenues for transmission lines.[14] 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.[15]

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.[16] 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.[17] I also assume that the good on sale is indivisible, and not in many divisible units. This

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[14] 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).

[15] 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.

[16] 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.

[17] 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.

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 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.[18] Moreover, I analyze the effect of ownership integration on competing independent buyers, something that, remarkably, has not 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

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

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[19]

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.[20] This implies that the buyers value the good

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[19] See section 8 for a notation overview.

[20] 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

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.[21] 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 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

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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 26, these common cost components are therefore inconsequential for the bidding behavior; this is determined by the unknown private value factors.

[21] 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).

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.[22]

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 on the interval $[0,1]$. The buyers are thus, at the outset, symmetrical;[23] they have identical, independent value distributions. I assume that the good on sale is sold as one indivisible good.[24] 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

[22] I thank an anonymous referee for this suggestion.
[23] This simplification serves to focus the analysis on the effect of an ownership share, and, likely, does not affect the qualitative results. See footnote 27 for an example.
[24] 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.

inverse, $x[\cdot]$, such that $x\left[b_X[v_X]\right]=v_X$.

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,*
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.[25] The profit function for the integrated buyer Y is given by[26]

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

[26] An identical, fixed, commonly known value component *R* in addition to the random private values does

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 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.

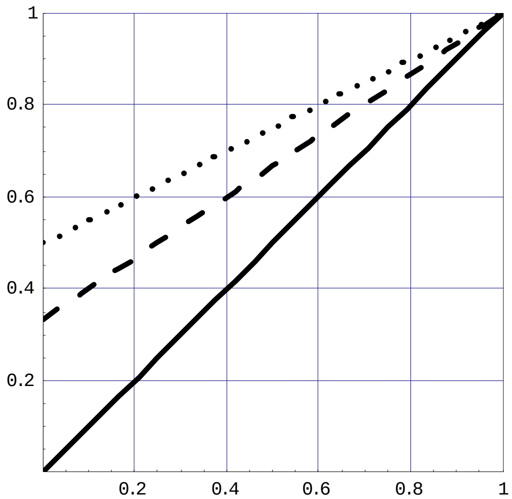
Having more independent buyers participating in the auction has opposing effects on the bidding function of the integrated buyer Y. On the one hand, having more buyers lowers the risk for the integrated buyer Y to win the auction with a bid higher than his value (the first line in the equation), and 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

---

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 $\frac{d\tilde{\pi}[b_Y, v_Y]}{db_Y} = \frac{d\pi[b_Y, v_Y]}{db_Y}$.

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.[27]

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 $\gamma = 0$

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 $\frac{11}{24}$,[28] 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

[27] 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 $v_Y \in [0,1]$.

[28] This result can be obtained for $n = \gamma = 1$ by using the formula in the proof of Proposition 1b on page 44 in the Appendix.

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). The last expression (Prop. 1e) shows that the strength of the incentive for Y to bid more aggressively increases in its ownership share γ.[29] 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 $\pi^{(n)}_{Y\,strategic}[\gamma] = \pi^{(n)}_{Y}[\gamma] - \left(\pi^{(n)}_{Y}[0] + \gamma m^{(n)}[0]\right)$. 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.

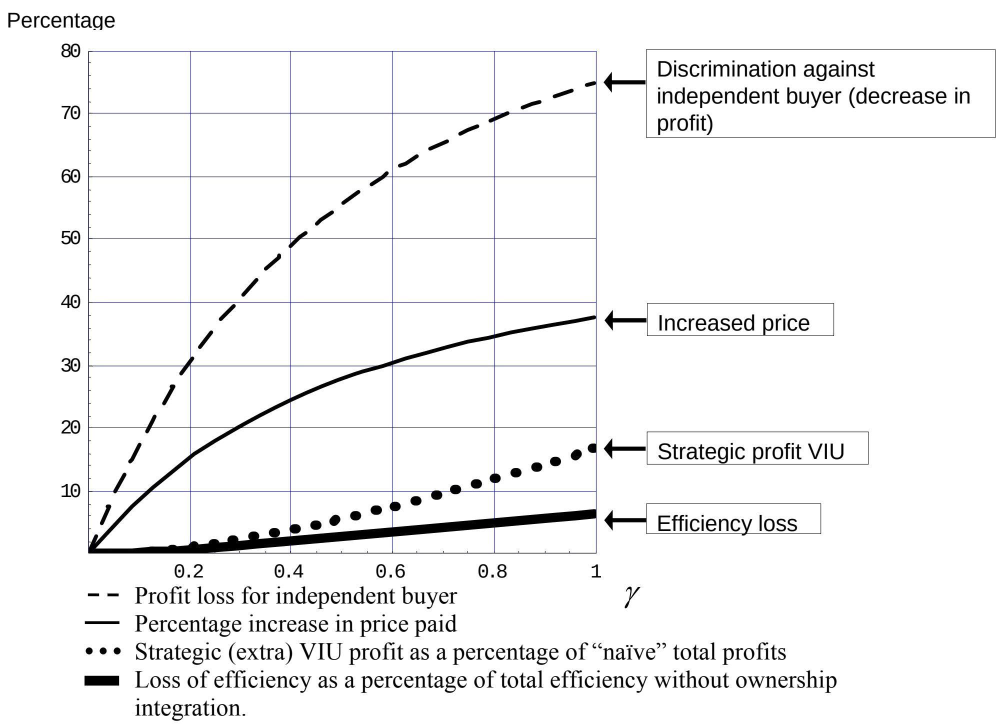


Figure 2 shows the effect of ownership share on auction outcomes when the integrated buyer competes with one independent buyer. There is a considerable efficiency

[29] 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).

loss,[30] up to 6.25%. The gain for the Vertically Integrated Utility (VIU), given by the strategic profit[31] 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 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).[32] In lowering the profits of independent generators, ownership integration – most likely – lowers the number of independent generators in the market

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

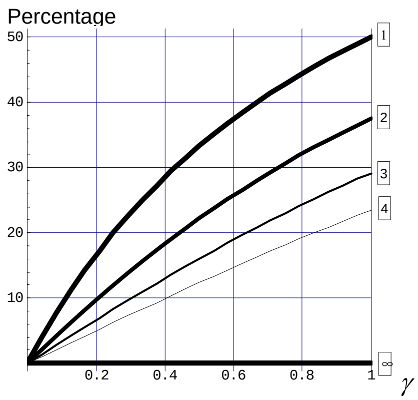
[31] The strategic profit percentage is calculated as $\frac{\pi_{Y\ Strategic}}{\bar{\pi}_{Y\ Naïve}}$.

[32] 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.

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.

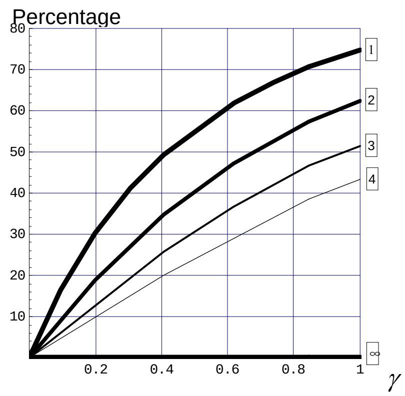
Figure 3: Outcomes in second-price auctions with 1, 2, 3, 4, and ∞ independent buyers.

a) Discrimination winning



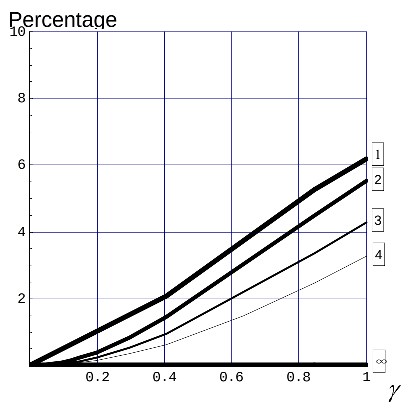
The relative increase in winning probability for Y

b) Discrimination profit



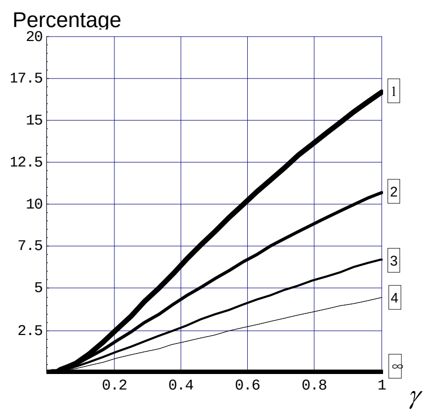
The relative loss in profit for each competing independent buyer

c) Inefficiency



Loss in efficiency

d) Incentive for aggressive bidding



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

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,[33] 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 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.[34] 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*

[33] 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).

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

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

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

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

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.25, 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 $\gamma : 0 < \gamma < 1$.[35] Figure 3 shows numerical approximations of the bidding functions for $0 < \gamma < 1$.[36]

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.

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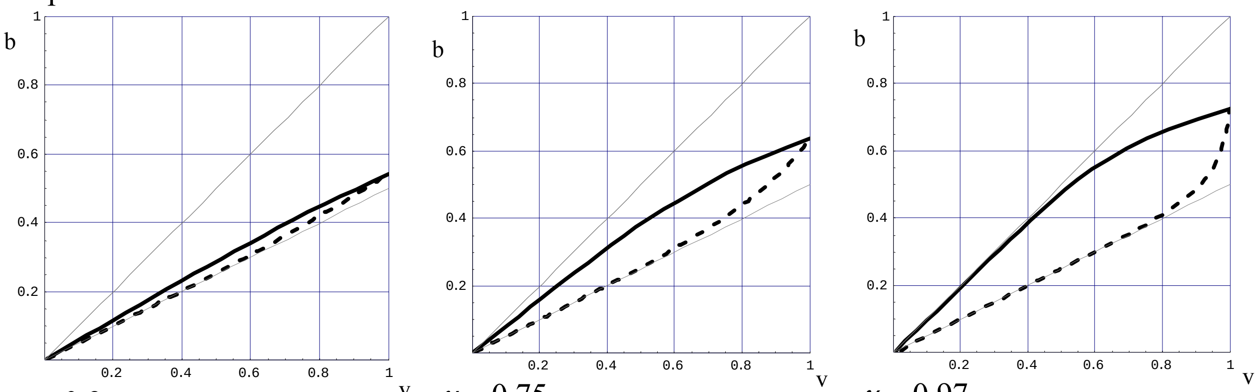
[35] To my best knowledge there exists no explicit analytical solution for the bidding function in first-price auctions with $\gamma : 0 < \gamma < 1$. Proposition 4 in the Appendix lays out the necessary restrictions that the bidding strategies must fulfill.

[36] 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.

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



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

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

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

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

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.

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 $\pi_Y = \gamma v_X$.[37] The integrated buyer thus makes the highest profit possible in these auctions; the independent buyer, on the other 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

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

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.[38] 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 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-

[38] 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).

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.[39]

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).[40] 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 generators that were bidding in the auction. **Error! Reference**

[39] 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

$$m[\gamma] = \frac{1}{4}\left(1 + \frac{4}{3-2\gamma} - \frac{1}{3-\gamma} - \frac{2}{2-\gamma} + \frac{2\,\mathrm{Gamma}[\frac{2-\gamma}{1-\gamma}]^2}{\mathrm{Gamma}[3+\frac{1}{1-\gamma}]\mathrm{Gamma}[\frac{1}{1-\gamma}]}\right).$$

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

source not found. gives an overview of the 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.[41] 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.

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

The raw data suggest that this might be the case. **Error! Reference source not found.** 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.

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

[41] 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.

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.

Table 2: Tranches won by the generator integrated to 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

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.[42]

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 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

[42] 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).

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 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.[43]

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

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.

[43] 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.

5. CONCLUSION

My analyses suggest that the integrated ownership of a buyer and seller has negative effects on auction outcomes under imperfect information. 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, 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.[44] 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.

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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.*[45] *The profit function for the integrated buyer Y is given by*

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

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

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

.

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:*

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

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

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

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* $\frac{1}{b_Y^n}\int_0^{b_Y} nz^{n-1} z dz$*, 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 2*nd *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 i*th *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 2*nd *highest bid of n-i buyers is equal to*

$\int_{b_Y}^{1} \frac{i(i-1)(1-z)(z-b_Y)^{i-2}}{(1-b_Y)^i} z dz$*, where* $i(i-1)(1-z)(z-b_Y)^{i-2}$ *is the probability distribution function of the 2*nd *highest value of n-i independent buyers. Solving the integrals in the first and third line, and collecting the elements 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 (*$1 \leq i \leq n$*),* $m_{X_i}^{(n)}[\gamma]$, *is thus equal to this* *expression divided by the number of independent buyers, n,*

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

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*

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

c) The expected profit of X_i***,*** $\pi_{X_i}^{(n)}[\gamma] = \tfrac{1}{n(n+1)(n+2)(1+\gamma)^{n+1}} \left\{ (1+\gamma)^{n+1}\left(n-2\gamma\right) + \gamma^{n+1}\left(n+2\gamma+2\right) \right\}$, ***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,* $W^{(n)}[\gamma] = \tfrac{n+\gamma+1}{(n+1)(n+2)} \left\{ n+1+\gamma\left(n-1+(\tfrac{\gamma}{1+\gamma})^n\right) \right\}$, *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* $\pi_{Y\,strategic}^{(n)}[\gamma] = \pi_Y^{(n)}[\gamma] - \left(\pi_Y^{(n)}[0] + \gamma m^{(n)}[0]\right)$. *The first part in the expression is the profit when maximizing total profits, as* $\pi_Y^{(n)}[\gamma]$ *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* $\pi_Y^{(n)}[0] + \gamma m^{(n)}[0]$. *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. 30. 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) $$\bar{b}=\tfrac{1}{2}\left(1+\gamma\int_0^{\bar{b}}x[b]\right).$$

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[46]			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 2003 -0.00 (0.06) Year 2004 0.02 (0.06) Year 2005 -0.05 (0.09) Year 2006 -0.02 (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)

[46] 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.

				Year 2007 0.08 (0.06 Year 2008 0.03 (0.06)	Year 2007 0.01 (0.09) Year 2008 -0.03 (0.09)	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
* Significant at the 10% confidence level
() Standard errors

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.

$\overline{\pi}_{Y\ Naïve}[\gamma]$ The naïve compound profit of the integrated buyer, $\overline{\pi}_{Y\ Naïve}[\gamma] = \pi_Y[0] + \gamma m[0]$, 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, $\pi_{Y\ Strategic}[\gamma] = \pi_Y[\gamma] - \overline{\pi}_{Y\ Naïve}[\gamma]$, 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).

Paper 2: Legally separated joint ownership of buyer and seller in electricity markets[†]

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CERGE-EI[‡]

Abstract

In the EU electricity industry, Vertically Integrated Utilities (VIUs) are mandated to legally separate their transmission activities, but are allowed to keep the ownership. VIUs typically own also electricity generation activities, and therefore their generators often are buyers in auctions for transmission that is owned by the same VIU. In Van Koten (2009) I show that in this configuration the VIU can – through increased auction revenue – increase its profits, while disadvantaging competitors and lowering efficiency, by having its generator bid more aggressively.

Here I analyze the regulatory measure of also legally separating the VIU-owned generator from the VIU; this measure effectively transforms the VIU into a holding company and prevents the "VIU" from influencing day-to-day decision-making of the "VIU"-owned generator and bans cross-subsidization between divisions. I show that such a measure may only be partially effective; the holding company can formulate a simple compensation scheme that does not violate the restrictions imposed by legal separation but induces the manager of the VIU-owned generator to bid more aggressively, thereby increasing the profits of the holding company and decreasing efficiency, as in Van Koten (2009).

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

JEL classification code: L22, L43, L51, L94, L98.

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1 Introduction

The present paper is motivated by the current process of liberalization of the electricity market in the European Union (EU).[47] The two main activities of the electricity industry are generation (the production of electricity) which is done by electricity generators, and transmission (the transport of electricity over long distances) which is done by a Transmission System Operator (TSO). In the past, both generation and transmission were owned by vertically integrated monopolies, also referred to as Vertically Integrated Utilities (VIUs) (European Commission Competition DG, 2007). Even though an active policy of liberalization has been pursued in the EU, VIUs still exist in the form of holding companies that own many of the generation facilities and all, or almost all, of the transmission infrastructure (European Commission Competition DG, 2007).

The combined ownership of transmission and generation by holding companies hampers the liberalization of the electricity industry. Holding companies have incentives to give their own generators (allied generators) preferential access to infrastructure capacity and curb competition by allocating minimal infrastructure capacity to competing new generators. This problem could be especially significant for competition in electricity generation between countries, as transmission lines between countries, called interconnectors, suffer from severe shortages of capacity (European Commission Competition DG, 2007, p.170).[48]

To forestall possible abuse of its dominant position, DIRECTIVE 2003/54/EC and REGULATION 1228/2003 mandate that in case of congestion on a transmission line, the holding company must allocate the access in a non-discriminatory, market-based, and efficient way. This is considered to be done best by implicit or explicit auction

[47] This part draws on Van Koten (2006), where a more detailed account can be found.
[48] This is partly a leftover from the past, as the transmission network was not intended to facilitate international power trade (CONSENTEC, 2004). In addition, Léautier (2001) and Brunekreeft, Neuhoff, Newbery (2006) suggest that a holding company might have incentives to underinvest in or even withhold transmission capacity.

(CONSENTEC, 2004). In this paper I will focus on explicit auctions, which are widely used.

However, non-discriminatory access to transmission gives holding companies, in order to lower the competitive pressure on their allied generators, incentives to build less than sufficient transmission capacity. This problem could be especially significant for competition in electricity generation between countries, as transmission lines between countries, called interconnectors, suffer from severe shortages of capacity. In order to alleviate the shortage in transmission capacity, unregulated for-profit building of transmission lines, also referred to as merchant transmission investment, is in principle allowed. This is meant to provide incentives to invest in new transmission capacity. A possible regulatory regime of particular interest suggested by the European Commission[49] is to allow the transmission owner to keep the profits of a line while still mandating a non-discriminatory, market-based and efficient method of allocating transmission capacity. I will analyze this regulatory regime and refer to it as the Merchant-Non-Discriminatory regulatory regime.

To further counter possible abuse of its dominant position, the European DIRECTIVE 2003/54/EC[50] and REGULATION 1228/2003[51] require, in addition to the above measures, the holding companies to legally separate their transmission activities from their generation activities. I will refer to this requirement as partial legal unbundling. I will refer to legally separating transmission activities and generation activities from one another *and* from the holding company as complete legal unbundling. Figure 1 illustrates partial and complete legal unbundling of the holding companies.

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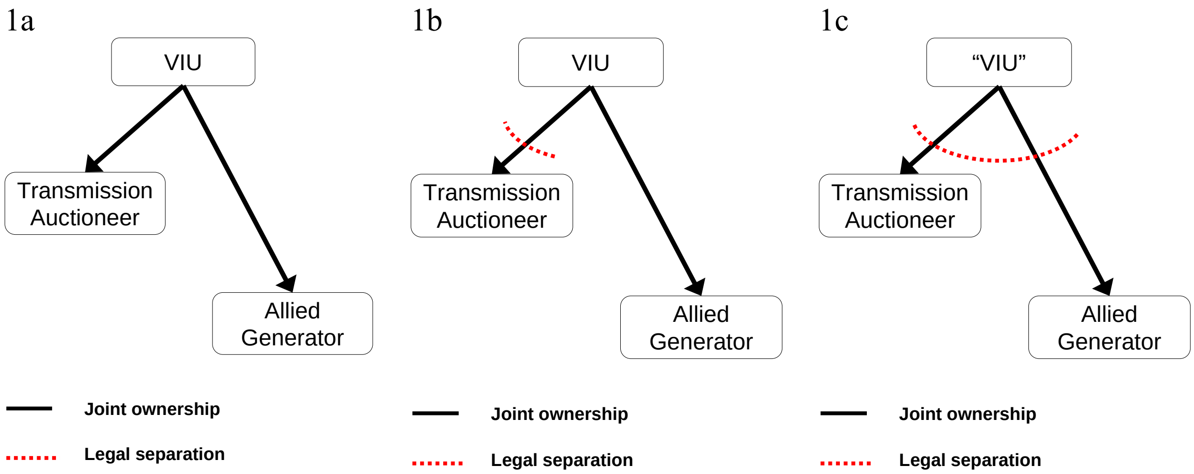
[49] NOTE OF DG ENERGY & TRANSPORT ON DIRECTIVES 2003/54-55 AND REGULATION 1228\03 IN ELECTRICITY; EXEMPTIONS FROM CERTAIN PROVISIONS OF THE THIRD PARTY ACCESS REGIME, 30.1.2004.

[50] Directive 2003/54/EC of 26 June 2003 of the European Parliament and of the Council concerning common rules for the internal market in electricity and repealing Directive 96/92/EC (OJ 2003 L 176/37).

[51] Regulation (EEC) No 1228/2003 of the European Parliament and of the Council on Conditions for Access to the Network for Cross-Border Exchanges in Electricity (OJ 2003 L 176/1).

Figure 1



Full integration of the transmission auctioneer and the allied generator.

Partial legal unbundling: legal separation of the transmission auctioneer (see Van Koten, 2009).

Complete legal unbundling: legal separation of both the transmission auctioneer and the allied generator (this paper).

