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Abstract

In most liberalized electricity markets, abuse of market power is a concern related to oligopolistic market structures, flaws in market architecture, and the specific characteristics of electricity generation and demand. Several methods have been suggested to improve the competitiveness of the liberalized electricity markets and to reallocate rents from generators to consumers. In this paper we study to what extend divestitures can improve the competitiveness of the electricity market. We quantify the expected developments under different divestiture scenarios for the German market, using Cournot and Supply Function Equilibrium simulations. We find an overall welfare gain in both models and show that those gains are highest if the divested assets are sold to independent and small firms, preventing the formation of additional firms that set prices strategically.

JEL: L94, L13, C72, D43

Keywords: Supply Function Equilibrium, Cournot competition, electricity markets, divestitures

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1 Introduction

Liberalized electricity markets are frequently subject to market power concerns due to an oftentimes oligopolistic market structure, flaws in market architecture, and specific characteristic of electricity like highly inelastic final demand. Most European markets show a high degree of concentration and the lack of sufficient cross border transmission capacities makes most markets national in nature (London Economics, 2007). In the light of this situation the European Commission is concerned about the future competitiveness[2] and there is an ongoing debate what measures are needed and reasonable to address these concerns. The German electricity market is no exception: the current wholesale market is dominated by four companies owning about 80% of conventional power plant capacity. Furthermore, the German Cartel Office classifies as dominant the duopoly consisting of E.ON and RWE with about 60% of generation (Bundeskartellamt, 2006).[3] This claim is opposed by E.ON showing that their position reduced in recent years and the duopoly now only accounts for 40% of the market (E.ON, 2010). However, due to significant electricity price increases in the last years, a debate about potential market power abuse and structural remedies has emerged in Germany (Weigt and Hirschhausen, 2008).

One possible remedy to address market power and competition concerns is the divestiture of generation assets of dominant firms to increase the number of market participants. From a political and legal point of view divestitures are considered a "hard" instrument compared to other possible measures like market monitoring or fostering market entry, as legal barriers are typically high, a revision of the divestiture is not possible, and consequently opposition by firms is high. Nevertheless, divestitures have been applied to increase or retain competition in merger cases (Hirschhausen et al., 2007). In Germany the possibility of divesting companies due to abuse of dominance is not included into the competition law but was proposed so by the Hessian Ministry of Economics (2007); more recently, the German Economics Ministry even prepared a law based on the idea (which was rejected by one of the ruling parties, though). However, the European Commission required E.ON to divest about 5 GW of generation assets to address concerns of the abuse of a dominant market position in the wholesale market (case COMP/39.388) under Article 102 of the Treaty on the Functioning of the European Union (TFEU).

In this paper we analyze the impact of divestiture on dominant firms in the German electricity market. We apply two different model types to simulate strategic company behavior: Cournot and Supply Function models. We simulate the expected market outcome under several divestitures scenarios. Both models are calibrated to the observed market data and the current market structure as in Willems et al. (2009). The amount of contracts that firms sign (which is not observed) is used as a calibration parameter. We then change the market structure and predict the market outcome under the assumption

[2] See: Communication from the Commission - Inquiry pursuant to Article 17 of Regulation (EC) No 1/2003 into the European gas and electricity sectors (Final Report) {SEC(2006) 1724}.

[3] According to the German Law Against Restraints on Competition two companies are assumed to have a dominant market position if they have a joint share of at least 50% of the relevant market (§ 19 Abs. 1 GWB).

that the amount of contracts remains constant. Two divestiture scenarios are tested: First the divested assets are assumed to be bought by new market participants (e.g. foreign firms or large utilities) increasing the total number of strategic players from four to six (*six firm case*). Second, the assets are assumed to be bought by fringe companies (e.g. several smaller companies or non-energy stakeholders), thus increasing the market share of price taking companies (*large fringe case*). The results of both the Cournot and SFE model are compared to test the robustness of the forecasts.

The remainder of our paper is structured as follows: in the next section a literature review on competition policy and divestiture in electricity markets is provided. In Section 3 the implementation of the models and the underlying assumptions are described. Section 4 presents the scenarios and discusses the simulation results. Section 5 closes with a summary and our conclusions about the potential impacts of divestitures in the German electricity market.