Figure 1a gives the initial, fully integrated setup. Figure 1b depicts partial legal unbundling as prescribed by DIRECTIVE 2003/54/EC and REGULATION 1228/2003; the holding companies have to move their transmission activities into a legally independent subsidiary. In Van Koten (2009) I have shown this unbundling regime to be insufficient in the Merchant-Non-Discriminatory regulatory regime; when the holding company is partially legally unbundled and the holding company receives the revenues from the auctioning of transmission capacity, then auctions are no longer non-discriminatory and efficient. The holding company will drive up the price of merchant cross-border transmission lines by aggressive bidding, thus increasing its profits, while decreasing welfare. Figure 1c depicts an alternative regulatory measure, complete legal unbundling, in which the holding companies have to move their transmission activities *and* their generation activities into legally independent subsidiaries.[52] Legal separation of the allied generator forces the holding company to delegate decisions to the generator,

[52] While ownership unbundling of the transmission activity, selling the transmission activity to an independent party, would undo the negative effects found in Van Koten (2006), there is strong resistance in the EU to ownership unbundling; many countries have not implemented ownership unbundling and the holding companies in different European countries continue to voice strong protests against unbundling (Van Koten, 2006). In 2005, ownership unbundling of the transmission activity was implemented in only 12 of the then 25 EU member countries (Van Koten and Ortmann, in print).

without being able to influence the day-to-day decision-making. However, the directives allow the holding company to set general performance indicators, compensation schemes and the yearly budget for the bidder. I will show that this allowance *de facto* might seriously undermine the effect of legal separation of the allied generator.

Specifically, I will analyze the effects of this regulatory measure on the outcomes of transmission auctions. In transmission auctions several generators typically participate as bidders. For simplicity I will consider just two bidders. One of them is the allied generator, who I will refer to as allied bidder Y and the other one is an independent generator, who I will refer to as independent bidder X.

I will show that the holding company can, by means of a simple compensation scheme, delegate its decision power strategically and increase its profits when participating in transmission auctions. The compensation scheme I consider respects the legal independence of holding company, allied generator and transmission auctioneer; compensation is based on performance indicators of the allied generator only and therefore does not depend on profit indicators of the holding company or the transmission auctioneer. However, the compensation scheme distorts bidding incentives and induces the allied generator to bid more aggressively, thereby increasing the profits of the holding company. I consider one specific functional form, which I call the Own-Bid-Kickback scheme[53] (OBK scheme). This compensation scheme – to offer the manager a linear combination of profit and sales – was originally proposed by Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987) and is here modified for application in an auctions setting. Use of this compensation scheme also upsets the revenue equivalence between first- and second-price auctions.

[53] It is possible to consider more general forms of compensation schemes, e.g. non-linear ones, but the compensation scheme under consideration is a simple scheme that suffices to show that the holding company can increase its profits this way.

The remainder of this paper is organized as follows. In the next section, I analyze the effects of compensation schemes on the outcomes of transmission auctions. I first sketch the general setup, then determine the equilibrium bidding functions of bidders and the equilibrium compensation scheme in second-price auctions, and show the effects on profits and welfare. I then determine the equilibrium bidding functions of bidders and the equilibrium compensation scheme in first-price auctions and show the effects on profits and welfare. Having obtained these results, I relate my findings to the existing literature. I conclude by discussing the implications of my results for the EU electricity market policy.

2 Effects of the Own-Bid-Kickback scheme

2.1 Setup

In my model figure two generators that could profitably sell electricity in a distant location. [54] However, the transmission line to this distant location does not have enough capacity for both of them and the right to use the transmission capacity is sold in an auction to the highest bidding generator. Allied generator Y, here also referred to as allied bidder Y, is owned by a holding company that also owns a share γ ($\gamma : 0 \leq \gamma \leq 1$) of the transmission capacity. The bidding function of allied bidder Y is determined by the manager of allied bidder Y, referred to as manager Y^m. Manager Y^m receives remuneration according to a compensation scheme set by the holding company. The other generator, X, is independent and its manager ("X^m") receives remuneration proportional to the profits of generator X[55]. As the bidding incentives of manager "X^m" and independent generator X are identical, I will not distinguish between the two and refer to the independent generator as independent bidder X. The value of transmission is the profit that could be made by selling electricity in the distant location. This profit is equal to the difference between the price in the distant location and the costs of the generator. The generators cannot influence the final price in the distant location, because the transmission capacity is fixed and small relative to the total demand (see e.g. CONSENTEC, 2004).

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[54] See section 7 for a notation overview.

[55] This is without loss of generality. We will see shortly that the best credible strategy for the independent bidder X is to induce its manager ("X") to maximize profits.

The value of transmission to a bidder (generator) is drawn from a uniform distribution $v_i \in [0,1]$ where $i \in \{X, Y\}$. Values are private and independent. [56] At the outset, the bidders are therefore symmetrical. I assume that the auctioneer auctions off the transmission capacity as one indivisible good. [57]

In line with the literature, I assume that there exists a differentiable, strictly increasing bidding strategy $b_Y[\cdot]$ ($b_X[\cdot]$), that maps the allied bidder's realized value $v_Y \in [0,1]$ ($v_X \in [0,1]$) into his bid $b_Y[v_Y]$ ($b_X[\cdot]$).[58] Then the bidding strategy $b_Y[\cdot]$ has an inverse $y[\cdot]$ such that $y[b_Y[v]] = v$. Analogously, the optimal bid of the independent bidder X, b_X, is determined by her bidding strategy $b_X[\cdot]$ that maps her realized value $v_X \in [0,1]$ into her bid $b_X[v_X]$. The strategy $b_X[\cdot]$ has an inverse $x[\cdot]$, such that $x[b_X[v]] = v$.

The holding company strives for the highest attainable profit from allied generator Y and the transmission auctioneer together. Because of legal separation, the holding company cannot influence the day-to-day decision-making of the bidder or the auctioneer. The holding company therefore offers the manager of allied bidder Y, Y^m, a compensation scheme that serves the interests of the holding company, while respecting the legal independence of the holding company, the allied bidder and the auctioneer.[59]

[56] The above assumption is motivated by the fact that there exist price differences between countries that can be profitably exploited. For ease of exposure, the price in the distant location is set equal to one. The size of the profit then depends on the costs of generating electricity. As a generator does not know the cost of his competitors (see e.g. Parisio and Bosco, 2003 and Léautier, 2001), he treats it as a random variable. The costs, $c_X, c_Y \in [0,1]$, are private and independent.

[57] While transmission capacity is usually auctioned in many units of 1 GW, I restrict my focus to single-unit auctions. Excluding multi-unit auctions simplifies the analysis of OBK-schemes in auctions. Multi-unit auctions mostly do not have efficient outcomes and mostly cannot be analytically solved, which complicates the task of demonstrating the effects of OBK schemes.

[58] The strategies $b_Y[\cdot]$ and $b_X[\cdot]$ (and their respective inverses $x[\cdot]$ and $y[\cdot]$) are dependent on the ownership share γ. For notational convenience I will not include the variable "γ" in the derivation to follow. I allow for a bidding function $b[\cdot]$ to be strictly increasing on an interval $[0, \overline{v}]$ with $\overline{v} : 0 < \overline{v} < 1$ and then to be flat on $[\overline{v}, 1]$. In this case the inverse is only defined on $[0, \overline{v}]$.

[59] For a compensation scheme not to violate the legal independence of holding company, allied bidder, and auctioneer, the compensation for the allied bidder ought to be based on performance indicators of the allied bidder only, and not on profit indicators of the holding company or the auctioneer.

The holding company can choose to give the manager compensation equal to a proportion i of a linear combination of profits and revenue as considered by Vickers (1985), Fershtman and Judd (1987) and Sklivas (1987).[60] Sklivas (1987) shows that such a compensation is equal to a proportion of the revenues minus costs, where the costs are weighted by factor a.

$$w = i \cdot (a\pi + (1-a)R),$$

(where π is the profit, R is the revenue, and a is the linear weight),

$$= i \cdot (a(R-c) + (1-a)R),$$

$$= i \cdot (R - ac).$$

From here on, I will refer to factor a as the cost weight. From this perspective, normal profit maximization is the special case where the cost weight is set equal to unity: $a = 1$. Proportion i is determined endogenously in the model, as the expected compensation for manager Y^m must equal his reservation wage, w^0:

$$\text{E}[w]=\text{E}[i \cdot (R - ac)] = w^0.$$

How does such a scheme affect the bidding behavior of a manager who takes part in an auction? In an auction, the costs and returns are expected values that are endogenously determined by the bids b that the bidders submit. In this case, the expected compensation for the manager is:

$$\text{E}[w] = i \cdot x[b_Y]\left(v_Y - ab_Y\right).$$

[60] Fershtman and Judd (1987) and Sklivas (1987) considered the effect of such compensation schemes in the context of two competing firms who each have a manager that makes the crucial output and pricing decisions. They found that due to an interactive effect the optimal compensation scheme has a cost weight a such that $a > 1$ ($a < 1$) for Bertrand competition (Cournot competition); the optimal compensation scheme exaggerates (understates) a part of the costs and makes the firms competing weaker (stronger). The firms become “fat cats” (“top dogs”) in the sense of Fudenberg and Tirole (1984).

The expected value of the transmission, $x[b_Y]v_Y$, corresponds to the revenue.[61] The expected bid payment of the auction, $x[b_Y]ab_Y$, is the expected cost of realizing the "revenue". I will call this the Own-Bid-Kickback (OBK) compensation scheme, as manager Y^m does not take the full bidding costs into account when $a < 1$. In that case, manager Y^m receives a kickback of $1-a$ times his bid if he wins.

In this setup the owner of the allied bidder Y, the holding company, offers manager Y^m a specific compensation scheme, while the owner of independent bidder X does not offer its manager ("X^m") such a scheme. We will see shortly that the owner of allied bidder Y, the holding company, has incentives to implement a compensation scheme with $a < 1$ in both first- and second-price auctions because of its position of residual claimant of the auction. The owner of independent bidder X does not have comparable incentives in second-price auctions. In first-price auctions, it might seem that the owner of independent bidder X has incentives to implement a compensation scheme with $a > 1$ for strategic reasons, but I will argue that the actual implementation of any compensation scheme with $a \neq 1$ cannot be part of a Nash equilibrium.

2.2 The second-price auction

It is a well-known result that in second-price auctions, bidders have a weakly dominant strategy to set their bids equal to their values, regardless of the bidding functions of other bidders. Therefore, independent bidder X has a weakly dominant strategy to bid her own value, regardless of the type of compensation scheme manager Y^m is offered. As manager Y pays only the proportion a of his bid, it is a weakly dominant strategy for him to set a times his bid equal to his value: $ab_Y = v_Y$.

The bidding functions for X and Y are therefore

$b_X[v_X] = v_X$

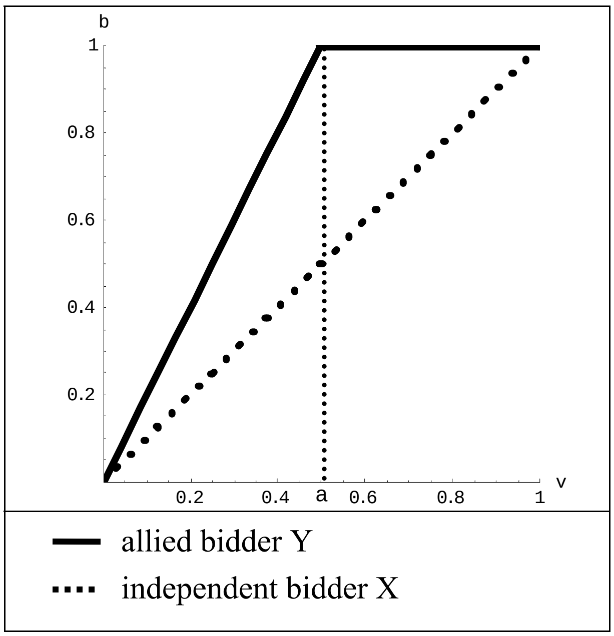
[61] We will see shortly that $x[b_Y]$ is the probability of winning the auction.

$$b_Y[v_Y] = \frac{v_Y}{a} \qquad \text{if } v_Y < a$$

$$b_Y[v_Y] = 1 \qquad \text{if } v_Y \geq a\,.$$

Figure 2 illustrates the bidding functions of Y and X for $a = \frac{1}{2}$. The lower dashed curve is the bidding curve of the independent bidder X who bids her true valuation. Allied bidder Y overbids his value, and has a higher probability of winning than before.

Figure 2



Setting the cost weight a smaller than one induces manager Y^m to set a more aggressive bidding strategy for allied bidder Y. This bidding strategy has several noteworthy effects on the ex-ante expected auction outcomes.[62]

a. Allied bidder Y is more likely to win the auction than before, because manager Y^m now sets more aggressive bids than X.
b. Allied bidder Y earns lower profits than before, because manager Y^m now disregards part of the bidding costs and therefore does not maximize profits.

[62] Detailed proofs can be found in proposition 1 in the Appendix.

c. The compensation of manager Y^m is higher than before, because when the cost weight is lower, Y^m pays a smaller part of the bidding cost.

d. The revenue of the auctioneer (or revenue from the auction), $m[a] = \frac{3-a}{6}$, is higher than before. When Y loses, the losing bid of Y is higher, and hence X pays more for transmission. When Y wins, Y either pays the same (Y would have won with or without the compensation scheme) or Y pays more (Y would have lost without the compensation scheme).

e. The profit of the holding company (i.e., the profit of both the auctioneer and the allied bidder), $\pi^Y_{Holding\ Company}[a] = \frac{3+a(1-a)}{6} - w^0$**,** reaches an optimum at $a^{II}* = \frac{1}{2}$ of $\pi^Y_{Holding\ Company}[a^{II}*] = \frac{13}{24} - w^0 \approx 0,5417 - w^0$. Decreasing the cost weight a has two opposing effects on the profit of the holding company. Both effects are the result of the holding company owning a part of the transmission auctioneer; I therefore refer to these effects as the "ownership effects". The first ownership effect is that the aggressive bidding of Y^m drives up the expected auction revenue, thereby increasing the profit of the holding company. The second ownership effect is that Y is more likely to win when the payment of X would have been larger than the value of transmission for Y, thereby decreasing the profit of the holding company.

f. Independent bidder X earns lesser profits than before, $\pi^X[a] = \frac{a}{6}$**,** because X is less likely to win the auction and when X wins, she pays a higher price.

g. The strategic profit[63] of the holding company, $\pi^Y_{Strategic}[a] = \frac{a(1-a)}{6}$ is positive and reaches an optimum at $a^{II}* = \frac{1}{2}$ of $\pi^Y_{Strategic}[a^{II}*] = \frac{1}{24} \approx 0.0417$.

h. Welfare, $W[a] = \frac{(3-a)(1+a)}{6}$, is lower than before because the auction has become less efficient. While Y has the same value distribution as X, Y now wins in some cases

[63] The strategic profit is the extra profit the holding company earns by using a compensation scheme. It is the marginal addition to the profit that results from manager Y^m changing his bidding schedule. The holding company can maximize the strategic profit by setting the appropriate compensation scheme for manager Y^m.

when he does not have the highest value for transmission. When the holding company chooses the optimum cost weight $a^{\mathrm{II}}* = \frac{1}{2}$, total welfare is $W[a^{\mathrm{II}}*] = \dfrac{15}{24} = 0.625$, which is $\frac{1}{24}$ lower than maximum welfare.

Partial ownership

In the more general case the holding company does not fully own the auctioneer, but a share $\gamma \in [0,1]$. The profit of the holding company is then

$$\pi^{Y}_{Holding\ Company}[a,\gamma] = \pi^{Y}_{Generator}[a] + \gamma m[a]$$

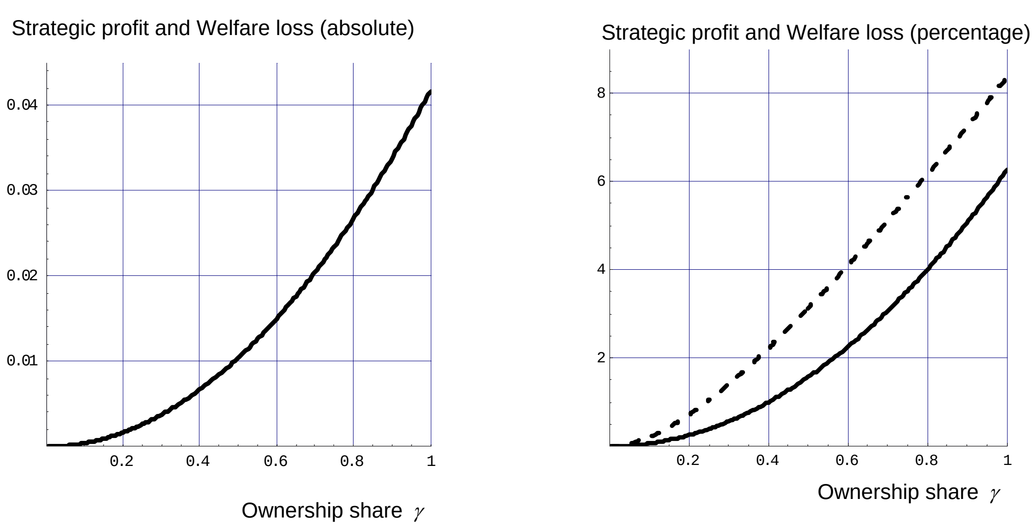
$$= \frac{a(2-a)}{6} + \gamma \frac{3-a}{6}.$$

Maximizing this expression with respect to a gives the optimal cost weight as a function of the ownership share γ

$$a^{\mathrm{II}}[\gamma] = ArgMax_{\alpha}\left[\frac{a(2-a)}{6} + \gamma\frac{3-a}{6}\right] = 1 - \frac{\gamma}{2}.$$

Note that $a^{\mathrm{II}}[0] = 1$; a holding company that has no ownership share in transmission prefers its bidder to maximize profits in second-price auctions. The effect on bidding of allied bidder Y is purely driven by the share of ownership: the ownership effect. This result explains why the owner of independent bidder X has no incentive to offer its manager "X^{m}" a similar compensation scheme; he has no ownership share in transmission.

Figure 3



— Welfare loss $W[a^{\text{II}}[\gamma]]$ — Welfare loss $W[a^{\text{II}}[\gamma]]$

-- Strategic profit $\pi^{Y}_{Strategic}[a^{\text{II}}[\gamma],\gamma]$ -- Strategic profit $\pi^{Y}_{Strategic}[a^{\text{II}}[\gamma],\gamma]$

Figure 3 illustrates the strategic profit,[64] $\pi^{Y}_{Strategic}\left[a^{\text{II}}[\gamma]\right]=\frac{\gamma^2}{24}$, and the welfare loss, $W\left[a^{\text{II}}[\gamma]\right]-\frac{2}{3}=\frac{\gamma^2}{24}$, for all possible ownership shares γ between zero and one[65]. The strategic profit and the welfare loss are strictly increasing in γ.

2.3 The first-price auction

While in second-price auctions the implementation of a compensation scheme for manager Y^m does not affect the bidding of manager X, this is not so in first-price auctions. Bidding schedule X depends on the compensation scheme for manager Y^m, a fact the holding company can use to strategically influence the bidding schedule of X.

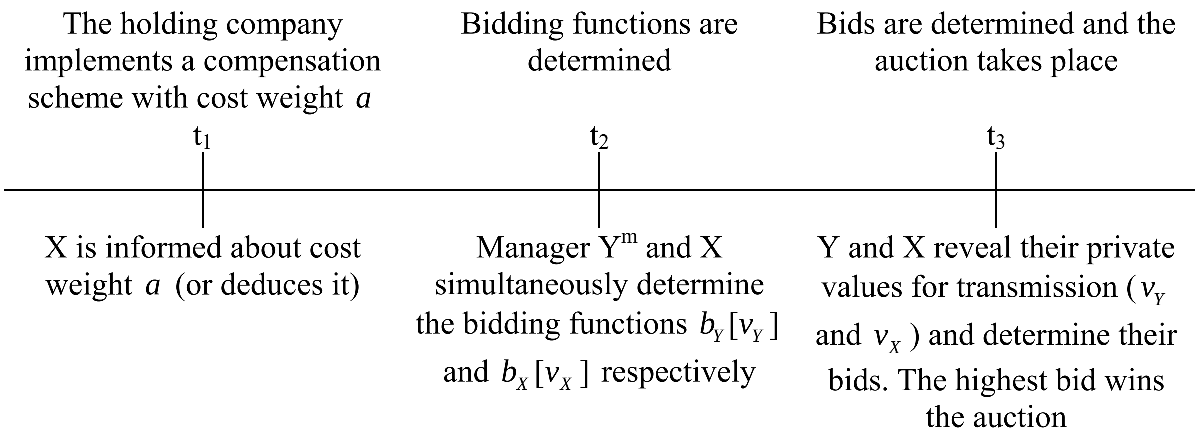
Figure 4 depicts the timeline of events in the auction. At time 1, the holding company implements a compensation scheme for manager Y^m with cost weight a. I make two assumptions. Firstly, that X is perfectly informed about the value of the cost weight. Secondly, that the rules on legal separation forbid the holding company from spreading false information about the compensation scheme. As a result the holding company can be sure that the compensation scheme it announces is known and believed by independent bidder X; this gives the holding company a first mover's advantage. Below, I will relax these two assumptions. At time 2, manager Y^m and X, anticipating each other's reactions, simultaneously determine the bidding functions $b_Y[v_Y]$ and $b_X[v_X]$, respectively. At time

[64] The ownership share γ has a direct and a strategic effect on the profit of the holding company. The direct effect translates into what I will refer to as the "passive" profit and is due to the fact that the holding company receives proportion γ of the auction revenue. The "passive" profit is the profit that the holding company would receive were it to own proportion γ but not to offer manager Y^m a compensation scheme. The strategic effect translates into the strategic profit.

[65] The strategic profit percentage is calculated as $\frac{\pi^{Y}_{Strategic}}{\bar{\pi}^{Y}_{Passive}}$. The welfare loss percentage is calculated as $\frac{W[0]-W[\gamma]}{W[0]}=1-\frac{3}{2}W\left[\gamma\right]$.

3, plugging in their respective values, Y and X determine their bids in the auction and the highest bidder wins.

Figure 4



Given the bidding strategy of X, $b_X[v_X]$, Y wins the auction when bid b_Y is larger than the bid of the independent bidder, $b_X[v_X]$:

$$b_X[v_X] < b_Y \Leftrightarrow$$

$$v_X < b_X^{-1}\left[b_Y\right] \equiv x\left[b_Y\right].$$

The probability of Y winning the auction is therefore $F[x[b_Y]]$, which is equal to $x[b_Y]$ as the values are drawn from the uniform distribution on [0,1]. The expected profit of allied bidder Y with value realization v_Y, bidding b_Y, is therefore

1) $$\pi^Y_{Generator} = x[b_Y]\left(v_Y - b_Y\right) - w^0.$$

Likewise, the expected profit of independent bidder X with value realization v_X, bidding b_X, is

2) $$\pi^X_{Generator} = y[b_X]\left(v_X - b_X\right).$$

When the compensation scheme of manager Y^m sets cost weight a, then the expected compensation for manager Y^m is

3) $$\pi^Y_{Manager} = i \cdot x[b_Y]\left(v_Y - ab_Y\right).$$

Without a compensation scheme, X and Y^m maximize the profits given by equations 1 and 2 respectively, with a symmetrical outcome for the bidding function $b[v] = \frac{1}{v}\int_0^z zdz = \frac{1}{2}v$ (e.g. Krishna, 2002).[66] Offering manager Y^m a compensation scheme with cost weight a makes him maximize equation 3. To calculate the reaction function of manager Y^m, differentiate equation 3 with respect to b_Y, set it equal to zero and solve for $x'[b]$:

4) $$x'[b] = \frac{a \cdot x[b]}{v_Y - ab} = \frac{a \cdot x[b]}{y[b] - ab}.$$

To calculate the reaction function of independent bidder X, differentiate equation 2 with respect to b_X, set it equal to zero and solve for $y'[b]$:

5) $$y'[b] = \frac{y[b]}{v_X - b} = \frac{y[b]}{x[b] - b}.$$

Equations 4 and 5 form a system of differential equations that can be solved for $x[b]$ and $y[b]$ with the conditions that $x[\bar{b}] = y[\bar{b}] = 1$ (a bidder makes the highest bid, $\bar{b}$, when he has the highest value, 1) and $x[0] = y[0] = 0$ (a bidder makes the lowest bid, 0, when he has the lowest, 0).[67] After taking inverses, this gives us the bidding functions of X and Y for $0 < v_Y, v_X \leq 1$:

6) $$b_Y[v_Y] = \frac{\sqrt{v_Y{}^2 + a^2(1 - v_Y{}^2)} - a}{(1 - a^2)v_Y} \text{ with inverse } y[b] = \frac{2ab}{1 - b^2 + a^2b^2}$$

7) $$b_X[v_X] = \frac{1 - \sqrt{a^2 v_X{}^2 + (1 - v_X{}^2)}}{(1 - a^2)v_X} \text{ with inverse } x[b] = \frac{2b}{1 + b^2 - a^2b^2}.$$

The maximum bid $\bar{b}$ is equal to $\bar{b} = \frac{1}{(1 + a)}$.

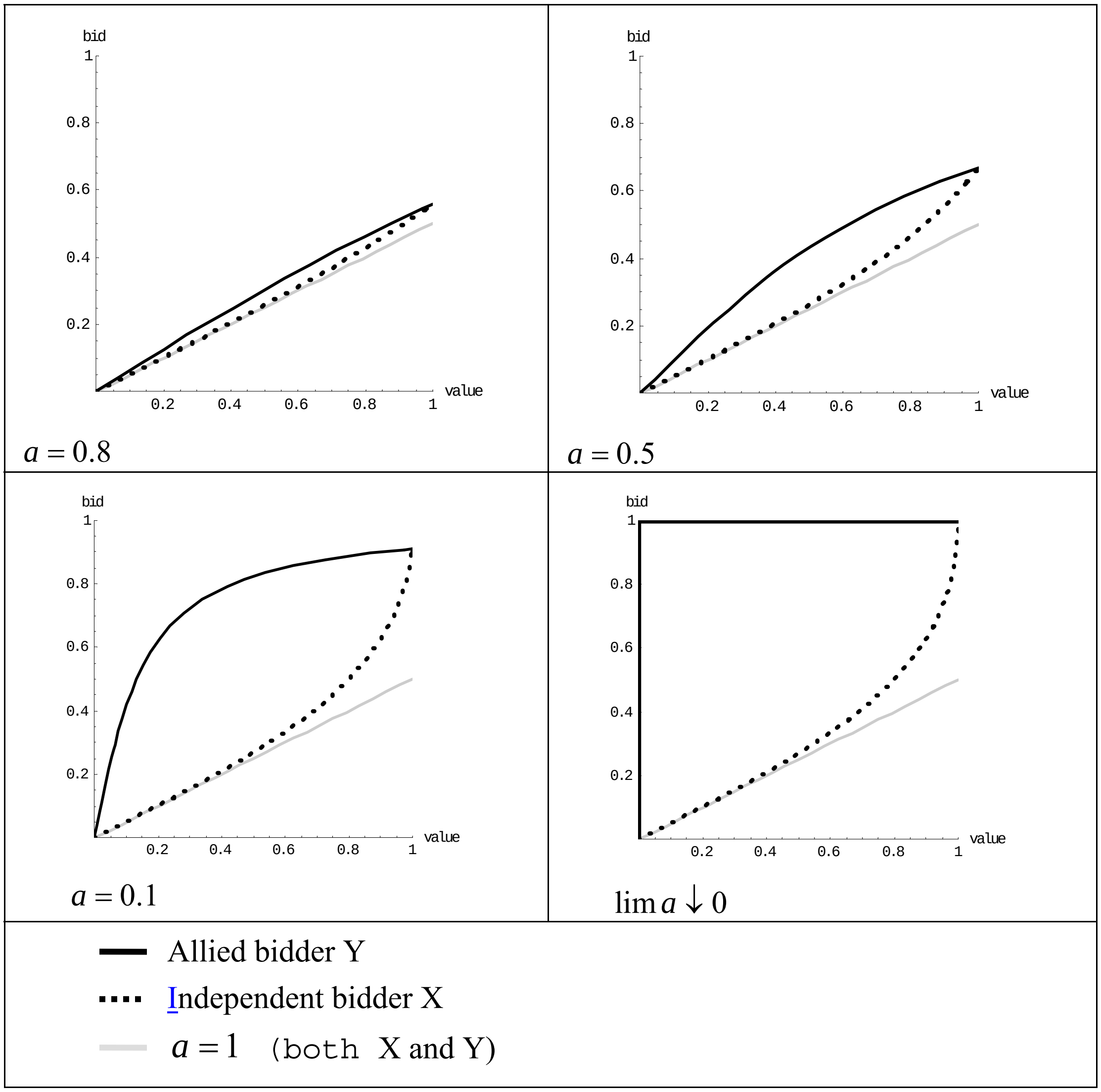
---

[66] More generally, the auction has for any symmetrical differentiable cumulative distribution of values $F[\cdot]$ the solution $b[v] = \frac{1}{F[v]}\int_0^v zf[z]dz$ (e.g. Krishna, 2002).

[67] A proof can be found in proposition 2 in the appendix.

Setting cost weight a smaller than unity makes Y bid more aggressively. In reaction to this, independent bidder X also bids more aggressively; an effect I will refer to as the interactive effect. Figure 5 shows the bidding functions for different $a < 1$.

Figure 5



The more aggressive bidding strategies of X and Y have several noteworthy effects on the ex-ante expected auction outcomes:[68]

a. Allied bidder Y is more likely than before to win the auction.

b. Allied bidder Y earns lower profits than before.

[68] The formula and proofs can be found in proposition 3 in the appendix. I do not report the formula here as they do not add insightful information.

c. The compensation of manager Y^m is higher than before.

d. The revenue of the auctioneer (or revenue from the auction) is higher than before and the revenue equivalence between first-price auctions and second-price auctions does not hold. Revenue equivalence is upset by the interactive effect - the independent bidder reacting to the more aggressive bidding of the allied bidder by also bidding more aggressively, because this effect only occurs in first-price auctions. Once the interaction effect is eliminated, revenue equivalence is restored.

A way to eliminate the interaction effect is by relaxing the first assumption (X is informed of the compensation scheme) and supposing that X is ignorant (or skeptical) of the existence of the compensation scheme for manager Y^m; X believes manager Y^m to maximize the generation profits instead. Assume that Y^m is aware of the ignorance of X, so that Y^m knows that X bids as in a symmetrical first-price auction. The bidding functions determined by X and Y^m are in that case $b_X = \frac{v_X}{2}$ and $b_Y = \frac{v_Y}{2a}$ and the expected auction revenue and profits are the same as those in the second-price auction.[69] The ignorance (or skepticism) of bidder X, by eliminating the interactive effect, has reinstated revenue equivalence.

e. The profit of the holding company (i.e., the profit of both the auctioneer and the allied bidder) reaches a maximum at $a^{I}* \approx 0.319$ of $\pi^{Y}_{Holding\ Company}[a^{I}*] \approx 0.560 - w^{0}$. Decreasing cost weight a has three effects on the profit of the holding company. The first two effects are, like in second-price auctions, ownership effects. The third effect is an interaction effect that is unique to first-price auctions. Firstly, the aggressive bidding of Y makes Y win more auctions, thereby increasing the profit of the holding company. Secondly, for a < 0.5, Y overbids his value for all v_Y such

[69] A proof can be found in proposition 4 in the appendix.

that $0 < v_Y < \sqrt{\frac{1-2a}{1-a^2}}$ [70]. This makes it more likely for Y to win the auction when the payment of X would have been larger than the value of transmission for Y, thereby decreasing the profit of the holding company. Thirdly, the interactive effect, X reacting to the more aggressive bidding of Y by also bidding more aggressively, tempers the first two effects.[71] Due to the interactive effect the optimum cost weight is lower than in second-price auctions; $a^{\mathrm{I}}* \approx 0.319 < 0.5 = a^{\mathrm{II}}*$, and the maximum profit of the holding company is higher than in second-price auctions $\pi^{COMPOUND}[a^{\mathrm{I}}*] \approx 0.560\text{-}w^0 > 0.542 - w^0 \approx \pi^{COMPOUND}[a^{\mathrm{II}}*]$.

f. Independent bidder X earns lesser profits than before and at $a^{\mathrm{I}}* \approx 0.319$ $\pi^X_{Generator}[a^{\mathrm{I}}*] \approx 0.065 < \frac{1}{6} = \pi^X_{Generator}[a=1]$.

g. The strategic profit of the holding company is positive and reaches a maximum of $\pi^Y_{Strategic}[a^{\mathrm{I}}*] \approx 0.060$, which is about 12% of total profits without a compensation scheme.

h. Welfare is lower than before; a welfare loss of the size of $\mathrm{WL}[a^{\mathrm{I}}*] \approx 0.0413$ occurs. This is a loss equal to about 6% of the optimum welfare (without a compensation scheme). Compared to the second-price auctions, the interaction effect (the independent bidder also bidding more aggressively), makes the auction relatively less asymmetric, thereby tempering the negative welfare effects. As a result the welfare loss is slightly lower for first-price auctions than for second-price auctions: $\mathrm{WL}[a^{\mathrm{I}}*] \approx 0.0413 < 0.0417 = \mathrm{WL}[a^{\mathrm{II}}*]$.

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[70] Given $a < 0.5$, solving $0 = v_Y^0 - b_Y[v_Y^0] = v_Y^0 - \frac{\sqrt{(v_Y^0)^2 + a^2(1-(v_Y^0)^2)} - a}{(1-a^2)v_Y^0}$ for v_Y^0 results in $v_Y^0 = \sqrt{\frac{1-2a}{1-a^2}}$ and at this point the derivative $\frac{d(v_Y - b_Y[v_Y])}{dv_Y}$ is positive.

[71] This interactive effect is the effect that Fershtman and Judd (1987) and Sklivas (1987) found and denote as the "strategic effect". The strategic effect I report for first-price auctions encompasses both the interaction effect and the ownership effect.

First mover's advantage

In first-price auctions there is, in addition to the ownership effect we found in second-price auctions, also an interactive effect in operation. The interactive effect is caused by the fact that bidders in first-price auctions, unlike those in second-price auctions, react to the strategies of the other bidder. In the analysis above the holding company is able to manipulate, by setting cost weight *a* extra small, the interactive effect to its own benefit thanks to its first mover's advantage. The first mover's advantage of the holding company only exists when the holding company can commit to its choice of compensation scheme. In the above case, this is guaranteed by the second assumption: "the rules on legal separation forbid the holding company to spread false information about the compensation scheme". Once the holding company has announced a particular compensation scheme, it is committed to it; any compensation scheme can therefore be part of a Nash equilibrium. A ban on providing false information gives the holding company in this way a first mover's advantage.

Without first mover's advantage

Once the second assumption is relaxed and the holding company is allowed, or otherwise able, to provide false information about the compensation scheme, then the holding company cannot credibly commit to just any compensation scheme. The first two steps in the timeline in Figure 4, t1 and t2 have now become a single step; the setting of the cost weight and the determination of the bidding functions is now done simultaneously and endogenously. The loss of its first mover's advantage results in less favorable auction outcomes for the holding company.

I calculate the Nash equilibrium cost weight by first supposing that the holding company announces a compensation scheme with cost weight a, and then, assuming that independent bidder X believes the announcement, maximizes its profits with a (possibly different) cost weight *q*. A Nash equilibrium exists if and only if the holding company announces a compensation scheme with cost weight a^{NE} for which

$q = \text{ARGMAX}_q \left(\pi^{Y}_{Holding\,Company}[a^{NE}, q] \right) = a^{NE}$.

For any announced compensation scheme with cost weight a that is believed by independent bidder X, the bidding function of X is:

$$b_X[v_X;a]=\frac{1-\sqrt{a^2v_X{}^2+(1-v_X{}^2)}}{(1-a^2)v_X}.$$

Manager Y then maximizes his profit given the bidding function of X, $b_X[v_X;a]$, and *q*, which results in

$$b_Y[v_Y;a,q]=\frac{\sqrt{v_Y{}^2+q^2-a^2v_Y{}^2)}-q}{(1-a^2)v_Y}.$$

The holding company then sets *q* to maximize its compound profit:

$q=\text{ARGMAX}_q(\pi^Y_{Holding\ Company}[a,q])$.

Numerical approximation for a^{NE} such that $q=a^{NE}$ gives $a^{NE}\approx 0.361>0.319\approx a^I*$[72]. Total profit is slightly lower,

$\pi^Y_{Holding\ Company}[a^{NE}]\approx 0.5598\text{-}w^0<0.5603\text{-}w^0\approx\pi^Y_{Holding\ Company}[a*]$ and so is the welfare loss, $\text{WL}[a^{NE}]\approx 0.034<0.041\approx\text{WL}[a^{\text{I}}*]$. While the results are slightly less pronounced, the qualitative results reported above remain.

A first mover's advantage for the independent bidder?

Just as a holding company, the owner of independent bidder X (owner X) can only implement a compensation scheme for its manager (manager X) that constitutes a Nash equilibrium. It is generally true that whatever the strategies of the other players are, the best action for owner X is to have his profits maximized. Therefore, without means to credibly commit to a cost weight larger than unity (which implies not maximizing profits), the only Nash equilibrium strategy is for owner X to provide a compensation scheme with cost weight $s=1$ (see Dewatripont, 1988 and Katz, 1991).

[72] I used a Mathematica program for approximation. The precise code (with comments) can be downloaded as a Mathematica file from http://home.cerge-ei.cz/svk/Legally_separated. For easy reference it has been included in the appendix.

For an illustration of this general principle, suppose that both the holding company and owner X had the opportunity to offer their managers compensation schemes and commit to it. The optimal choices of cost weights for both managers are then determined simultaneously; owner X would offer cost weight $s^* \approx 1.431$, which makes both bidders bid less aggressively, and the holding company would offer cost weight $\tilde{a} \approx 0.308 < 0.319 \approx a^{\mathrm{I}*}$, which makes both bidders bid more aggressively. The bidding functions of independent bidder X and allied bidder Y would be:

$$b_X[v_X; \tilde{a}, s^*] = \frac{\sqrt{s^{*2}(1-v_X{}^2)+\tilde{a}^2 v_X{}^2} - s^*}{(\tilde{a}^2 - s^{*2})v_X}, \; b_Y[v_Y; \tilde{a}, s^*] = \frac{\sqrt{\tilde{a}^2(1-v_Y{}^2)+s^{*2} v_Y{}^2} - \tilde{a}}{(s^{*2} - \tilde{a}^2)v_Y}.$$ [73]

The maximum bid would be $\bar{b} \approx 0.575$. In this case, the profits of X would increase to $\pi^X_{Generator}[\tilde{a}, s^*] = 0.071 > 0.065 = \pi^X_{Generator}[a^{\mathrm{I}}*, s=1]$.[74]

However, owner X cannot credibly commit to this particular compensation scheme; he has the possibility to provide a (secret) side contract that sets $s=1$ (maximizing profits). Independent bidder X then finds his bidding function by maximizing his profits, *given* the above bidding function of Y; $b_Y[v_Y; \tilde{a}, s^*]$. While Y would believe that X chooses the bidding function $b_X[v_X; \tilde{a}, s^*]$ as described above, X chooses instead the bidding function:

$\dfrac{\sqrt{1-v_X{}^2+\tilde{a}^{*2} v_X{}^2}-1}{(\tilde{a}^{*2} - s^{*2})v_X}$	for v_X <0.699
0.575	for v_X >0.699.

X then earns a profit of $\pi^X_{Generator}[\tilde{a}, s=1] \approx 0.105 > 0.071 \approx \pi^X_{Generator}[\tilde{a}, s^*]$. As this deviation is profitable for owner X, him setting $s^* > 1$ cannot be part of a Nash equilibrium.

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[73] These formulas are obtained by solving 4) and a likewise equation for the manager of allied bidder X with cost weight *s*.

[74] Other interesting auction outcomes would be that the profits of the holding company would fall, $\pi^Y_{Holding\ Company}[\tilde{a}] \approx 0.530 - w^0 < 0.560 - w^0 \approx \pi^Y_{Holding\ Company}[a^{\mathrm{I}}*]$, and that, as the auction would be more asymmetric, the welfare loss would increase, $\mathrm{WL}[\tilde{a}, s^*] \approx 0.065 > 0.041 \approx \mathrm{WL}[a^{\mathrm{I}}*, s=1]$.

Partial ownership

When the holding company does not fully own the auctioneer, but holds ownership share γ in the auctioneer, then the holding company's profit is

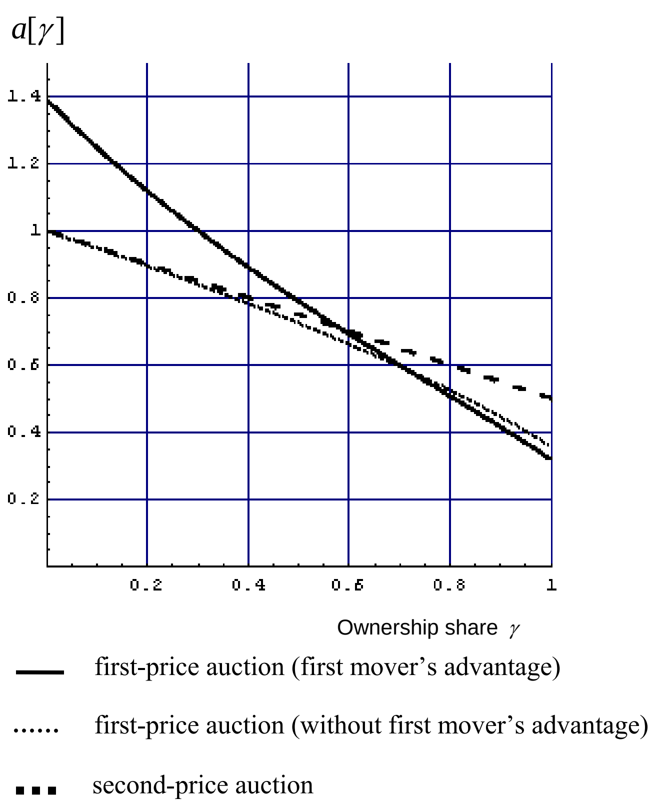
$$\pi^{Y}_{Holding\,Company}[a,\gamma] = \pi^{Y}_{Generator}[a] + \gamma m[a].$$

Maximizing the holding company's profit with respect to a gives the optimal cost weight as a function of ownership share γ;

$$a[\gamma] = ArgMax_{\alpha}\left[\pi^{Y}_{Holding\,Company}[\alpha,\gamma]\right].$$

Figure 5 shows the optimal cost weight, $a[\gamma]$ for ownership shares γ between zero and one[75] for first-price (both with and without a first movers' advantage) and second-price auctions.

Figure 5: Optimal cost weight, $a[\gamma]$



[75] The values for $a[\gamma]$ in first-price auctions have been obtained by numerical approximation.

When the ownership share of the auctioneer is small, $\gamma < 0.3$, the holding company with a first mover's advantage in first-price auctions sets the cost weight *higher* than unity to make Y bid *less* aggressively and to *lower* the auction revenue. This is profitable because of the interaction effect in first-price auctions; by making Y a "fat cat" by overstating the costs of bidding (Fudenberg and Tirole, 1984), the competing independent bidder reacts by also bidding less aggressively which lowers the bidding costs for both bidders[76]. The negative effect this has through lower auction revenues is of little importance as the holding company has a low ownership share $\gamma < 0.3$. The less aggressive bidding increases both the strategic profit and the welfare loss when the ownership share goes to zero.