2 Literature Review

One of the possible tools to increase the competitiveness of oligopolistic electricity markets is the divestiture of existing generation capacities to increase the number of market participants. Particularly in the US, antitrust and merger divestitures are a common tool, and competition authorities can base their action on a significant body of experience and analytical work (e.g., see FTC, 1999). Under European legislation, divestitures used to be limited to merger control under the EC Merger Regulation (e.g., see EC, 2005). Willis and Hughes (2008) provide a legal viewpoint on the issue of structural remedies in the circumstances of energy merger cases and Lévêque (2007) reviews the experiences within Europe with merger based remedies. With EC Regulation 1/2003 structural remedies have been extended to cases under Article 101 and 102 including cases against E.ON related to the wholesale and balancing market (see Chauve et al. 2009), against RWE related to a possible foreclosure its natural gas network (see Koch et al., 2009), and a case against ENI in the natural gas market (COMP/39.315).

One further exception to merger based divestitures in the EU is the liberalization of the British electricity market where it was applied for competitive purposes without involving a merger or acquisition (Sweeting, 2007).

Several studies analyze and summarize experiences with competition policy, merger cases, and divestitures in liberalized markets. Hirschhausen et al. (2007) give an overview of international experiences with divestiture in energy markets in the US and in Europe focusing on both merger cases and “pure” divestitures. Practical experiences with divestiture in electricity markets can be drawn from the UK and from California. In the former case divestiture has been applied twice in order to improve the competitiveness of the market (Sweeting, 2007). Newbery and Pollitt (1997), Pollitt and Domah (2001) and Littlechild (2006) provide empirical evidence on the positive effects of restructuring on efficiency and welfare. In California divestiture was applied to reduce the market power potentials for the incumbents and increase the number of marker participants. Although, the divestiture resulted in

an HHI below 1000 (Blumstein et al. 2002), the liberalization failed due to flaws in the market architecture and the lack of vertical integration between retailers and producers (Bushnell et al., 2008). Wolak and McRae (2008) discuss the remedies imposed in a US merger case between Exelon and PSEG including divestiture of assets with low opportunity costs.

In the course of the European liberalization several countries have applied "virtual" divestitures to cope with competition concerns. Virtual divestiture refers to a spin-off of generation capacities of an incumbent without changing the property right structure of these facilities. Thus, the divestiture is a mere financial transaction, not a physical one.[4] The advantage of virtual divestitures can be seen in the possibility to withdraw the measure after a certain time, or to continue if the desired outcome has not been accomplished. We will not discuss those virtual divestitures in our paper.

Several studies address pre- and post-divestiture states in electricity markets via modeling approaches or empirical analyses. Green and Newbery (1992) are among the first to use SFE for electricity market analysis. They compare the duopoly of National Power and PowerGen in the British market with a hypothetical five firm oligopoly, concluding that the latter results in a range of supply functions closer to marginal costs. Green (1996) applies the SFE approach to analyze the divestiture decision in 1994, when National Power and PowerGen had to dispose 15% of their capacity, comparing this decision to a more stringent restructuring into five firms and the impact of new investments. He concludes that although a drastic splitting of the generators would have had the greatest effect, the political infeasibility makes the conducted divestiture a valid and effective option. Brunekreeft (2001) applies a multiple-unit, multiple-period auction approach to analyze the British electricity pool. He shows that decreasing (increasing) the number of firms in the market increases (decreases) both the bids and the markups as larger firms have little incentives to undercut the preceding bids and thus raise the system marginal price. Day and Bunn (2001) apply a computational modeling approach to the second round of capacity divestiture in the liberalized electricity market of England and Wales in 1999. They conclude that although the divestiture was substantial, it may still be insufficient to pave the way to a fully competitive market. Evans and Green (2005) apply an SFE model with symmetric firms with non-linear cost functions and a competitive fringe to analyze the British market before and after the introduction of NETA in March 2001. They show that the observed price reduction can not directly be explained by the introduction of NETA whereas the reduction of market concentration due to the divestiture of the two large generators and new power plants had a significant impact on wholesale prices.