When the ownership share of the auctioneer is large or medium, $\gamma > 0.3$, the holding company sets the cost weight lower than unity to make Y bid more aggressively and to increase the auction revenue. For large ownership shares, $\gamma > 0.6$, the holding company sets a lower cost weight in first-price auctions than in second-price auctions. Due to the interaction effect in first-price auctions, the independent bidder also bids more aggressively which decreases the asymmetry of the auction and thereby makes lowering the cost weight less costly for the holding company.

The holding company without a first mover's advantage cannot strategically use the interaction effect in first-price auctions and in second-price auctions, no interaction effect exists. Therefore, in these cases, the cost weight is equal to unity for no ownership, $\gamma = 0$, and for $0 \le \gamma \le 1$ a strictly decreasing function of the ownership share γ. Figure 6 illustrates the effects on strategic profits and welfare losses.

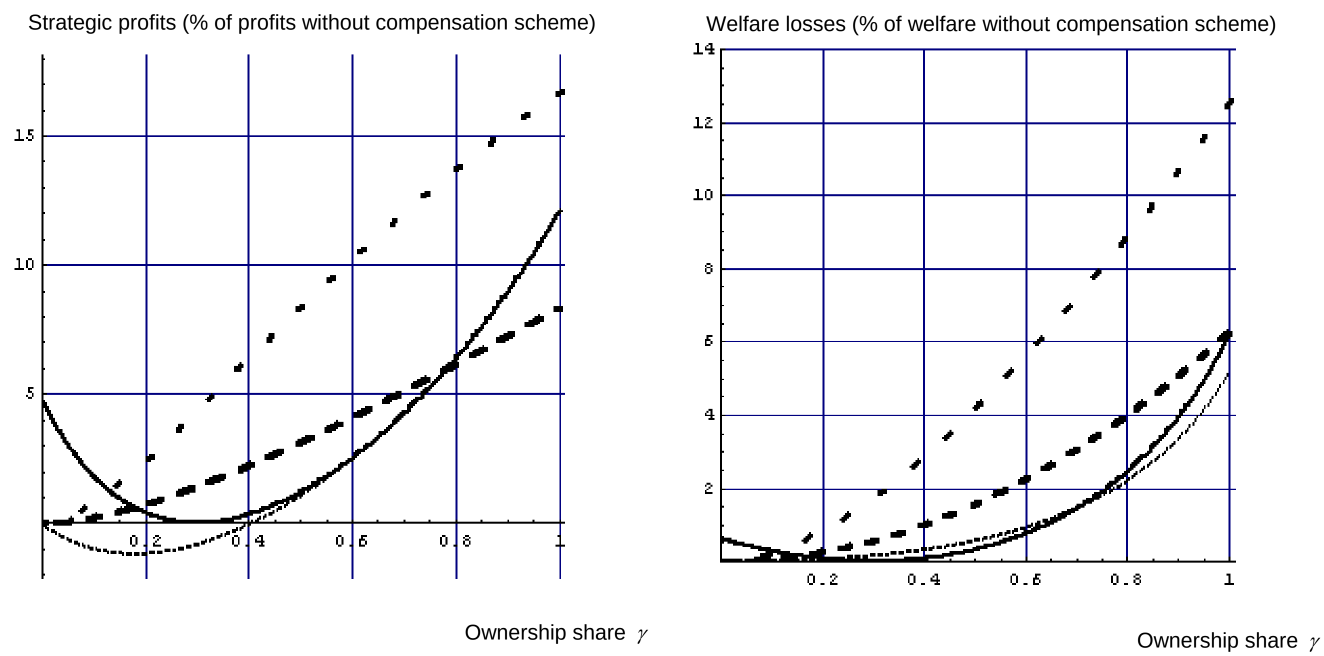
Note that a holding company *without* a first mover's advantage receives negative strategic profits. Legal separation of the generator from the VIU without a ban on spreading false information about the compensation scheme becomes a burden for a holding company that

[76] This effect is comparable to the "fat cat" effect in Bertrand competition found in Fershtman and Judd (1987) and Sklivas (1987).

owns less than 40% of transmission. After that the strategic profit fairly resembles the first-price auction with a first movers' advantage.

When the holding company has no first mover's advantage, then the first-price auction is to be preferred above the second-price auction – the welfare loss is smaller than in the second-price auction. When the holding company has a first mover's advantage, then the first-price auction is still to be preferred as long as the holding company owns more than 17% of the transmission. When the holding company owns less than 17% of the transmission, the second-price auction is to be preferred.

Figure 6



$\pi^{Y}_{Strategic}[a[\gamma],\gamma]$

- first-price auction (first movers' advantage)
- ...... first-price auction (without first movers' advantage)
- ■ ■ ■ second-price auction
- — — second-price auction (total holding company profit maximizing)

$W[a[\gamma]]$

- first-price auction (first movers' advantage)
- ...... first-price auction (without first movers' advantage)
- ■ ■ ■ second-price auction
- — — second-price auction (total holding company profit maximizing)

For comparison I have also included the results from Van Koten (2009) when the holding company can order its allied generator to maximize the total holding profits. It shows that the legal separation of the generator tempers both the size of the strategic profit and the welfare loss. However, from the above analysis of legally separating the generator two points can be made. Firstly, the OBK scheme is likely to be used as it either results in a positive strategic profit (in the case of second-price auctions and first-price auctions with first mover's advantage) or it is the only Nash equilibrium (in the case of first-price auctions without first mover's advantage). Secondly, using the OBK scheme generally incurs a considerable welfare loss.[77]

3 Discussion

In an earlier paper, Van Koten (2009), I showed that a holding company that owns an unregulated transmission line could increase its profits by having its bidder follow the Any-Bid-Kickback scheme (ABK scheme). The ABK scheme consists of the bidder taking into account the full effect of his bidding on the transmission auction revenue and makes the bidder bid more aggressively. In turn, this increases the price of transmission, increases the profits of the holding company, and lowers welfare.

In the present paper, I explore in a similar setup to which extent the legal separation of the bidder from the holding company could improve welfare. When the bidder is legally separated, the holding company cannot implement a compensation scheme to maximize the profits of the overall holding company.[78] This rules out application of the ABK scheme. However, the OBK scheme analyzed in this paper respects the legal separation; the OBK compensation scheme is based on performance indicators of the bidder only. By implementing the OBK kickback scheme, the holding company is able to mimic the workings of the ABK scheme to a considerable degree.

[77] except when the holding company owns about 30% of transmission in a first-price auction with first mover's advantage

[78] I assume here that legal separation is effective. In cases where it is likely that violations of the restrictions imposed by legal separation go unpunished, the holding company can freely instruct the allied bidder to maximize the profits of the holding company. I show in Van Koten (2006) that the qualitative outcomes remain unchanged (the holding company profits, welfare suffers).

For illustration I make a rough estimate of the welfare cost in the scenario where a holding company who fully owns a generator in Germany builds a merchant transmission line connecting Germany and the Netherlands. I assume that the total auction revenue, 123.4 million Euro (CONSENTEC, 2004, p.A3) on the existing line between Germany and the Netherlands in 2003 is a representative number and that the new merchant transmission line extends the existing capacity by 20%. I estimate that the economic size of the transmission line is then about 25 million Euro a year (20% of 123.4 million Euro). By using the OBK scheme, the holding company would then be able to earn a strategic profit of 2 million Euro a year (8%) and incur a welfare loss of 1.5 million Euro a year (6%). As the EU has 29 more border crossings and as the need for more interconnection is growing, this scenario could become a reality on a larger scale, implying even higher welfare losses.

4 Conclusions

My analysis suggests that, for two prominent auction formats, a holding company that is legally unbundled (but ownership integrated) can nonetheless provide the manager of its legally unbundled generator with incentives to bid more aggressively by means of a simple but well-chosen OBK compensation scheme. The OBK scheme does not refer to performance indicators outside of the generator and therefore fully respects the legal separation between the allied generator, the holding company, and the transmission auctioneer.

The OBK compensation scheme, which can be used with a legally *unbundled* generator, can trigger an aggressiveness of bidding that increases the profit of the holding company and causes a welfare loss. While the increase of the profit and the welfare loss are considerable, they are less than under the ABK scheme which can be used with a legally *integrated* generator. Legal separation of the generator therefore does improve welfare, but not to the same extent as ownership unbundling. This suggests that the regulatory measure of legal unbundling of the generator is unsatisfactory.

This result should be of interest to regulators of the EU electricity industry, as they might consider applying legal unbundling of the generator to remedy problems of abuse of market power by holding companies. The result is especially relevant when unregulated for-profit building of transmission lines is allowed to address the issue of underinvestment in interconnector capacity. My model shows that legal unbundling of the generator is not likely to bring much improvement. In this setting, auctions lose their favorable features (non-discriminatory, market-based and efficient) and holding companies are therefore likely not to allocate transmission capacity in a non-discriminatory and efficient manner.

My model does suggest that ownership unbundling provides a remedy. Once the holding company is not a residual claimant of the auction revenue any more, it loses the incentive to have its allied generator bid excessively aggressively.

5 Appendix

Proposition 1: In second-price auctions, …

a. The probability of winning for allied bidder Y, $P^{Y\,wins}\left[a\right]=\frac{2-a}{2}$, is strictly decreasing in cost weight a.

b. The profit of allied bidder Y, $\pi^{Y}_{Generator}[a]=\frac{a(2-a)}{6}-w^{0}$**,** is strictly increasing in cost weight a for $a<1$.

c. The compensation of manager Y^{m}, $\pi^{Y}_{Manager}[a]=i\cdot\frac{a^{2}-3a+3}{6}$**,** is strictly decreasing in a for $a<1$ and given *i***.**

d. The auction revenue, $m\left[a\right]=\frac{3-a}{6}$**,** is strictly decreasing in cost weight a.

e. The profit of the holding company, $\pi^{Y}_{Holding\,Company}[a]=\frac{3+a(1-a)}{6}-w^{0}$**,** reaches an optimum for $a^{\text{II}}*=\frac{1}{2}$.

f. The profit of independent bidder X, $\pi^{X}[a]=\frac{a}{6}$**,** is strictly increasing in cost weight a.

g. The strategic profit of Y, $\pi^{Y}_{Strategic}\left[a\right]=\dfrac{a(1-a)}{6}$, reaches an optimum for $a^{\text{II}}*=\tfrac{1}{2}$.

h. The welfare, $W[a]=\dfrac{(3-a)(1+a)}{6}$**,** is strictly increasing in cost weight a for $a<1$.

Proofs:

a. The probability of winning for allied bidder Y, $P^{Y\,wins}\left[a\right]=\dfrac{2-a}{2}$, is strictly decreasing in cost weight a.

Proof:

The probability that Y wins is as follows,

$$P^{Y\,wins}\left[v_y;a\right]=1 \qquad if\ v_y\geq a$$

$$=\frac{v_y}{a} \qquad if\ v_y<a.$$

The ex-ante expected probability of winning, $P^{Y\,wins}\left[a\right]$, is $P^{Y\,wins}\left[v_y;a\right]$integrated over all possible realizations of v_y;

$$P^{Y\,wins}\left[a\right]=\int_0^a P^{Y\,wins}\left[v_Y;a\mid v_Y<a\right]\cdot dv_y+\int_a^1 P^{Y\,wins}\left[v_Y;a\mid v_Y\geq a\right]dv_Y$$

$$=\int_0^a\frac{v_Y}{a}dv_Y+\int_a^1 1dv_Y$$

$$=\left[\frac{v_Y^2}{2a}\right]_0^a+\left[v_Y\right]_a^1$$

$$=\frac{a}{2}+(1-a)$$

$$=\frac{2-a}{2}.$$

b. The profit of allied bidder Y, $\pi^{Y}_{Generator}[a]=\dfrac{a(2-a)}{6}-w^0$**,** is strictly increasing in cost weight a for $a<1$.

Proof:

$$\pi^{Y}_{Generator}[a] = \int_0^a \frac{v_Y}{a}\left(v_Y - E[b_X \mid b_X < b_Y]\right)dv_Y + \int_a^1 (v_Y - E[b_X])dv_Y - w^0$$

$$= \int_0^a \frac{v_Y}{a}\left(v_Y - E[v_X \mid v_X < \frac{v_Y}{a}]\right)dv_Y + \int_a^1 (v_Y - E[v_X])dv_Y - w^0$$

$$= \int_0^a \frac{v_Y}{a}\left(v_Y - \frac{v_Y}{2a}\right)dv_Y + \int_a^1 \left(v_Y - \frac{1}{2}\right)dv_Y - w^0$$

$$= \int_0^a v_Y^2\left(\frac{2a-1}{2a^2}\right)dv_Y + \int_a^1 \left(v_Y - \frac{1}{2}\right)dv_Y - w^0$$

$$= \left[v_Y^3\left(\frac{2a-1}{6a^2}\right)\right]_0^a + \left[\frac{v_Y^2}{2} - \frac{v_Y}{2}\right]_a^1 - w^0$$

$$= \frac{a(2a-1)}{6} + \frac{a}{2} - \frac{a^2}{2} - w^0$$

$$= \frac{a(2-a)}{6} - w^0.$$

c. The compensation of manager Y^m, $\pi^{Y}_{Manager}[a] = i \cdot \frac{a^2 - 3a + 3}{6}$**,** is strictly decreasing in a for $a < 1$ and given i**.**

Proof:

$$\frac{\pi^{Y}_{Manager}[a]}{i} = \int_0^a \frac{v_Y}{a}\left(v_Y - aE[b_X \mid b_X < b_Y]\right)dv_Y + \int_a^1 (v_Y - aE[b_X])dv_Y$$

$$= \int_0^a \frac{v_Y}{a}\left(v_Y - aE[v_X \mid v_X < \frac{v_Y}{a}]\right)dv_Y + \int_a^1 (v_Y - aE[v_X])dv_Y$$

$$= \int_0^a \frac{v_Y}{a}\left(v_Y - a\frac{v_Y}{2a}\right)dv_Y + \int_a^1 \left(v_Y - \frac{a}{2}\right)dv_Y$$

$$= \int_0^a \frac{v_Y^2}{2a}dv_Y + \int_a^1 \left(v_Y - \frac{a}{2}\right)dv_Y$$

$$= \left[\frac{v_Y^3}{6a}\right]_0^a + \left[\frac{v_Y^2}{2} - \frac{av_Y}{2}\right]_a^1$$

$$= \frac{a^3}{6a} + \frac{1}{2} - \frac{a}{2}$$

$$= \frac{a^2 - 3a + 3}{6}.$$

d. The auction revenue, $m[a]=\frac{3-a}{6}$, is strictly decreasing in cost weight a.

Proof: The ex-ante net expected revenue of the auctioneer is

$$m[a]=m^X[a]+\left(m^Y[a]\right)$$

$$=\int_0^1 av_X\cdot E[b_Y\mid b_Y<b_X])dv_X+\left(\int_0^a\frac{v_Y}{a}\cdot E[b_X\mid b_X<b_Y]dv_Y+\int_a^1 1\cdot E[b_X]dv_Y\right)$$

$$=\int_0^1 av_X\cdot E[\frac{v_Y}{a}\mid v_Y<av_X])dv_X+\left(\int_0^a\frac{v_Y}{a}\cdot E[v_X\mid v_X<\frac{v_Y}{a}]dv_Y+\int_a^1 1\cdot E[v_X]dv_Y\right)$$

$$=\int_0^1 av_X\cdot\frac{av_X}{2a}dv_X+\left(\int_0^a\frac{v_Y}{a}\cdot\frac{v_Y}{2a}dv_Y+\int_a^1\frac{1}{2}dv_Y\right)$$

$$=\int_0^1\frac{av_X^2}{2}dv_X+\left(\int_0^a\frac{v_Y^2}{2a^2}dv_Y+\int_a^1\frac{1}{2}dv_Y\right)$$

$$=\left[\frac{av_X^3}{6}\right]_0^1+\left(\left[\frac{v_Y^3}{6a^2}\right]_0^a+\left[\frac{v_Y}{2}\right]_a^1\right)$$

$$=\frac{a}{6}+\left(\frac{3-2a}{6}\right)$$

$$=\frac{3-a}{6}.$$

e. The profit of the holding company, $\pi^Y_{Holding\ Company}[a]=\frac{3+a(1-a)}{6}-w^0$, reaches an optimum for $a^{\text{II}}*=\frac{1}{2}$.

Proof:

$$\pi^Y_{Holding\ Company}[a]=m[a]+\pi^Y_{Generator}[a]$$

$$=\frac{3-a}{6}+\frac{a(2-a)}{6}-w^0$$

$$=\frac{3+a(1-a)}{6}-w^0.$$

f. The profit of the independent bidder X, $\pi^X[a]=\frac{a}{6}$, is strictly increasing in cost weight a

Proof :

The ex-ante expected profit of X is equal to:

$$\pi^{X}_{Generator}[a] = \int_0^1 av_X (v_X - E[b_Y \mid b_Y < b_X])dv_X$$

$$= \int_0^1 av_X (v_X - E[\frac{v_Y}{a} \mid v_Y < av_X])dv_X$$

$$= \int_0^1 av_X \left(v_X - \frac{av_X}{2a} \right) dv_X$$

$$= \int_0^1 \frac{av_X^2}{2} dv_X$$

$$= \left[\frac{av_X^3}{6} \right]_0^1$$

$$= \frac{a}{6}.$$

g. The strategic profit of Y, $\pi^{Y}_{Strategic}\left[a\right] = \dfrac{a(1-a)}{6}$, reaches an optimum for $a^{\mathrm{II}} * = \frac{1}{2}$.

Proof:

$$\pi^{Y}_{Strategic}\left[a\right] = \pi^{Y}_{Generator}[a] + m\left[a\right] - (\pi^{Y}_{Generator}[1] + m\left[1\right])$$

$$= \frac{a(2-a)}{6} - w^0 + \frac{3-a}{6} - \left(\frac{1}{6} - w^0 + \frac{2}{6} \right)$$

$$= \frac{a(1-a)}{6}.$$

Which is maximized for $a = \frac{1}{2}$.

h. The welfare, $W[a] = \dfrac{(3-a)(1+a)}{6}$**,** is strictly increasing in cost weight a for $a < 1$.

Proof:

$$W[a] = \pi^{Y}_{Generator}[a] + \pi^{X}[a] + m[a] + w^0 =$$

$$= \frac{a(2-a)}{6} - w^0 + \frac{a}{6} + \frac{1}{2} - \frac{a}{6} + w^0$$

$$= \frac{3 + a(2-a)}{6}$$

$$= \frac{(3-a)(1+a)}{6}.$$

$$\frac{dW[a]}{da} = \frac{1-a}{3} > 0.$$

Proposition 2

The bidding functions of X and Y are

6) $$b_Y[v_Y] = \frac{\sqrt{v_Y^2 + a^2(1-v_Y^2)} - a}{(1-a^2)v_Y} \text{ with inverse } y[b] = \frac{2ab}{1-b^2+a^2b^2}$$

7) $$b_X[v_X] = \frac{1-\sqrt{a^2v_X^2 + (1-v_X^2)}}{(1-a^2)v_X} \text{ with inverse } x[b] = \frac{2b}{1+b^2-a^2b^2}.$$

The maximum bid $\bar{b}$ is equal to $\bar{b} = \frac{1}{(1+a)}$.

Proofs:

Solving 4) and 5), we will use the constraints

$x[0] = y[0] = 0$ (a bidder with value zero bids zero).

$x[\bar{b}] = y[\bar{b}] = 1$, where $\bar{b}$ is the maximum bid $0 < \bar{b} < 1$

(a bidder with value 1 bids a unique maximal bid).

Rewriting 4) and 5) gives

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

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

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

10) $$(y'[b]-a) \cdot (x[b] - b) = y[b] - ax[b] + ab.$$

Adding up 9) and 10) gives

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

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

Integrating equation c) over 0 until the maximum bid $\bar{b}$ using $x[0]=y[0]=0$ gives

$$(1-\bar{b})\cdot(1-a\bar{b})=a\bar{b}^2 \Leftrightarrow$$

$$1+a\bar{b}^2-(1+a)\bar{b}=a\bar{b}^2.$$

Therefore the maximum bid $\bar{b}$ is given by

12) $$\bar{b}=\frac{1}{(1+a)}\,.$$

Integrating equation 11) over 0 until b using $x[0]=y[0]=0$ gives

13) $$(x[b]-b)\cdot(y[b]-ab)=ab^2.$$

Applying 13) to 5) and 6) gives

14) $$x'[b]=\frac{x[b](x[b]-b)}{b^2}$$

15) $$y'[b]=\frac{y[b](y[b]-ab)}{ab^2}\,.$$

Using 12) substituted into the condition $x[\bar{b}]=y[\bar{b}]=1$, 14) and 15) can be shown to have the solutions 16) and 17)

16) $$x[b]=\frac{2b}{1+b^2-a^2b^2}$$

17) $$y[b]=\frac{2ab}{1-b^2+a^2b^2}.$$

Taking inverses gives us the optimal pure bidding strategies 6) and 7):

6) $b_Y[v_Y] = \dfrac{\sqrt{a^2 + {v_Y}^2 - a^2 {v_Y}^2} - a}{v_Y - a^2 v_Y}$

7) $b_X[v_X] = \dfrac{1 - \sqrt{1 - {v_X}^2 + a^2 {v_X}^2}}{v_X - a^2 v_X}$.

Proposition 3

a. The probability of winning for allied bidder Y, $p^{Y\,wins}[a] = \dfrac{1}{1+a}$, is strictly decreasing in cost weight a.

b. The profit of allied bidder Y,

$$\pi^{Y}_{Generator}[a] = \frac{(2-a)\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right) - \sqrt{1-a^2}}{2\left(1-a^2\right)^{\frac{3}{2}}} - w^0$$

, is strictly increasing in cost weight a for $a<1$.

c. The compensation of manager Y^m,

$$\pi^{Y}_{Manager}[a] = i \cdot \frac{1}{2-2a^2}\left(1 - 2a + \frac{a^2\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right)}{\sqrt{1-a^2}}\right)$$

, is strictly decreasing in cost weight a for $a<1$.

d. The auction revenue,

$$m[a] = \left(\frac{1}{(1-a^2)} - \frac{a\cdot \mathrm{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}}\right)}{\left(1-a^2\right)^{\frac{3}{2}}}\right) + a\left(\frac{1}{a^2-1} - \frac{\mathrm{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}}\right)$$

, is strictly decreasing in cost weight a for $a<1$.

e. The profit of the holding company,

$$\pi^{Y}_{Holding\,Company}[a] = \frac{\sqrt{1-a^2} - (2-a)\,a\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right)}{2\left(1-a^2\right)^{\frac{3}{2}}} - w^0$$

$$+\gamma\left(\frac{1}{(1-a^2)} - \frac{a \cdot \mathrm{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}}\right)}{\left(1-a^2\right)^{\frac{3}{2}}} - a\left(\frac{\mathrm{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}} + \frac{1}{1-a^2}\right)\right)$$

,

$\pi^{Y}_{Holding\,Company}[a] = \frac{3+a(1-a)}{6} - w^0$, reaches an optimum for $a^{\mathrm{I}}* \approx 0.319404$. The profit is then $\pi^{COMPOUND}[a^{\mathrm{I}}*] \approx 0.560315 - w^0$.

f. The profit of independent bidder X,

$\pi^{X}_{Generator}[a] = \frac{a\left((a-2)\sqrt{-1+a^2} + ArcSinh(\sqrt{a^2-1})\right)}{2\left(-1+a^2\right)^{\frac{3}{2}}}$, is strictly increasing in cost weight a for $a < 1$.

g. The strategic profit of the holding company is positive and reaches a maximum of $\pi^{Y}_{Strategic}[a^{\mathrm{I}}*] \approx 0.060$.

h. The welfare, $W[a] = \frac{1}{2}\left(1 - \frac{a^2\mathrm{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}}\right)}{\left(1-a^2\right)^{\frac{3}{2}}} - \frac{a\ \mathrm{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}}\right)$, is strictly increasing in cost weight a for $a < 1$.

Proofs:

a. The probability of winning for allied bidder Y, $p^{Y\,wins}[a] = \frac{1}{1+a}$, is strictly decreasing in cost weight a.

Proof:

Using propositions 1 and 4, it follows that allied bidder Y with a realized value of v_y wins with probability

$$x \circ b_Y[v_Y;a] = \frac{v_Y}{\sqrt{v_Y^2 + a^2(1-v_Y^2)}} \ .$$

The expected proportion of auctions that is won by allied bidder Y is then

$$p^{Y\,wins}[a] = \int_0^1 x \circ b_Y[v_Y;a]dv_Y$$
$$= \int_0^1 \frac{v_Y}{\sqrt{{v_Y}^2 + a^2(1-{v_Y}^2)}}dv_Y$$
$$= \frac{1}{1+a}\,.$$

b. The profit of allied bidder Y,

$$\pi^Y_{Generator}[a] = \frac{(2-a)\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right) - \sqrt{1-a^2}}{2\left(1-a^2\right)^{\frac{3}{2}}} - w^0$$ **,** is strictly increasing in cost weight a for $a<1$.

Proof:

The profit of allied bidder Y is

$$\pi^Y_{Generator}[a] = \int_0^1 x \circ b_Y[v_Y;a]\cdot\left(v_Y - b_Y[v_Y;a]\right)dv_Y - w^0$$
$$= \int_0^1 \frac{v_Y}{\sqrt{{v_Y}^2 + a^2(1-{v_Y}^2)}} \cdot \left(v_Y - \frac{\sqrt{a^2 + {v_Y}^2 - a^2{v_Y}^2} - a}{v_Y - a^2 v_Y}\right)dv_Y - w^0$$
$$= \frac{(2-a)\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right) - \sqrt{1-a^2}}{2\left(1-a^2\right)^{\frac{3}{2}}} - w^0\,.$$

This expression is increasing in cost weight a for

$$\frac{d\pi^Y_{Generator}[a]}{da} > 0$$ has been determined numerically.

c. The compensation of manager Y^m,

$$\pi^Y_{Manager}[a] = i \cdot \frac{1}{2-2a^2}\left(1-2a+\frac{a^2\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right)}{\sqrt{1-a^2}}\right)$$, is strictly decreasing in cost weight a for $a<1$.

Proof:

$$\frac{\pi^Y_{Manager}[a]}{i} = \int_0^1 x \circ b_Y[v_Y;a] \cdot \left(v_Y - ab_Y[v_Y;a]\right)dv_Y$$

$$= \int_0^1 \frac{v_Y}{\sqrt{v_Y^2 + a^2(1-v_Y^2)}}\left(v_Y - a\frac{\sqrt{a^2+v_Y^2-a^2v_Y^2}-a}{v_Y - a^2 v_Y}\right)dv_Y$$

$$= \frac{1}{2-2a^2}\left(1-2a+\frac{a^2\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right)}{\sqrt{1-a^2}}\right).$$

$$\frac{d\pi^Y_{Manager}[a]}{da} < 0$$ has been determined numerically.

d. The auction revenue,

$$m[a] = \left(\frac{1}{(1-a^2)} - \frac{a\cdot \mathrm{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}}\right)}{\left(1-a^2\right)^{\frac{3}{2}}}\right) + a\left(\frac{1}{a^2-1} - \frac{\mathrm{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}}\right)$$, is strictly decreasing in cost weight a for $a<1$.

Proof

$$m[a] = m^Y[a] + m^X[a]$$

$$= \int_0^1 \left(\left(x \circ b_Y[v_Y]\right)\cdot\left(b_Y[v_Y]\right)\right)dv_Y + \int_0^1 \left(y \circ b_X[v_X]\right)\cdot b_X[v_X]dv_X$$

$$= \int_0^1 \left(\frac{v_Y}{\sqrt{v_Y^2 + a^2(1-v_Y^2)}} \cdot \frac{\sqrt{a^2 + v_Y^2 - a^2 v_Y^2} - a}{v_Y - a^2 v_Y} \right) dv_Y$$

$$+ \int_0^1 \left(\left(\frac{a v_X}{\sqrt{1-(1-a^2)v_X^2}} \right) \cdot \frac{1 - \sqrt{1 - v_X^2 + a^2 v_X^2}}{v_X - a^2 v_X} \right) dv_X$$

$$= \left(\frac{1}{(1-a^2)} - \frac{a \cdot \text{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}} \right)}{\left(1-a^2\right)^{\frac{3}{2}}} \right) + a \left(\frac{1}{a^2-1} - \frac{\text{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}} \right).$$

This expression is strictly decreasing in a; $\frac{dm[a]}{da} > 0$ has been determined numerically.

e. The profit of the holding company,

$$\pi^{Y}_{Holding\,Company}[a] = \frac{\sqrt{1-a^2} - (2-a)\, a\, ArcCsch\left(\frac{a}{\sqrt{1-a^2}} \right)}{2\left(1-a^2\right)^{\frac{3}{2}}} - w^0$$

$$+ \gamma \left(\frac{1}{(1-a^2)} - \frac{a \cdot \text{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}} \right)}{\left(1-a^2\right)^{\frac{3}{2}}} - a \left(\frac{\text{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}} + \frac{1}{1-a^2} \right) \right)$$

, reaches an optimum for $a^{I}* \approx 0.319404$. The profit is then $\pi^{COMPOUND}[a^{I}*] \approx 0.560315 - w^0$.

Proof:

$$\pi^{Y}_{Holding\,Company}[a] = m[a] + \pi^{Y}_{Generator}[a]$$

$$= \left(\frac{1}{(1-a^2)} - \frac{a \cdot \text{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}} \right)}{\left(1-a^2\right)^{\frac{3}{2}}} \right) + a \left(\frac{1}{a^2-1} - \frac{\text{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}} \right)$$

$$+\frac{(2-a)\,ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right)-\sqrt{1-a^2}}{2\left(1-a^2\right)^{\frac{3}{2}}}-w^0 .$$

The optimal cost weight, $a^{I}* \approx 0.319404$, has been approximated numerically.

f. The profit of independent bidder X,

$\pi^X_{Generator}[a]=\frac{a\left((a-2)\sqrt{-1+a^2}+ArcSinh(\sqrt{a^2-1})\right)}{2\left(-1+a^2\right)^{\frac{3}{2}}}$, is strictly increasing in cost weight a for $a<1$.

Proof:

The profit of independent bidder X is

$$\pi^X_{Generator}[a]=\int_0^1 y\circ b_X[v_X;a]\cdot\left(v_X-b_X[v_X;a]\right)dv_X$$

$$=\int_0^1\frac{v_Y}{\sqrt{{v_Y}^2+a^2(1-{v_Y}^2)}}\cdot\left(v_Y-\frac{\sqrt{a^2+{v_Y}^2-a^2{v_Y}^2}-a}{v_Y-a^2v_Y}\right)dv_X$$

$$=\frac{a\left((a-2)\sqrt{-1+a^2}+ArcSinh(\sqrt{a^2-1})\right)}{2\left(-1+a^2\right)^{\frac{3}{2}}}.$$

$\frac{d\pi^X_{Generator}[a]}{da}>0$ has been determined numerically.

g. The strategic profit of the holding company is equal to the profit of the holding company, $\pi^Y_{Holding\ Company}[a]$, minus the passive profit $\pi^Y_{Holding\ Company}[a=1]=\frac{1}{6}+\frac{\gamma}{3}$, and therefore reaches its maximum of $\pi^Y_{Strategic}[a^{I}*]\approx 0.060$ at $a^{I}*\approx 0.319404$ just as $\pi^Y_{Holding\ Company}[a]$.

h. The welfare, $W[a]=\frac{1}{2}\left(1-\frac{a^2\text{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}}\right)}{\left(1-a^2\right)^{\frac{3}{2}}}-\frac{a\ \text{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}}\right)$, is

strictly increasing in cost weight a for $a<1$.

Proof:

$W[a]=\pi^X_{Generator}[a]+\pi^Y_{Generator}+m[a]+w^0$

$$=\frac{a\left((a-2)\sqrt{-1+a^2}+ArcSinh(\sqrt{a^2-1})\right)}{2\left(-1+a^2\right)^{\frac{3}{2}}}-w^0+\frac{(2-a)\ ArcCsch\left(\frac{a}{\sqrt{1-a^2}}\right)-\sqrt{1}}{2\left(1-a^2\right)^{\frac{3}{2}}}$$

$$+\left(\frac{1}{(1-a^2)}-\frac{a\cdot\text{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}}\right)}{\left(1-a^2\right)^{\frac{3}{2}}}\right)+a\left(\frac{1}{a^2-1}-\frac{\text{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}}\right)+w^0$$

$$=\frac{1}{2}\left(1-\frac{a^2\text{ArcCsch}\left(\frac{a}{\sqrt{1-a^2}}\right)}{\left(1-a^2\right)^{\frac{3}{2}}}-\frac{a\ \text{ArcSinh}\left(\sqrt{a^2-1}\right)}{(a^2-1)^{\frac{3}{2}}}\right).$$

This expression is decreasing in cost weight a.

$\frac{dW[a]}{da}>0$ has been determined numerically.

Proposition 4

When independent bidder X believes allied bidder Y to maximize profits then the outcomes in a first-price auction are identical to those in a second-price auction.

Proof:

Independent bidder X believing allied bidder Y to maximize profits is equal to X believing the allied bidder maximizes a compensation scheme with a cost weight set equal to one. X then bids, as in the symmetrical model,

$b_X = \frac{v_X}{2}$ and $x[b] = 2b$.

Let us assume that Y is aware of the ignorance (or skepticism) of X. This makes it possible for Y to logically deduce that $x[b] = 2b$. Substituting for $x[b]$ into equation 4 gives:

$$v_Y - ab_Y = \frac{a \cdot x[b_Y]}{x'[b_Y]} = \frac{a \cdot 2b_Y}{2} = ab_Y$$

$b_Y = \frac{v_Y}{2a}$, implying $y[b] = 2ab$.

With the above bidding functions, it follows that:

a) The auction revenue is equal to $m[a] = \frac{3-a}{6}$

b) The profit of allied bidder Y is given by $\pi^Y_{Generator}[a] = \frac{a(2-a)}{6} - w^0$

c) The profit of allied bidder X is given by $\pi^X_{Generator}[a] = \frac{a}{6}$.

The above outcomes are identical with the outcomes of second-price auctions. As the profit of the holding company and welfare is computed from the three outcomes above, these are also identical. As a result, revenue equivalence has been restored. Moreover, the effect of ownership share γ on the holding company's choice of cost weight will be the same; hence the same cost weight will be maximizing.

a) Proof of $m[a] = \frac{3-a}{6}$.

$$m[a] = m^X[a] + \left(m^Y[a]\right)$$

$$= \int_0^1 av_X\,(b_X)dv_X + \left(\int_0^a \frac{v_Y}{a}(b_Y)dv_Y + \int_a^1 \frac{1}{2}dv_Y\right)$$

$$= \int_0^1 \frac{a v_X^2}{2} dv_X + \left(\int_0^a \frac{v_Y^2}{2a^2} dv_Y + \int_a^1 \frac{1}{2} dv_Y \right)$$

$$= \left[\frac{a v_X^3}{6} \right]_0^1 + \left(\left[\frac{v_Y^3}{6a^2} \right]_0^a + \left[\frac{v_Y}{2} \right]_a^1 \right)$$

$$= \frac{a}{6} + \left(\frac{a}{6} + \frac{1-a}{2} \right)$$

$$= \frac{3-a}{6}.$$

b) Proof of $\pi^Y_{Generator}[a] = \frac{a(2-a)}{6} - w^0$:

$$\pi^Y_{Generator}[a] = \int_0^a \frac{v_Y}{a} (v_Y - b_Y) dv_Y + \int_a^1 \left(v_Y - \frac{1}{2} \right) dv_Y - w^0$$

$$= \int_0^a \frac{v_Y}{a} \left(v_Y - \frac{v_Y}{2a} \right) dv_Y + \int_a^1 \left(v_Y - \frac{1}{2} \right) dv_Y - w^0$$

$$= \int_0^a \frac{v_Y^2}{a} \left(\frac{2a-1}{2a} \right) dv_Y + \int_a^1 \left(v_Y - \frac{1}{2} \right) dv_Y - w^0$$

$$= \left[\frac{v_Y^3}{3a} \cdot \frac{2a-1}{2a} \right]_0^a + \left[\frac{v_Y^2 - v_Y}{2} \right]_a^1 - w^0$$

$$= \frac{a(2a-1)}{6} + \frac{a-a^2}{2} - w^0$$

$$= \frac{a(2a-1)}{6} + \frac{3a-3a^2}{6} - w^0$$

$$= \frac{a(2-a)}{6} - w^0.$$

c) Proof of $\pi^X_{Generator}[a] = \frac{a}{6}$;

$$\pi^{X}_{Generator}[a] = \int_0^1 a v_X \left(v_X - b_X\right) dv_X$$
$$= \int_0^1 a v_X \left(v_X - \frac{v_X}{2}\right) dv_X$$
$$= \int_0^1 \frac{a v_X^2}{2} dv_X$$
$$= \left[\frac{a v_X^3}{6}\right]_0^1$$
$$= \frac{a}{6}.$$

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7. Notation

a	$a \in [0,1]$ is the cost weight the holding company sets on the bidding costs of allied bidder Y when computing the bonus of manager Y^{m}. When manager Y^{m} wins the auction with bid b, his bonus increases on the margin with the value of transmission minus a times the bid.
b	$b \in [0, \overline{b}] \subseteq [0,1]$ is the officially stated bid offered by a bidder. $\overline{b} \in [0,1]$ is the highest bid in the auction.
$b_Y[v]$	The optimal bid of allied bidder Y given his realized value $v \in [0,1]$. This strategy $b_Y[\cdot]$ has the inverse $y[\cdot]$ (such that $y[b_Y[v]] = v$).
$b_X[v]$	$b_X[v]$ is the optimal bid of independent generator X given her realized value $v \in [0,1]$. This strategy $b_X[v]$ has the inverse $x[\cdot]$ (such that $x[b_X[v]] = v$).
γ	$\gamma \in [0,1]$ is the ownership share that the holding company holds in the auctioneer. The holding company therefore receives portion γ of the revenue of the auctioneer.
$p^{Y\,WINS}[a]$	The ex-ante expected probability that allied bidder Y wins when using (his optimal) strategy $b_Y[\cdot]$, given cost weight a.
$\pi^{Y}_{Generator}[a]$	The ex-ante expected private profit of allied bidder Y.
$\pi^{Y}_{Holding\ Company}[a,\gamma]$	The expected profit of the holding company when it sets the cost weight equal to a when the holding company has an ownership share of γ. When

setting the optimal cost weight, the expected profit of the holding company is equal to $\pi^{Y}_{Holding\ Company}[\gamma] = \pi^{Y}_{Holding\ Company}[a[\gamma], \gamma]$.

$\bar{\pi}^{Y}_{Passive}[\gamma]$ — $\bar{\pi}^{Y}_{Passive}[\gamma] = \pi^{Y}_{Holding\ Company}[a = 1, \gamma] + \gamma m[a = 1]$ is the ex-ante expected passive profit of the holding company. It is the profit when the holding company has an ownership share of γ, but sets the cost weight in the compensation scheme equal to one.

$\pi^{Y}_{Strategic}[\gamma]$ — $\pi^{Y}_{Strategic}[\gamma] = \pi^{Y}_{Holding\ Company}[\gamma] - \bar{\pi}^{Y}_{Passive}[\gamma]$ is the ex-ante expected strategic profit. It is the extra profit that can be made by giving manager Y^{m} a compensation scheme.

$m^{Y}[\gamma]$ — The ex-ante expected payment of allied bidder Y when the allied bidder has a realized value of v_{Y} and the ownership share is γ.

$m[\gamma]$ — $m[\gamma] = m^{Y}[\gamma] + m^{X}[\gamma]$ is the ex-ante expected revenue of the auctioneer, when the ownership share is γ.

v — $v \in [0,1]$ is the value of transmission in the auction. It is a random variable uniformly distributed on $[0,1]$.

$W[\gamma]$ — The ex-ante expected welfare. It is the value of transmission in use by the bidder that won the auction.

$x[\cdot]$ — The inverse of strategy $b_{X}[v]$ (such that $x[b_{X}[v]] = v$).

$y[\cdot]$ — The inverse of strategy $b_{Y}[\cdot]$ (such that $y[b_{Y}[v]] = v$).

Paper 3: The unbundling regime for electricity utilities in the EU: A case of legislative and regulatory capture?[♦]

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The Unbundling Regime for Electricity Utilities in the EU: A Case of Legislative and Regulatory Capture?

Abstract

Theory and empirics suggest that by curbing competition, incumbent electricity companies which used to be, and here are referred to as, Vertically Integrated Utilities (VIUs), can maintain a high profitability through combined ownership of generation and transmission and/or distribution networks. Because curbing competition is generally believed to be welfare-reducing, EU law requires unbundling (separation) of the VIU networks. However, the EU allows its member states the choice between incomplete (legal) and complete (ownership) unbundling. There is tantalizing anecdotal evidence that VIUs have tried to influence this choice through questionable means of persuasion. Such means of persuasion should be more readily available in countries with a more corrupted political culture. This paper shows that among the old EU member states, countries which are perceived as more corrupt are indeed more likely to apply weaker forms of unbundling. Somewhat surprisingly, we do not obtain a similar finding for the EU member states that acceded in 2004. We provide a conjecture for this observation.

Keywords: electricity markets; regulation; vertical integration; corruption

JEL classification code: K49, L43, L51, L94, L98.

1. Introduction

The European electricity market is undergoing major changes. Prompted by EU legislation (most notably DIRECTIVE 2003/54/EC[79] and REGULATION 1228/2003[80]), the EU

[79] "Directive 2003/54/EC of 26 June 2003 of the European Parliament and of the Council concerning common rules for the internal market in electricity and repealing Directive 96/92/EC" (OJ 2003 L 176/37).
[80] "Regulation (EEC) No 1228/2003 of the European Parliament and of the Council on Conditions for

member states are restructuring their electricity industry to allow for more competition which is widely believed to be welfare-enhancing. A major complication is that, at the outset, the electricity markets were almost completely controlled by large, Vertically Integrated Utilities (VIUs) that used to be regulated state monopolies. These VIUs typically still own almost all generators, as well as transmission and/or the distribution networks.[81] Such an ownership pattern is believed to be an obstacle for free competition (e.g., European Commission Competition DG, 2007, p.169).

To prevent VIUs from using their influence to reduce competition, the EU has required its member states to unbundle (separate) their generation and network activities. Many members, however, have been slow in implementing these directives and many have chosen the weaker (but permitted) form of unbundling. These developments, and the fact that weaker forms of unbundling are allowed at all, are widely believed to be welfare-reducing (e.g. European Commission Competition DG, 2007, pp.151-169). These observations suggest that the pertinent political, legislative, and regulatory processes might have unduly been influenced.

Motivated by tantalizing anecdotal evidence and a well-established literature on legislative and regulatory capture, we conjecture that a significant part of the timing of the implementation of unbundling regimes and the choice of weaker forms of unbundling regimes, as well as the fact that this choice is possible in the first place, can be explained by questionable (and possibly illegal) influence activities by VIUs. We conjecture specifically that such influence activities are more effective in countries where the policy and regulatory process is more susceptible to manipulations. Our data analysis supports our hypothesis for the old EU member states (the EU-15 countries[82]), but not for the EU

Access to the Network for Cross-Border Exchanges in Electricity (OJ 2003 L 176/1)".

[81] Generators produce electricity. The transmission network is operated by a Transmission System Operator (TSO) and is used for the transport of electricity over long distances. The distribution network is operated by a Distribution System Operator (DSO) and is used for the transport of electricity over short distances, mostly to the final consumer.

[82] EU-15: Austria (A), Belgium (B), England (UK), Germany (D), Denmark (DK), Spain (E), France (F), Finland (FIN), Greece (GR), Italy (I), Ireland (IRL), Luxembourg (L), the Netherlands (NL), Portugal (P), Sweden (S).

member states that acceded in 2004 (from here on, the new member states, or the NMS-10[83]).

The remainder of this paper is organized as follows. In the next section, we give examples of the welfare-reducing effects of having a fully integrated VIU and then discuss types of unbundling. We also formulate our key conjecture that countries with higher CPI score (less corruption) have more complete unbundling regimes and present a summary of the data that we use. In section 3, we explain the sources of our data, describe our strategy for analyzing the data, and state our hypothesis. In section 4, we report our results. We conclude with a discussion in section 5.

2. Motivation

Arguably, the major obstacle in both creating a single market in energy and allowing more competition is the dominance of large, formerly regulated VIUs that were typically state monopolies. The fact that VIUs own both generators and (transmission/distribution) networks is especially problematic as it allows VIUs to use their network ownership to increase their profits and hinder competition.

For example, VIUs can cross-subsidize their generation activities and recover their generation losses with high transmission fees. Apart from blunt refusal, VIUs have several additional tactics available to hinder access of competing generators to the network such as imposing discriminating requirements[84] or charging unreasonably high access and service fees.[85] Furthermore, VIUs have little incentive to invest in new transmission

[83] NMS-10: Cyprus (CY), the Czech Republic (CZ), Estonia (EST), Hungary (H), Lithuania (LT), Latvia (LV), Malta (M), Poland (PL), Slovakia (SK), and Slovenia (SLO).

[84] An inquiry by the European Commission finds that many market participants are "highly critical of the efficiency of existing unbundling obligations, believing that discrimination in favor of affiliates continues, and calling for stricter measures." European Commission Competition DG (2006, executive summary, p.4).

[85] For example, the Commission of the European Communities (2005, technical annex, p.14) claims that in 2005 in 16 out of 25 EU members, the fees for balancing services were set so as to hinder competition. Balancing is the real-time equalization of electricity supply and demand by the TSO; failure of balancing leads to electricity outages. Imbalances are caused by generators who cannot supply the exact amount they contracted for. The TSO has to make up for the shortage or excess in electricity supply and charges out-of-balance generators fees for balancing services. A TSO that is owned by a VIU can curb competition by charging excessive fees for its balancing services. This effect is aggravated by the fact that new and small entrant generators are more likely to cause imbalances than large incumbent generators (Commission of the

capacity[86] as more transmission capacity makes it more likely that generators from neighboring countries or distant areas can compete with the VIU-owned generators (European Commission Competition DG, 2007; Léautier, 2001; Brunekreeft, Neuhoff and Newbery, 2004). In addition, the European Commission Competition DG (2007, p.165) reported cases of VIUs having given commercially valuable inside information to their affiliated generators. This puts independent generators at a disadvantage and thereby decreases competition.

To prevent VIUs from using control over their networks to reduce competition, the EU requires member states to unbundle (separate) their transmission and distribution networks from generation. The EU distinguishes five types of such unbundling:

0) Unified ownership requires no unbundling; both network and generation activities continue to be owned and managed by the same company.
1) Accounting unbundling is the least drastic form of unbundling; separate accounts must be kept for the network activities and generation activities to prevent cross subsidization.
2) Functional unbundling (also called management unbundling) requires, in addition to keeping separate accounts, that the operational activities and management are separated for transmission and generation activities.
3) Legal unbundling requires that transmission and generation be put in separate legal entities.
4) Ownership unbundling is the most drastic form of unbundling. Generation and transmission have to be owned by independent entities. These entities are not allowed to hold shares in both activities.

European Communities, 2005, technical annex, p.13). See Newbery, van Damme, and von der Fehr (2003), p.16, for an example of how the balancing system in Belgium (where in 2003 the VIU owned all networks and practically all generation) impedes electricity imports from the Netherlands.

[86] There is a pressing shortage of transmission capacity between countries (European Commission Competition DG, 16.02.2006, p.152). This is a serious issue since it obstructs the creation of one single market in electricity (Directive 96/92/EC).

Table 1: Unbundling regimes in EU member states.[87]

EU-15 countries						
Unbundling regime	2001	2002 [88]	2003 [88]	2004	2005	2006
0) None	0	0	0	0	0	0
1) Account	0	0	1 (L)	0	0	0
2) Functional	3 (D, F, GR)	2 (F, L[89])	1 (F)	1 (L)	0	0
3) Legal	8 (A, B, DK, E, I, IRL[89], NL, P)	5 (A, B, D, DK, P)	4 (A, B, D, DK)	7 (A, B, D, DK, F, GR, IRL)	7 (A, B, D, F, GR, IRL, L)	7 (A, B, D, F, GR, IRL, L)
4) Ownership	3 (FIN, S, UK)	5 (E, FIN, NL, S, UK)	6 (E, FIN, NL, P, S, UK)	7 (E, FIN, I, NL, P, S, UK)	8 (DK, E, FIN, I, NL, P, S, UK)	8 (DK, E, FIN, I, NL, P, S, UK)

NMS-10						
Unbundling regime	2001	2002	2003	2004	2005	2006
0) None		0	0	0	0	0
1) Account		1 (H)	2 (EST, H)	1 (LV)	0	0
2) Functional		2 (CY, EST[89])	2 (CY, PL)	1 (CY)	1 (CY)	0
3) Legal		6 (CZ, LT, LV[89], PL[89], SK, SLO)	5 (CZ, LT, LV[89], SK, SLO)	7 (CZ, EST, H, LT, PL, SK, SLO)	4 (EST, LV, PL, SK)	5 (CY, EST, LV, PL, H)
4) Ownership		0	0	0	4 (CZ, H[89], LT, SLO)	4 (CZ, LT, SLO, SK)

Interestingly, the EU allows its member states the choice of an unbundling regime (legal or ownership) and the time path of implementation (quick or slow[90]) although there seems

[87] Malta has no transmission network and is therefore not listed in Table 1.
[88] Greece and Ireland in 2002 and 2003 have been categorized as having implemented a combination of functional (3) and legal (4) unbundling. Italy in 2002 and 2003 has been categorized as having implemented a combination of legal (4) and ownership (5) unbundling. We leave these observations out in the main analysis but we ran several robustness tests including these observations. It turns out that inclusion does not change the results in any significant manner. For our treatment of these observations see section A.1 in the Appendix
[89] In the one of the following years the unbundling regime becomes less rigorous. While leaving these observations in the main analysis for consistency, we ran robustness tests excluding these observations. Again, this inclusion had no significant impact.
[90] For transmission, legal or ownership unbundling had to be implemented by July 2004; for distribution, legal or ownership unbundling had to be implemented by July 2007. However, some countries have adopted such a slow pace of implementation that it borders on noncompliance. In 2005, while 18 EU member countries reported to have implemented legal unbundling, in 8 of these it has not been done effectively in that the network activities of the VIU are not overseen by a separate board of directors (Commission of the European Communities, 2005, p.80).

to be wide agreement that the quick implementation of ownership unbundling would be welfare-enhancing (e.g., OECD, 2001; Pittman, 2003; European Commission Competition DG, 2007, p.168). Legal unbundling leaves intact the incentives for curbing competition.[91] Not surprisingly, in many countries VIUs opposed ownership unbundling in favor of legal unbundling.[92] It is therefore an interesting question (to which our results below provide a suggestive answer) whether VIUs were able to manipulate the legislative and regulatory process in favor of the weaker form of unbundling, and whether these manipulations were a function of the integrity of legislative and regulatory processes.

Table 1 documents the considerable variation in the unbundling regimes implemented in EU member states, and the distribution of regimes over time,[93] both for the old (EU-15 countries) and the new member states that acceded the EU in 2004 (NMS-10)**.**

Remarkably, but perhaps not surprisingly given the available choices, many countries did not choose to implement ownership unbundling. The fact that legal unbundling is the modal choice for the NMS-10 and the EU-15 countries set in 2001-2 (and a close contender even in 2003-5) is one indication that VIUs may be able to exert influence over the transmission company.[94] We therefore conjecture that part of the variation in the unbundling regime choice and the speed of implementation can be explained by influence activities of VIUs. These activities may be legal (e.g., transparent lobbying activities) or may include questionable (and possibly illegal) strategies such as under-the-table payments to allegedly independent lobbyists to effect public opinion and the legislative and regulatory process. Of course, it may also be possible that outright bribes were paid.

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[91] There are several concrete examples of legally unbundled VIUs that curb competition through their combined ownership of generation and transmission or distribution networks, see European Commission Competition DG (6.02.2006, p.144-148).

[92] For example, see Mulder, Shestalova, and Lijesen (2005) for the debate in the Netherlands.

[93] The sources of the data are described in section 3.

[94] The Dutch branch of the energy company Essent provides an example of the incumbents' rhetoric against ownership unbundling. Suggesting that unified ownership of the network provides protection against possible foreign take-over, Essent says: "We are now being chopped up, ready for swallowing by large foreign groups with headquarters in Munich or Paris" (http://www.essent-finance.nl/pressroom/release36.jsp).

A recent scandal in the Netherlands illustrates one questionable strategy. In January 2006, it became known that energy companies Nuon, Eneco, Essent, and Delta had secretly promised, contingent on the Netherlands' government deciding against ownership unbundling of the distribution network, a "success fee" of EURO 1,7 million to IMSA, an environmentally oriented consultancy company that presents itself as independent and idealistic.[95] IMSA had forcefully argued against ownership unbundling of energy networks in the Dutch media and in an IMSA consultancy report (Van Dieren, Tuininga, and van Soest, 2006). This example is suggestive of the value of weaker unbundling for energy companies, but it begs the question whether the Dutch scandal was an isolated incident or unique only in that it had been exposed.

The effect of such questionable influence activities depends on the integrity of legislative and regulatory processes. Data that directly measure the integrity of such processes do not exist. We therefore use the Corruption Perception Index (CPI) of Transparency International as a proxy. The CPI is a widely used and well-established corruption assessment instrument (e.g., Mauro, 1995; Treisman, 2000) that reflects the (perception of) corruption of a country, it assigns countries a score between 1 (very corrupt) and 10 (hardly corrupt at all). The score is based on a number (up to 18) of sources, not all of them just about perception. In some sense the name of the CPI has become an anachronism. The CPI of 2006 was based on 12 sources from 9 independent institutions (Lambsdorff, 2006).

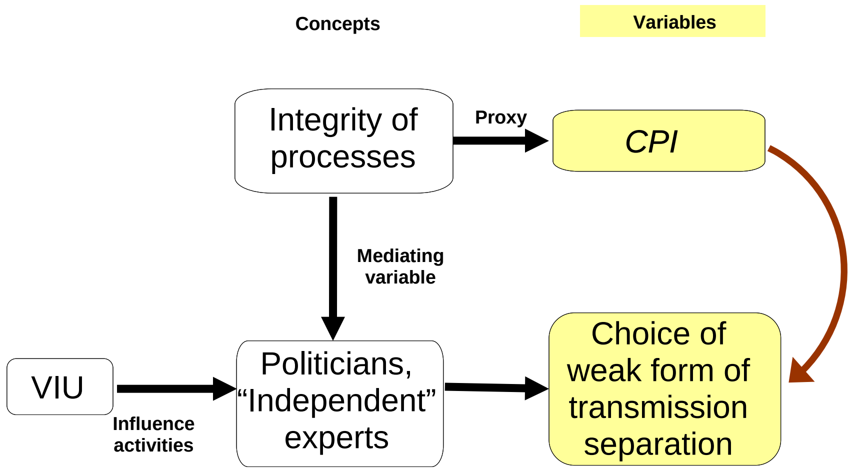
We can now formulate our conjecture as follows:

Countries with higher CPI score (less corruption) have more complete unbundling regimes.

Figure 1 illustrates the relations between concepts and variables.

[95] See http://www.imsa.nl/ for the idealistically flavored mission statements of IMSA. The director of IMSA and benefactor of the success fee, Mr. van Dieren, keeps a public appearance as an independent environmental activist. He is a member of the Club of Rome and the founder of a Dutch militant environmental organization called Friends of the Earth Netherlands.

Figure 1: Relations between concepts and variables.



Our study relates to an established literature on rent-seeking and corruption (Mauro, 1995, 1997; Tanzi and Davoodi, 2000; Treisman, 2000). Mauro (1997) reviews studies that show how government policies (e.g. trade, price, and industrial policies) create rents which invite influence activities and corruption. In our view, the unbundling policy is such a source of government-induced rents since the implementation of unbundling regimes less stringent than ownership unbundling are likely to bring about higher profits for VIUs. In line with the literature on rent-seeking and corruption, we expect VIUs to attempt to appropriate these rents by persuading politicians to allow the less stringent unbundling regime. We expect that VIUs will be more successful in these attempts at persuasion in more corrupt countries.

3. Data description and analysis

We collected the data on unbundling regimes and market share of the (three) largest electricity generator(s) from EU Commission (2002, 2003, 2004, 05.01.2005, 15.11.2005, 2006, and 2008) reports on the implementation of DIRECTIVE 2003/54/EC and REGULATION 1228/2003. For consistency we use these official data for our main analysis.[96]

[96] The sources used to determine the transmission unbundling regime are summarized in section A.4 in the Appendix.

Malta and Cyprus both have a small and isolated electricity system.[97] Moreover, Malta has no transmission network. We therefore have no observations on Malta and excluded those on Cyprus. We ran a robustness check by including the data for Cyprus together with a dummy variable, *Small_Isolated.*[98] As expected, *Small_Isolated* had a negative sign, indicating that a small and isolated system has less rigorous unbundling. Also, the categorization of the transmission unbundling regime in Latvia in the report of the Latvian regulator (The [Latvian] Public Utilities Regulation Commission, 2005) is in conflict with the categorization in the DG Tren reports. While we stick to the official EU data (the DG Tren reports) for consistency, we did a robustness test using the categorization of the Latvian regulator; this did not affect the significance of the coefficient of *CPI* in the regression for the NMS-10.

Bulgaria and Romania acceded the EU in January 2007. These countries joined 3 years later than the NMS-10 and therefore had a different time schedule for implementing EU directives. We conjectured that including Bulgaria and Romania together with the NMS-10 would not be appropriate; robustness tests including Bulgaria and Romania confirmed our conjecture (see footnote 110).

The DG Tren reports do not indicate when exactly a particular unbundling regime was in place. We therefore used the following decision rule: If the report said that the data were, say, collected in 2001, then we report them in the column "2001" even if the report itself was published in 2002. Likewise, it does not matter whether a legislative or regulatory change was enacted in January or December. We can not think of any reason why our (strong) results reported below should be significantly affected by these caveats.

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[97] Countries that operate a small isolated system (Cyprus and Malta) have little to gain from unbundling as the low demand for electricity and the absence of interconnectors leave no room for effective competition (The Ministry for Resources and Infrastructure of Malta, 2006, p.42). In Malta the total installed capacity is 550 MW and in Cyprus the total installed capacity is 988 MW (Cyprus Energy Regulatory Authority, 2005, p. 17). The European Commission has indeed granted Cyprus derogation on the unbundling requirements; Cyprus is exempted from the obligation to implement transmission unbundling before July 2004. These facts seem substantial enough to affect the choice of unbundling regime.

[98] Malta is such a small country that it makes do without a transmission network; electricity is transported through the distribution network. One typically does not find an assessment of the transmission and distribution unbundling regimes in Malta or Cyprus in the DG Tren reports. Therefore, we draw on information from the Malta Resources Authority (2005); the Ministry for Resources and Infrastructure of Malta (2006); and the Cyprus Energy Regulatory Authority (2005).

The CPI data were obtained from Transparency International.[99] The data on per capita GDP in thousands of Euros (fixed series at 1995 prices and exchange rates), GDP in billions of Euros (fixed series at 1995 prices and exchange rates), electricity prices (per kWh in Euro without taxes) and net electricity import relative to total available production were obtained from Eurostat.[100]

To test our hypothesis, we ran ordered logit regressions with transmission unbundling regime and quality of implementation, respectively, as the dependent variable and *CPI* and various controlling variables as regressors.

As controlling variables, we use a time trend, *TimeTrend*, the per capita gross domestic product at 1995 prices and exchange rates, *GDP_pc*, the gross domestic product at 1995 prices and exchange rates, *GDP*, the net import of electricity relative to the total net generation of electricity[101], *NetElecIMP*, and an approximation of the Herfindahl-Hirschman Index[102] concentration of generation, *HHI_med*.

We expect the time trend to have a positive effect (more unbundling) because over time, the European Commission has required more stringent unbundling. We included the per capita gross domestic product and the gross domestic product because we suspect that wealth and economic size of a country influence the choice of the transmission unbundling regime. We expect the new member countries (NMS-10) to have less unbundling, as they joined the reform process at a later stage. On the other hand, the

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[99] Available on http://www.transparency.org/
[100] Eurostat website for energy.
[101] Net imports (Eurostat code: 100600) divided by total net electricity generation (Eurostat code:107100), from the Eurostat website for energy.
[102] We are grateful to an anonymous referee for the suggestion to include this indicator which turned out to have a significant impact. The Herfindahl-Hirschman Index (HHI) sums the squares of the market shares in percentages of all relevant firms. The value of the HHI is thus between 0 and 10.000. Surprisingly, the HHI is not readily available. We constructed therefore a proxy that we call *HHI_med* and in which we use data on the market share of the largest (*MSLG*) and the largest three generators (*MSL3G*). The proxy is equal to a generalized average of *HHI_high* and *HHI_low*; respectively the upper and the lower bound of the true HHI. We obtained qualitatively the same results running our regressions with *HHI_high* or *HHI_low* instead of with *HHI_med*. See our website http://home.cerge-ei.cz/svk/Unbundling&Corruption for details on the construction of this proxy.

NMS-10 experienced much stronger pressure for implementation of the EU directives on unbundling than the EU-15 countries; implementation of the EU directives was one of the conditions for accession in 2004.[103] These differences seem substantial enough to run separate regressions for the NMS-10 and the EU-15 countries.

We have no prior about the effect of *NetElecIMP*, the net import of electricity.[104] On the one hand, we expect a VIU that is a net exporter to gain more from owning the network. On the other hand, a VIU that is a net importer can hamper competing imports from abroad and thereby increase its profit.

We estimate the following equation:

$$\Pr(T\_unbund = i) = \Pr(\kappa_{i-1} < \alpha + \beta_1 \cdot CPI + \beta_2 \cdot TimeTrend + \beta_3 \cdot GDP\_pc + \beta_4 \cdot GDP + \beta_5 \cdot NetElecIMP + \beta_6 \cdot HHI\_med + u_j < \kappa_i)$$

where the variables are defined as follows:

- *T_unbund* stands for the transmission unbundling regime implemented and can take the categorical values $i \in$ {Unified ownership, Accounting unbundling, Functional unbundling, Legal unbundling, and Ownership unbundling}.
- *CPI* stands for the Corruption Perception Index.
- *TimeTrend* stands for time trend.
- *GDP_pc* stands for the per capita Gross Domestic Product in thousands of Euros (fixed series at 1995 prices and exchange rates).
- *GDP* stands for Gross Domestic Product in billions of Euros (fixed series at 1995 prices and exchange rates).
- *NetElecIMP* stands for the net import of electricity relative to the total electricity consumption.in a country.
- *HHI_med* is an approximation of the Herfindahl-Hirschman Index of electricity generation in a country.

[103] For the obligation of transmission network unbundling no country was granted derogation. Slovenia, Cyprus, and Estonia were granted derogations for implementing parts of the energy directive 2003/54/EC, but not with regard to chapter 4, the unbundling regime.
[104] We included this variable in response to a referee's suggestion.

Our main hypothesis is:

H_0: β_1 and β_2, the coefficient on *CPI* is equal to zero.

H_A: β_1 and β_2, the coefficient on *CPI* is greater than zero.

We assume that the variables that we control for are clustered by country, and we therefore use the robust Huber/White/sandwich estimator clustered by country for the variance (Froot, 1989).

4. Results

Table 2 shows the results for the EU-15 countries and the NMS-10.[105] For the EU-15 countries, Model 1 shows the regression with significant and insignificant control variables while Model 2 shows the regression with only the significant control variables (*HHI_med* becomes insignificant after excluding *GDP*). Both models show that for the EU-15 countries, the effect of the CPI is highly significant and positive. This supports our hypothesis: The less corrupt of the EU-15 countries (a high CPI score) tend to implement more rigorous transmission unbundling. The significant effect of the CPI is robust to the method of data analysis, the particular specification of controls, in- or exclusion of most of the control variables and varying our treatment of problematic observations.[106]

[105] At the suggestion of an anonymous referee we also ran regressions using as control variables gross electricity generation — as an indicator of the size of the market, and working days lost in strikes per thousand workers — as an indicator of unionization. The variable gross electricity generation correlates highly with *GDP* (p=0.97), using it instead of *GDP* therefore makes no significant difference for the results. The control variable working days lost in strikes was not significant for either the EU-15 countries or the NMS-10 and did not significantly change the results for the EU-15 countries. For the NMS-10 the inclusion of this control variable made the effect of the CPI insignificant, largely because the missing observations in this control variable diminished the number of available observations from 40 to 22.

[106] We obtained essentially the same results using survival analysis, an alternative methods of data analysis. We used the Cox proportional-hazards regression model (Cox, 1972) and used ownership unbundling as the survival criteria. We categorized a country as being "alive" as long as it has not implemented ownership unbundling, a country "fails" at the moment it implements ownership unbundling. In the analysis of EU-15 countries, variables *CPI* and *GDP_pc* showed up in the same direction and highly significant ($p<0.01$). The survival analysis of the NMS-10 was inconclusive as the model could not be reliable fitted due to the low number of degrees of freedom (eight observations and four independent variables). We obtained basically the same result running, as a further robustness test, linear regressions. Using ordered probit regression, a method of data analysis that uses the same technique but assumes a different distribution than ordered logistic regression, resulted in almost identical quantitative results.

To further illustrate the importance of the variable *CPI* we use our regressions to predict the binary choice between ownership unbundling and less binding unbundling regimes (legal, functional, account and none) for the EU-15 countries.[107] Inclusion of the variable *CPI,* in addition to the significant control variables, adds 30% to the percentage of correct predictions for the EU-15 countries.

Not surprisingly, given that the EU directives require legal unbundling by 2004, the time trend variable *TimeTrend* shows that in later years it is more likely for any country to have more unbundling. Furthermore, the regression results show that the wealthier of the EU-15 countries (as measured by per capita GDP) are less likely to implement rigorous transmission unbundling. This is not straightforward result. We conjecture that for a given level of corruption, a wealthier country has more resources and might thus invite more

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It takes time to decide on and implement an unbundling regime. It could therefore be argued that the unbundling regime should be regressed on the lagged *CPI*. However, the *CPI* indeces are moving averages; the *CPI* of any year during the period 2001-2005 is based on numerous indexes and reports over a time period including the two previous years (Lambsdorf, 2005) and in 2006 including the previous year (Lambsdorf, 2006). For example, the *CPI* of 2005 is based on information over the period 2003-2005 and the *CPI* of 2006 is based on information over the period 2005-2006. Performing a regression on the *CPI* lagged by one year gave coefficients and significance levels that were virtually identical to the ones in model 1 and 2.

As a robustness test we used data on the per capita Gross Domestic Product and on the Gross Domestic Product not as fixed series at 1995 prices and exchange rates, but corrected for purchasing power parity. As a result in the regression for the EU-15 countries in model 1 the significance of *CPI* slightly increased and, in model 2, the significance of *CPI* ($p<0.012$) and *netimp_gen* ($p<0.234$) slightly decreased, while the significance of all other variables remained unaffected. The significance of the variables in the regression for the NMS-10 was virtually unaffected. The data on per capita Gross Domestic Product and on the Gross Domestic Product corrected for purchasing power parity we obtained from Eurostat, section "Economy and finance".

Inclusion or exclusion of control variables did not greatly affect the significance of the CPI; the only critical control variable is *GDP_pc*, the per capita GDP. Without this variable the significance of the *CPI* fell to $p<0.200$. Exclusion of the other control variables left the CPI always significant at the 5% confidence level and mostly at the 1% confidence level.

In addition we ran a pooled, seemingly unrelated regression (Greene, 2003, p. 340) with the observations on the EU-15 countries and the NMS-10 together. We allowed a variable to have different effects for the EU-15 countries and the NMS-10 by using interaction variables. We thus created two sets of interaction variables: one set of variables multiplied with *EU15*, a dummy for the EU-15 countries, and one set multiplying with *NMS10*, a dummy for the NMS-10. For example the effect of the CPI was measured for the EU-15 countries by the variable *CPI*EU15* (which was created by multiplying *CPI* with *EU15*) and for the NMS-10 by the variable *CPI*NMS10* (which was created by multiplying *CPI* with *NMS10*). As a result the effect of *CPI* strengthened for the EU-15 countries ($p<0.001$), and weakened for the NMS-10 ($p<0.088$). All control variables had the same signs and their significance was largely the same as those reported in Table 2.

For our treatment of problematic observations see section A.1 in the Appendix.

[107] We thank Jan Hanousek for suggesting this analysis.

rent-seeking activities.[108] As wealth of a country has a strong negative correlation with corruption in our dataset as well as in general (Tanzi and Davoodi, 2000; Treismann, 2000), this effect can only be found when controlling for corruption. The effect of *NetImportElec* is positive and significant ($p<0.05$) but not very large.[109]

Table 2: Regression models.

	EU-15 countries (old member states)		NMS-10 (new member states)	
	Model 1	Model 2 (Only significant variables)	Model 3	Model 4 (Only significant variables)
CPI	2.83*** (1.03)	2.55*** (0.74)	-1.14** (0.45)	-1.63*** (0.43)
TimeTrend	1.35** (0.52)	1.04*** (0.26)	1.18** (.46)	1.55*** (.50)
GDP_pc (in thousands)	-0.56*** (.20)	-0.53*** (0.11)	0.43*** (.12)	0.53*** (.13)
GDP (in millions)	-0.56 (0.79)		-28.2** (13.0)	-24.4*** (6.22)
HHI_med	-0.00048*** (0.00017)		-0.00019 (0.00024)	
NetImport_Gen	19.3*** (5.2)	8.38*** (2.76)	-4.42*** (1.47)	-3.79*** (1.15)
N	58 (14 clusters)	83 (15 clusters)	29 (8 clusters)	40 (8 clusters)

*** Significant at the 1% confidence level
** Significant at the 5% confidence level
* Significant at the 10% confidence level
() Robust standard errors within parentheses

Interestingly, the effect of the CPI on the NMS-10 (model 3 and 4) is opposite to the effect in EU-15 countries (model 1 and 2); more corrupt countries in the NMS-10 sample tend to implement *more* rigorous transmission unbundling.[110] Also the effect of wealth is

[108] See for example Svensson (2000) for a model where an increase in rents increases rent dissipating activities.
[109] While the effect is significant, the variable does probably not exert a large influence. When we used our regressions to predict the binary choice between ownership and less binding unbundling regimes (legal, functional, account and unified ownership) for EU-15 countries, the exclusion of *NetImportElec* from the regression lowered the percentage of correct predictions by 6% (from 76% to 70%).
[110] Including Cyprus together with a dummy variable S*mall_Isolated* in model 3 did not change coefficients and significance levels. The coefficient on the dummy S*mall_Isolated* was negative (less unbundling for small and isolated systems) and significant ($p<0.01$), as expected. Including the newest EU member states Bulgaria and Romania did not affect the significance of the CPI, but lowered the significance of *GDP* and *NetImport_Gen*. Artificially shifting the time trend of Bulgaria and Romania 3 years back, in order to align their accession date with the NMS-10**,** resulted in high significance of all variables in model 3 ($p<0.01$). This confirms our conjecture that the later accession date of Bulgaria and Romania sets these countries apart from the NMS-10.

reversed; richer NMS-10 (as measured by *GDP_pc*, the per capita GDP) are *more* likely to implement rigorous transmission unbundling. The effect of being a net importer, captured by *NetImportElec*, is also reversed; countries that are a net importer are less likely to choose a stricter unbundling regime. The effect of *NetimportElec* is however not very large.[111] The economic size of a country (as measured by *GDP*) has a strongly significant effect; economically larger countries are less likely to implements rigorous transmission unbundling. This later result is in step with the results for the EU-15 countries.

A possible explanation is that the reverse *CPI* effect is spurious; the effect is significant but not as robust as the CPI effect we found for EU-15 countries and effectively it is very small.[112] Moreover, we have reasons to suspect that the transmission unbundling regime has not always been reported accurately for the NMS-10. For example, in four out of the eight countries in our NMS-10 sample the unbundling regime becomes *less* rigorous in time over certain periods. The occurrence of such "backwards progression" could be an indication of misreporting.[113]

It seems likely that the occurrence of misreporting is related to the level of corruption in the NMS-10. After all, in the pre-accession stage the European Commission has exerted strong pressure on the NMS-10 to show clear signs of reform to be eligible for EU membership in 2004. Compliance with the unbundling requirements is a step towards creating a liberal market-economy and a way for an accession country to signal its

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[111] When we used our regressions to predict the binary choice between ownership and less binding unbundling regimes (legal, functional, account and unified ownership) for the NMS-10, the exclusion of NetImportElec from the regression lowered the percentage of correct predictions by only 2% (from 62% to 60%).

[112] The effect of the *CPI* became insignificant if one of the control variables in model 4 was left out of the regression. This could indicate overfitting; the regression in model 4 in Table 2 includes five independent variables for a sample that consists of only 8 truly independent groups of observations (NMS-10).

Furthermore, using our regressions to predict the binary choice between ownership unbundling and less binding unbundling regimes (legal, functional, account and none) for the NMS-10, inclusion of the variable *CPI,* in addition to the significant control variables, added only a mere 2% to the percentage of correct predictions for the NMS-10.

[113] The countries that reported a "backwards progression" in unbundling regime are Estonia (2002 to 2003; Functional to Account unbundling), Hungary (2005 to 2006; Ownership to Legal unbundling), Ireland (2001 to 2002 and 2003; Legal to a mixed regime of Functional and Legal), Latvia (2002 and 2003 to 2004; Legal to Account unbundling), Luxemburg (2002 to 2003; Functional to Account unbundling), Poland (2002 to 2003; Legal to Account unbundling). Running a regression with these observations excluded did not change the results significantly.

commitment for reform to the EU.[114] Especially for very corrupt countries such formal compliance is a cheap signal relative to actually curbing anticompetitive practices and governmental corruption. This might explain why more corrupt countries choose (at least formally) more rigorous unbundling. As the rationale for misreporting was eliminated once the NMS-10 had acceded the EU in 2004, we expect to observe variance in the effect of *CPI* over time. Indeed, additional analysis showed that the effect of *CPI* differs significantly over time ($p<0.0003$); the negative effect of the CPI on the unbundling regime was most pronounced in the period 2002 - 2004, but less so in 2005 and 2006.[115] Furthermore, the pressure to show clear signs of reform was most likely more intense for economically smaller countries, as they had less bargaining power vis-à-vis the EU. This would explain that economically large countries in the NMS-10 sample (as measured by the GDP) are less likely to implement rigorous transmission unbundling.

The case of Latvia illustrates our conjecture. The unbundling regime in Latvia was reported in the evaluating DG Tren reports of the EC on 2002 and 2003 (published timely *before* accession) as Legal. This report allowed Latvia to fulfill the accession criteria in this respect. However the unbundling regime in Latvia was reported in the DG Tren reports on 2004 (published *after* accession) as Accounting, having Latvia practically fail the accession criteria in this respect. In addition, the unbundling regime in Latvia in 2002 and 2003 are now being reported by the Latvian regulator as Accounting, which indicates that the reported Legal unbundling in 2002 and 2003 were misreports. Interestingly, Latvia was indicated by the CPI as the most corrupt country in 2001 and 2002 in our

[114] Prior to the accession of a selected group of candidate countries in 2004, these candidate countries were evaluated by the European Commission, see for example the European Economy Enlargement Papers. As can be seen in the European Economy Enlargement Papers, one of the criteria on which the candidate countries were evaluated was the state of liberalization and regulation of the energy sector. The European Economy Enlargement Papers are available at http://ec.europa.eu/economy_finance/publications/enlargementpapers_en.htm

[115] At the suggestion of an anonymous referee, we tested for an interaction effect between *CPI* and time by inspecting the effect of *CPI* for individual years. We found that for the NMS-10 the effect of the interaction variables $CPI^* t_i$ ($2\leq i \leq 5$) are negative in all years, and strongly significant ($p<0.01$) in for the years 2002 – 2004, weakly significant ($p<0.10$) in 2005 and not significant ($p<0.21$) in 2006. In contrast, for the EU-15 countries the effect of *CPI* is positive and highly significant for all years.
An LR test ((Long and Freese, 2001, p.146), showed that in the NMS-10 the effect of *CPI* differs significantly over time ($p<0.0003$). In contrast, in the EU-15 countries the effect of *CPI* is not significantly different over time ($p<0.5795$). A more extensive analysis of the interaction effect between *CPI* and time can be found in section A.3 in the Appendix.

sample of EU-25 countries, and one of the smallest economies in our sample of the NMS-10 (its GDP is about 20% of the average).[116] As such, Latvia is a prototypical example for the relationships we found between the variables in our regression.

Sensitivity Analysis

We ran tests to determine the sensitivity of our results to the exclusion of specific countries and influential observations. First we applied a jackknife technique: we repeatedly ran ordered logistic regressions of the transmission unbundling regime on the *CPI* and significant control variables, while excluding one specific country.[117] For EU-15 countries, the significance of *CPI* ($p<0.001$) was virtually unaffected, the largest weakening was caused by the exclusion of France ($p<0.003$). France is a country that lacks rigorous unbundling and scores relatively poorly on the *CPI* (relatively corrupt).

To identify potentially influential observations, we approximated our model by simple linear regression and then drew plots of leverage against normalized squared residuals. Influential observations can be identified as outliers in such plots. Eight potentially influential observations were found, one on Denmark (42:2006), one on Greece (72: 2001), three on Italy (96: 2004, 97: 2005, 98: 2006), and three on Luxemburg (116:2003, 118:2005, 119:2006). Running our equation excluding these observations did not affect the significance of the *CPI* ($p<0.004$).

For countries in the NMS-10 sample the effect of the *CPI* on unbundling regime was less robust to the exclusion of countries. The significance of the *CPI* ($p<0.009$) was weakened most by the exclusion of Estonia ($p<0.468$). Interestingly, the inclusion of the observations on Bulgaria and Romania — artificially shifted three years back to align their accession date with that of the NMS-10 — into our sample strengthened the statistical relationship considerably. As a result the exclusion of Estonia from this regression lowered the significance of the CPI less drastically ($p< 0.031$).

[116] However, running the ordered logit regression for the NMS-10 excluding Latvia does not affect the significance of the coefficients much. See the sensitivity analysis below.

[117] We thank Jan Hanousek for suggesting this analysis.

Approximating our model by simple linear regression we identified three potentially influential observations in the sample of NMS-10, all of which are instances of the backwards progression explained in footnote 113; two on Latvia (101, 102: the misreports in 2002 and 2003), and one on Poland (136: 2002). Running the regression excluding these three observations did not chance the results qualitatively.

Marginal effects for EU-15 countries and the NMS-10

To explore the size of the effect of the *CPI* on the transmission unbundling regime,[118] we calculate the marginal effect of the *CPI* on the probability of choosing an unbundling regime.

Table 3: Marginal effects (in percentages) for EU-15 countries.

	Account	Functional	Legal	Ownership
CPI	- 0.1% (0.00)	-1.0% (0.01)	-56.0%*** (0.14)	57.0%*** (0.14)
TimeTrend	-0.0% (0.00)	-0.4% (0.00)	-22.8%*** (0.07)	23.2%*** (0.07)
GDP_pc	0.0% (0.00)	0.2% (0.00)	11.6%*** (0.03)	-11.8%*** (0.03)
NetImportElec	-0.2% (0.00)	-3.1% (0.03)	-184.2%*** (0.71)	187.5%*** (0.72)

*** Significant at the 1% confidence level
** Significant at the 5% confidence level
* Significant at the 10% confidence level
() Robust standard errors within parentheses

Table 3 shows that an increase in the *CPI* with one point (the country is *less* corrupt) increases the likelihood of the average EU-15 country to choose ownership unbundling for transmission by 57%. Likewise, a decrease in the *CPI* (the country is *more* corrupt) increases the probability to have legal, functional or accounting unbundling.

[118] We expected that the same effect could be found for the unbundling regime for distribution. Running an ordered logit regression of the distribution unbundling regime of EU-15 countries on the *CPI* and controlling variables resulted in a positive (0.67) but insignificant (P<0.207) coefficient. In a regression of the distribution unbundling regime of the NMS-10 the coefficient on the *CPI* was negative (-1.42) and not significant (p< 0.136). A possible explanation is that distribution unbundling was scheduled to be implemented later (July 2007) than transmission unbundling (July 2004), and that the effect of the *CPI* will show up significantly once data over 2007-2008 are available.

Table 4: Marginal effects for the NMS-10.

	Account	Functional	Legal	Ownership
CPI	3.1% (0.03)	2.5% (0.02)	5.8% (0.04)	-11.3%** (0.04)
TimeTrend	-2.9% (0.02)	-2.4% (0.02)	-5.4% (0.04)	10.8%*** (0.03)
GDP_cp	-1.0% (0.00)	-0.8% (0.01)	-1.9% (0.01)	3.6%*** (0.01)
GDP	45.9%** (0.34)	37.6%* (0.26)	86.4% (0.68)	-169.9%*** (0.65)
NetImportElec	7.1%** (0.05)	5.8% (.04)	13.4% (.11)	-26.3%*** (0.10)

*** Significant at the 1% confidence level
** Significant at the 5% confidence level
* Significant at the 10% confidence level
() Robust standard errors within parentheses

Table 4 shows that an increase in the *CPI* by one point (the country is *less* corrupt) lowers the likelihood for the average country in the NMS-10 sample to chose ownership unbundling for transmission with 11.3%, while increasing the probability to have legal, functional or accounting unbundling.

Legal origin and unbundling regimes

In a series of papers (Djankov, La Porta, Lopez de Silanes, and Shleifer, 2002; Djankov, Glaeser, La Porta, Lopez-de-Silanes, and Shleifer, 2003; La Porta, Lopez-de Silanes, Shleifer, and Vishny, 1997, 1998, 1999; and La Porta, Lopez-de-Silanes, Pop-Eleches, and Shleifer, 2004) the authors suggest that legal origin has an important, unambiguous, significant and unidirectional influence on a collection of institutional performance indicators such as quality of government, judiciary and regulation; corruption; and availability of external finance. La Porta et al. (1997, 1998, 1999 and 2004) found that common law countries have governments of higher quality, have less corruption, are less regulated and have more external finance available for firms than countries with other law origins. Countries of French legal origin have the worst score, while countries of German and Scandinavian legal origin are in the middle group. In line with these findings, we expect that common law countries have the most progressive unbundling regimes, that

French law countries have the least progressive unbundling regimes, and that Scandinavian and German law countries are in between.

By and far, our data seem to contradict the findings of La Porta et al. (1998). While countries of French and German legal origin — in line with the findings of La Porta et al. (1998) — show less unbundling than countries of common law origin in a regressions, the differences are not statistically significant. Moreover, countries of Scandinavian legal origin show — in contrast with the findings by La Porta et al. (1998) — significantly ($p < 0.10$) more unbundling than countries of common law origin. We conclude that legal origin does not play an important role in explaining the variation in unbundling regimes.

5. Discussion

For the EU-15 countries, we found a significant and robust effect of a well-established corruption measure on the realized unbundling regime: countries that are more corrupt are more likely to have chosen weaker unbundling regimes than seems desirable. The fact that politicians that are likely to be more corrupt allow less unbundling is an indication that less unbundling is indeed a way to grant VIUs higher rents.[119] It also suggests that the choice EU law provides – a choice not suggested by economic theory – might be the result of a legislative process that has been compromised through questionable means of persuasion.

Our result adds empirical evidence to a literature that casts doubt on the wisdom of allowing a weak unbundling regime which facilitates the continuing existence of large utilities that are effectively still integrated. Our result suggests specifically that the questionable practices of persuasion that were uncovered in the Netherlands (and that we discussed in section 2) may be systemic; our result also suggests that VIUs in countries that are more corrupt might use -- apart from legal lobbying channels and questionable (but not illegal) practices -- illegal means to further their interests.

[119] Indeed, as we document in section A.2 in the Appendix, less unbundling seems to lead to more rents available to VIUs, both for EU-15 countries and the NMS-10.

The analysis which focused only on the NMS-10 shows a weaker but statistically significant effect in the opposite direction. We conjecture that countries in the NMS-10 sample reported early adoption of formal EU requirements as a cheap means to increase their chances to be judged eligible for accession into the EU. This strategy should be especially attractive for corrupt countries, for which it is costly to implement other EU requirements such as curbing anticompetitive practices and governmental corruption. The case of Latvia seems to provide a good illustration.

6. References

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7. Appendix

A.1 Robustness tests (see footnotes 106 and 44)

In this section, we report on a variety of tests we performed to understand the robustness of our results. We performed robustness tests for the observations that reported a mixed transmission unbundling regime and for contradictory data on Latvia. All tests supported the results reported in the body of the text.

1. Mixed transmission unbundling regime

To assess whether the removal of observations that report a mixed transmission unbundling regime - Legal/Management (L/M) for Ireland and Greece and Ownership/Legal (O/L) for Italy – affects the results in model 1, we did three robustness tests. [121] In the first test, we included the mixed regimes as ordered categories; for example L/M is more unbundled than Management unbundling, but less than Legal unbundling. This resulted in seven categories. The second test assigned the lower unbundling regime to each combination e.g. L/M becomes Management unbundling. The third test assigned the higher unbundling regime to each combination e.g. L/M became Legal unbundling. In all tests the significance of the coefficient of *CPI* was virtually unaffected ($p<0.001$).

Our regressions in Table 2 did not include observations for which a mixed transmission unbundling regime was reported - Legal/Management (L/M) for Ireland and Greece and Ownership/Legal (O/L) for Italy (six observations in total). As a robustness test we included the mixed regimes as ordered categories; for example L/M is more unbundled than Management unbundling, but less than Legal unbundling. The significance of *CPI* increased strongly to $p<0.000$. Also, the effect on the significance of the jackknife test,

[120] At the time of writing the authors, most likely because of the turmoil caused by their compromised independence, did not allow the final version of the report to be downloaded anymore. The paper is available at our website http://home.cerge-ei.cz/svk/Unbundling&Corruption.

[121] As Ireland and Greece belong to EU-15, the results for the NMS-10 are unaffected.

excluding a specific country, diminished drastically; the significance of *CPI* was never higher than $p<0.001$.

2. Contradictory data on Latvia

In the DG Tren reports the unbundling regime of Latvia is classified as accounting unbundling in 2003, and as legal unbundling before 2002 and after 2004 and 2005 (Commission of the European Communities, 2002, 2003, 2004, 2005). The (Latvian) Public Utilities Regulation Commission (2005) indicates that Latvia implemented legal unbundling only in 2005 and had accounting unbundling up to 2004. For consistency, we use the classification officially reported by the Commission of the European Communities. However, we ran a robustness check with the data from the (Latvian) Public Utilities Regulation Commission (2005). In this check, the significance of the coefficients of *CPI* was essentially unaffected.

A.2 Rents from unbundling (see footnote 119)

In this section, we report an additional test we performed to verify our results. Specifically, we tested for the effect of unbundling on rents available to VIUs. We conjectured that less unbundling leads to more rents available to VIUs. Our conjecture was confirmed both for the EU-15 countries and the NMS-10.

To measure the rent from less unbundling,[122] we considered the industrial electricity price relative to the domestic electricity price. We expected this indicator to be lower for countries with more rigorously unbundled transmission networks, both for EU-15 countries and the NMS-10. Industrial consumers have more bargaining power than domestic consumers and therefore profit more from rigorous unbundling, which lowers the value of the indicator.[123] A higher indicator value therefore reflects the stronger bargaining position of VIUs thanks to their control over transmission and can be used as a proxy for rents captured by the VIU. We therefore expected the regression of the indicator on the unbundling system (and controlling variables) to show a negative effect. Indeed for

[122] We thank Libor Dusek for his suggestion.

[123] Steiner (2001) states that industrial consumers are larger – they have the scale to contract their own generator or access spot markets – and therefore have more elastic demand.

the EU-15 countries and the NMS-10 together the regression showed as expected a robust negative and significant effect ($p<0.01$). When running separate regressions for the EU-15 countries and the NMS-10 the effects are, as expected, for both sets of countries negative, but — probably due to a lower number of observations — not significant ($p< 0.148$ for EU-15 countries and $p<0.268$ for the NMS-10).

A.3 Effect of the CPI by year (see footnote 115)

In our analysis we found that the effect of *CPI* on unbundling is opposite to the effect in EU-15 countries; more corrupt countries in the NMS-10 sample tend to implement (or at least report) more rigorous transmission unbundling. Our conjecture was that the strong pressure on the NMS-10 to show clear signs of reform in order to be eligible for EU membership motivated the more corrupt countries in the NMS-10 group to misreport, thereby reversing the effect of *CPI* on unbundling regime. As the rationale for misreporting was eliminated once the NMS-10 had acceded the EU in 2004, we hypothesized that, for the NMS-10, the effect of the CPI is not constant over time. In contrast, we hypothesized that the effect of the CPI is constant over time for the EU-15 countries. Our hypotheses were confirmed.

In order to understand the effect of the CPI for each individual year we created interaction variables $CPI^* t_i$ ($1\leq i \leq 6$) by multiplying the variable *CPI* with a dummy for each year. Model 1 in Table A1 shows that for the EU-15 countries all interaction variables $CPI^* t_i$ ($1\leq i \leq 6$) are positive and highly significant. Model 3 shows that for the NMS-10 the effect of the interaction variables $CPI^* t_i$ ($2\leq i \leq 5$) are negative in all years, and highly significant in the period 2002-2004, weakly significant in 2005, and insignificant in 2006.

To test whether the effect of *CPI* varies significantly with time, we ran a regression in which we restricted the effect to be the same in every year by collapsing the interaction variables $CPI^* t_i$ ($1\leq i \leq 6$) into the single variable *CPI*. The resulting coefficients for *CPI* and *T* are reported in model 2 and model 4 for the EU-15 countries and the NMS-10, respectively. We found, by performing LR-tests (Long and Freese, 2001, p.146) that this restriction does not significantly ($p<0.5795$) decrease the log likelihood of the regression for the EU-15 countries. This is not true for the NMS-10; such a restriction significantly (p<0.0059) decreases the log likelihood of the regression. We conclude that while the effect of the CPI is the same in every year for the EU-15 countries, it is different over time for the NMS-10, thus confirming our hypotheses.

Table A1: regression models

	EU-15 countries (old member states)		NMS-10 (new member states)	
Variables	Model 1[124]	Model 2[124]	Model 2[125]	Model 4[125]
*CPI * t1*	3.36*** (0.73)			
*CPI * t2*	3.15*** (0.72)		-3.89** (1.51)	
*CPI * t3*	2.82*** (0.72)		-4.18*** (1.43)	
*CPI * t4*	2.77*** (0.73)		-3.44*** (1.21)	
*CPI * t5*	2.61*** (0.80)		-1.76* (0.96)	
*CPI * t6*	2.40*** (0.90)		-1.52 (1.02)	
CPI		2.55*** (0.74)		-1.63*** (0.43)
T	2.57*** (0.76)	1.04*** (0.26)	-0.55 (2.00)	1.55*** (0.44)
N	83 (15 clusters)	83 (15 clusters)	40 (8 clusters)	40 (8 clusters)

*** Significant at the 1% confidence level
** Significant at the 5% confidence level
* Significant at the 10% confidence level
() Robust standard errors within parentheses

A.4 Overview of the sources used to determine the transmission unbundling regime (see footnote 96)

Official EU Sources		Remarks
2001	First DG Tren report (Commission of the European Communities, 2001)	• The observation on Luxemburg is missing. • Does not contain data on the NMS-10.

[124] For the observations on the EU-15 countries, we used the control variables that showed up significant in our main analysis in model 1: *GDP_pc* and *NetImport_Gen*. Their coefficients do not differ significantly from the results reported in the main analysis in model 1, and therefore we do not report them here.

[125] For the observations on the NMS-10, we used the control variables that showed up significant in our main analysis in model 3: *GDP_pc*, *GDP*, and *NetImport_Gen*. The coefficients do not differ significantly from the results reported in the main analysis in model 1, and therefore we do not report them here.

2002	Second DG Tren report (Commission of the European Communities, 2002),	• For the EU-15 countries member states, two observations are categorized as a mix of functional and legal unbundling and one observation as a mix of legal and ownership unbundling; these observations are omitted from Table 1. We did, however, do various robustness tests including these data; they are reported in section A1 in the Appendix.
2003	In the Third DG Tren report (Commission of the European Communities, 2004)	• For the EU-15 countries member states, two observations are categorized as a mix of functional and legal unbundling and one observation as a mix of legal and ownership unbundling; these observations are omitted from Table 1. We did, however, do various robustness tests including these data; they are reported in section A1 in the Appendix.
2004	Report on Progress in Creating the Internal Gas and Electricity Market, Technical Annex (Commission of the European Communities, 05.01.2005).	
2005	Report on progress in creating the Internal Gas and Electricity Market (Commission of the European Communities, 05.11.2005).	
2006	Report on Progress in Creating the Internal Gas and Electricity Market. (Commission of the European Communities, 15.04.2008)	• Observation on Cyprus 2006 is not reported unambiguously.
Additional sources		Remarks
	Malta Resources Authority (2005), p.3.	• Observations on Malta for 2001-2005.
	Cyprus Energy Regulatory Authority (2005), p.15.	• Observations on Cyprus for 2002-2005.
	The (Latvian) Public Utilities Regulation Commission (2005)	• Used for a robustness check of a possible mistake in the official EU data
	CYPRUS – Internal Market Fact Sheet. January 2007 (http://ec.europa.eu/energy/energy_policy/	• Observation on Cyprus 2006

doc/factsheets/market/market_cy_en.pdf)

The construction of *HHI_med;* a proxy of HHI (see footnote 102). This section is will be published on our website http://home.cerge-ei.cz/svk/Unbundling&Corruption.

In his section we give a detailed account of how we constructed *HHI_med*, which we use as a proxy for the HHI. We created *HHI_med* by using data on the market share of the largest generator (variable *ms1*) and of the largest 3 generators (variable *ms3*). From these data we first reconstructed an upper (HHI_high) and a lower (HHI_low) bound of the HHI consistent with the reported values for *ms1* and *ms3*. We then calculated our proxy as

$$HHI\_med = \left(\frac{\sqrt{HHI\_high} + \sqrt{HHI\_low}}{2} \right)^2 .$$

Derivation

For easier explanation we let the difference between *ms1* and *ms3* be given by $r = ms3 - ms1$. The HHI is given by the following formula:

$$HHI = f(a,b,c,d_i) = a^2 + b^2 + c^2 + \sum_i d_i^2 ,$$

with restrictions:

1. $a \geq b \geq c \geq d_1$ and $\forall i, j \in \mathrm{N} : i > j \Rightarrow d_i \geq d_j$,

2. $a = ms1$ and $a + b + c = ms3$,

where a, b, c, and d_i are market shares the largest firms in the industry

The first restriction — without loss of generality — orders the terms in *f* from larger to smaller. The second restriction is given by the data we have on market shares: the first element is equal to the measured market share of the largest generator (*ms1*), and the first three elements together are equal to the market share of the three largest generators (*ms3*).

Given values of *ms1* and *ms3*, the lowest possible value that the HHI can take is

$$HHI\_low = \underset{b,c,d_i}{MIN}\ f(a,b,c,d_i)$$

$$= ms1^2 + \left(\frac{r}{2}\right)^2 + \left(\frac{r}{2}\right)^2 + \lim_{x\to\infty}\sum_{1}^{x}\left(\frac{100-ms3}{x}\right)^2 = ms1^2 + 2\left(\frac{r}{2}\right)^2.$$

The share $r = ms3 - ms1$ is divided equally between the second largest and the third largest generator, which minimizes the addition to the HHI. The remaining share *e* is spread over an infinite number of firms, thus adding zero to the HHI.

Given values of *ms1* and *ms3*, the highest possible value that the HHI could take is

$$HHI\_high = \underset{b,c,d_i}{MAX}\ f(a,b,c,d_i) = \underset{b,c,d_i}{MAX}\ a^2 + b^2 + c^2 + \sum_i d_i^2 .$$

with restrictions:

1. $a \geq b \geq c \geq d_1$ and $\forall i, j \in \mathrm{N} : i > j \Rightarrow d_i \geq d_j$,
2. $a = ms1$ and $a + b + c = ms3$.

To simplify the maximization problem, we define a function $g(\cdot)$ with

$$g(a,b,c) = a^2 + b^2 + c^2 + INT(\frac{100-ms3}{c})c^2 + \left(DEC(\frac{100-ms3}{c})c\right)^2 .$$

The function $g(\cdot)$ is equal to the function $f(\cdot)$ with additional constraints, thus $MAX\ g(\cdot) \leq MAX\ f(\cdot)$. Also, we now shown that under restrictions 1 and 2, $g(a,b,c) \geq f(a,b,c,d)$. If the market share of the third largest generator, *c*, is equal to zero, then — because of restriction 1 — $\forall i \in \mathrm{N} : d_i = 0$ and thus $g(\cdot) = f(\cdot)$. If *c* is larger than zero, then the HHI is maximized by having the fourth generator have a market share as large as possible without violating restriction 1, hence $d_1 = c$. For the same reason we would assign the market share *c* to generator number five, six, and so on. The exact number of generators that, in addition to the third largest generator) can have a market share equal to *c* is given by the integer part of the remaining market share, $100 - ms3$, divided by the size of the market share *c*. The above formula captures this with the expression $INT(\frac{100-ms3}{c})$. The HHI is maximized by giving one firm the remaining market share. The remaining market share is given by c times the decimal part of the remaining market share, e, divided by the market share c. The above formula captures this with the last expression, $\left(DEC(\frac{100-ms3}{c})c\right)^2$ (note that $DEC(\frac{100-ms3}{c})\cdot c < 1\cdot c = c$, thus respecting restriction 1). As $g(\cdot) \geq f(\cdot)$ it follows that $MAX\ g(\cdot) \geq MAX\ f(\cdot)$, and as also $MAX\ g(\cdot) \leq MAX\ f(\cdot)$, this establishes that $MAX\ g(\cdot) = MAX\ f(\cdot)$. To find the maximum of f, it is sufficient to find the maximum of g.

To maximize $g(a,b,c)$ we first substitute for a and b in g from the second constraint and then differentiate g twice. We find that $\frac{d^2 g(ms1, b(c), c)}{(dc)^2} = 4$; hence g has a global minimum. A constrained maximum can thus be found as a corner solution; either with c assuming the lowest possible value $c = 0$, and thus $b = r$ or the highest possible value $c = b = \frac{1}{2}r$.

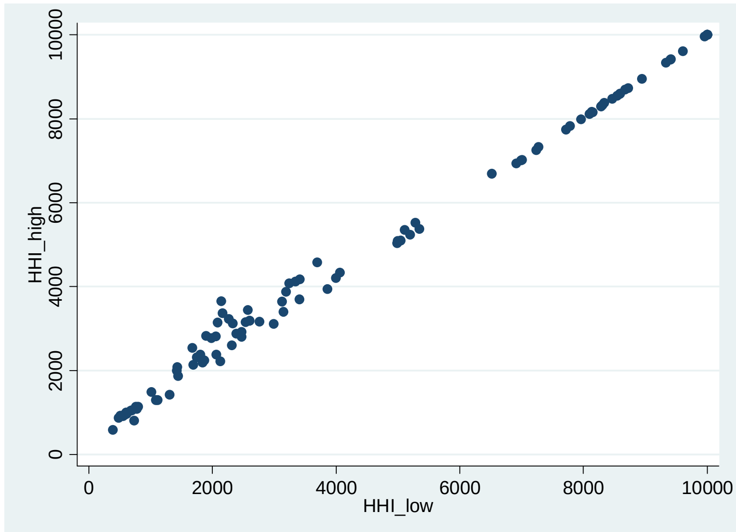
Hence the maximum is reached at one of the following two points:
$HHI\_high1 = ms1^2 + r^2 + 0^2$ or

$$HHI\_high2 = ms1^2 + \left(\frac{r}{2}\right)^2 + \left(\frac{r}{2}\right)^2 + INT\left(\frac{100-ms3}{\left(\frac{r}{2}\right)}\right)\left(\frac{r}{2}\right)^2 + \left[DEC\left(\frac{100-ms3}{\left(\frac{r}{2}\right)}\right)\left(\frac{r}{2}\right)\right]^2.$$

We calculate the upper bound on the HHI as
$HHI\_high = MAX(HHI\_high1, HHI\_high2)$.

In our data the average *HHI_high* is only 2.3% higher than the average *HHI_low*, and the correlation between *HHI_high* and *HHI_low* is 0.997. Indeed Figure A1 gives a plot of *HHI_high* against *HHI_low* for all observations in our data and shows that these numbers are remarkably close. Rerunning our main regressions we indeed find virtually no difference using either *HHI_high* or *HHI_low*.

Figure A1: *HHI_high* against *HHI_low*



We construct our proxy *HHI_med* as a generalized average of the upper and lower bound on the HHI:

$$HHI\_med = \left(\frac{\sqrt{HHI\_high} + \sqrt{HHI\_low}}{2} \right)^2.$$

We believe this is a good proxy for the true HHI. Firstly, the upper and lower bounds on the HHI are very close. Secondly, a linear regression of *HHI_med* on the market share of the largest and the three largest generators and a constant explains 97% of all variation. Thirdly, running our main regressions with either *HHI_med*, *HHI_high* or *HHI_low* basically makes no difference.

An example

The average market share of the largest generator is equal to *ms1*= 62 (rounded) and the average market share of the largest three generators is equal to *ms3*=71 (rounded). Thus $r = ms3 - ms1 = 71\text{-}62 = 9$, and $100 - ms3 = 100\text{-}71 = 29$

Then the lower bound on the HHI is given by:

$HHI\_low = 62^2 + 4.5^2 + 4.5^2 = 4136.5$.

The possible upper bounds on the HHI are given by:

$$HHI\_high1 = 62^2 + 9^2 = 4177$$

$$HHI\_high2 = 62^2 + 4.5^2 + 4.5^2 + INT\left(\tfrac{29}{4.5}\right)\cdot 4.5^2 + \left(DEC\left(\tfrac{29}{4.5}\right)\cdot 4.5\right)^2$$

$$= 62^2 + 4.5^2 + 4.5^2 + 6\cdot 4.5^2 + \left(\tfrac{4}{9}\cdot 4.5\right)^2 = 4262\,.$$

And thus $HHI\_high = MAX(4177, 4262) = 4262$.

We see that high numbers for *ms1* and *ms3* put strong restrictions on the possible upper and lower bounds of the true HHI; $\dfrac{HHI\_high}{HHI\_low} = \dfrac{4262}{4136.5} = 1.03$

The value of the proxy is:

$$HHI\_med = \left(\frac{\sqrt{HHI\_high} + \sqrt{HHI\_low}}{2}\right)^2 \qquad = \left(\frac{\sqrt{4262} + \sqrt{4136.5}}{2}\right)^2 = 4199$$

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A list of all the variables

Variable	(Constructed from)	Date of extraction
CPI	http://www.transparency.org	-
GDP_fixed1995	Eurostat GDP and main components - Constant prices, *b1gm* Gross domestic product at market prices, *mio_eur_kp95* Millions of euro (at 1995 prices and exchange rates)	Date of extraction: Mon, 17 Sep 07 02:17:19
GDP_pc_fixed1995	Eurostat GDP and main components - Constant prices, *b1gm* Gross domestic product at market prices, *eur_hab_kp95* Euro per inhabitant (at 1995 prices and exchange rates)	Date of extraction: Mon, 17 Sep 07 02:17:19
GDP_pc_pps	Eurostat: Gross domestic product at market prices – At current prices PPS per inhabitant	Date of extraction: 15.05.2008
GDP_pps	Eurostat: Gross domestic product at market prices - At current prices Millions of PPS	Date of extraction: 15.05.2008
GEG	Eurostat: Total gross electricity generation *107000* Total gross electricity generation *gwh* Gigawatt hour *6000* Electrical Energy	Date of extraction: Sun, 30 Mar 08 09:12:53
MS3LG	DG Tren Reports Market share of the largest 3 generator	-

MSLG	Eurostat Market share of the largest generator in the electricity market	Date of extraction: Fri, 4 Apr 08 05:47:28
Netimport/net generation	Eurostat Net imports (Eurostat code: 100600)	Date of extraction: Tue, 13 May 08 09:47:42
	Eurostat total net electricity generation (Eurostat code:107100)	Date of extraction: Tue, 13 May 08 09:47:42
PIndHous (Industrial prices/ household prices)	Eurostat Electricity prices - industrial users	Date of extraction: Mon, 19 May 08
	Eurostat Electricity prices - households	Date of extraction: Mon, 19 May 08
Tunbund	See the "Overview of the sources used to determine the transmission unbundling regime"	-
WDLpT	Eurostat Working days lost per 1000 workers by economic activity (NACE) - available country results	Date of extraction: Fri, 4 Apr 08 05:44:30

Glossary

Account unbundling	See unbundling, Account.
Auction	A formal and organized procedure to sell a good to several buyers. In a standard auction the highest bidder wins the auction.
Common value	Each buyer has an identical value for the good on auction. *(only paper 1)*
First-price	The highest bidder wins the auction and pays his bid.
Imperfect information	The value the good on auction has for a buyer is known only to himself, and not to anyone else.
Perfect information	The value the good on auction has for a buyer is common knowledge to all participating buyers. *(only paper 1)*
Private value	Each buyer has an independent valuation of the good on auction.
Second-price	The highest bidder wins the auction and pays the second highest bid.
Cost weight	The manager receives a financial remuneration that is equal to the revenue minus a proportion of the cost. I refer to this proportion of the cost as the cost weight. *(only paper 2)*
Compensation scheme	The manager receives a financial remuneration that is equal to an affine combination of revenues and profits. This can be shown to be equal to the profit minus a proportion of the cost. *(only paper 2)*
Distribution	The transport of electricity over short distance, usually by low voltage lines.
Generation	The production of electricity.
Holding company	Here used for a VIU that is legally unbundled.
Independent buyer	A generator that competes in an auction to buy a good and who is independent; not owned by a VIU that owns the seller in the same auction.
Integrated buyer	A generator that competes in an auction to buy a good and who is owned by a VIU that owns the seller in the same auction.
Integrated seller	A seller that sells a good in the auction who is owned by a VIU that owns a buyer (the integrated buyer) that bids in the same auction.
Interconnector	Cross-border transmission line in the EU.
Legal unbundling	See unbundling, Legal.

Management unbundling	See unbundling, Management.
Ownership unbundling	See unbundling, Ownership.
Ownership share γ	The share of the seller that the VIU owns. It is the proportion for which the VIU is residual claimant.
OBK-scheme	Own-Bid-Kickback scheme. The compensation scheme that a VIU offers to the manager of its legally unbundled generator. This scheme gives the manager effectively a discount on his bid when he wins. *(only paper 2)*
Procurement auction	An auction where a buyer in an auction sells, in the form of a sales contract, the right to supply him with a good.
Unbundling,	The separation of activities to lower the degree of vertically integration of a firm, i.e. a VIU.
Account	The VIU must have separate accounts for its network and generation activities. *(only paper 3)*
Complete legal unbundling	The network and generation activities must each be incorporated in companies that are legally independent from the VIU. *(only paper 2)*
Management	The VIU must have separate teams and management for operating its network and generation activities. Also called functional unbundling. *(only paper 3)*
Legal	The network activities must be incorporated in a company that is legally independent from the VIU.
Ownership	One company may not have ownership of both network and generation companies.
Toehold auction	An auction where a company that wants to take over another company (the target) already owns a proportion of the shares of the target company. *(only paper 1)*
Transmission	The transport of electricity over long distance, usually by high voltage lines.
Vertical Integrated Utility	An electricity company that owns generation and network activities (distribution or transmission).
VIU	See Vertical Integrated Utility.