Moselle et al. (2006) analyze the Dutch electricity market and design a Cournot model including a competitive fringe and forward contracts to test the divestiture requirement in the Nuon-Essent merger case. They show that although the Commission's guidelines (relying on HHI indices) are already fulfilled with a divestiture of 1900 MW, a total of 4200 MW is necessary if one wants to avoid the merged firm to remain pivotal. Ishii and Yan (2006) analyze the impact of imposed divestitures within

the restructuring process in US electricity markets on new power plant investments. Based on observations between 1996 and 2000, they develop a net present value model estimating the expected profit of investment with and without divestiture opportunities to determine whether divestitures "crowded out" new investment projects. They conclude that divestitures crowded out on average only 177 MW of new capacity, which is low compared to the 70 GW divested and 60 GW invested generation capacity between 1996 and 2000.

Federico and López (2009) study divestitures in electricity markets in a setting with a dominant firm and a competitive fringe. They show that the divestment of units that are price setting before the divestiture are the most efficient divestment option in terms of price reduction.

Rahimiyan and Mashhadi (2010) evaluate the efficiency of divestitures in electricity markets using (1) an analytic model to determine the market concentration (measured as the Herfindahl-Hirschman Index) respecting the actual dispatch and network capacity restrictions and (2) an agent-based model adjusting the bidding behavior of agents via learning. The first method provides a range of possible market concentrations correlated to specific dispatch conditions and can be applied even if no detailed cost data is available. Additionally the second method provides an impact assessment of local market power. Tanaka (2009) analyzes the Japanese electricity market using a transmission constrained Cournot model. Besides simulating the impact of upgrading the existing bottlenecks within the network he also simulates the divestiture of the largest electricity company into two to four companies. Those cases lead to a significant reduction in deadweight welfare loss and a more efficient use of existing network capacities reducing the need for upgrades. In a Cournot setting Vasconcelos (2007) analyzes the connection between efficiency gains of mergers and structural remedies imposed by the antitrust authority who is actively aiming at maximizing consumer surplus. He shows that divestitures create new merger possibilities and the authority tends to over-fix the amount of divestiture and thus tries to obtain a more competitive market after the divestiture than before. Leveque (2006) argues on the other hand that the antitrust authorities should do more than restoring the ex-ante situation but considers it still an open question to what extend antitrust enforcement is needed in Europe's electricity and natural gas markets.

3 Model formulation, data and calibration

We will apply both Cournot and SFE models in our simulations. In earlier work (Willems et al., 2009) we show that with the publically available data, it is impossible to determine empirically which type of model (Cournot or SFE) better reflects the current market situation in Germany. In order to obtain robust predictions we implement both models.

[4] Virtual divestitures (Willems, 2006) have been applied or considered as measurement in the merger case for instance in the proposed Nuon-Essent merger in the Netherlands, for a vertical merger by Electrabel in Belgium, for the allowance of EDF to acquire EnBW shares, and in a merger case involving CEZ in the Czech Republic,

3.1 Reference Model

A pre-divestiture benchmark is needed prior to testing the impact of divestitures on the German electricity market. Therefore, the model structure presented in Willems et al. (2009) is extended beyond the first two months of 2006 to cover the complete year. The analysis looks at peak hours only, because strategic company behavior is more likely to occur in hours with high demand and tighter capacity situations, and secondly, the model structure with approximated cost functions and simplified market interactions is not well-suited to capture the unit commitment process determining pricing in off-peak periods.[5]

The residual German demand D during peak hours is assumed to be price inelastic, varying through time t, and with a random component ε:

$$D_t = \alpha_t - \varepsilon_t \tag{1}$$

Oligopolists face an elastic residual demand due to imports from neighboring countries. Imports Q_I are determined by the difference of the price p_G in Germany and the neighboring regions p_j by regressing:[6]

$$Q_{It} = \gamma_I p_{Gt} - \sum_n \gamma_n p_{nt} + \sum_z \mu_z \delta_{zt} + \varepsilon_{It} \tag{2}$$

Hourly price data is taken from energy exchanges in the Netherlands, France, Austria, Poland, Sweden, East Denmark and West Denmark. Imports Q_I are obtained from ETSOVista (2007). One import elasticity γ_I for the entire peak period in 2006 is calculated. The residual demand function for the oligopolists D^O rewrites to:

$$D_t^O = \alpha_t - \gamma_I p_{Gt} - \varepsilon_t \tag{3}$$

Equation (3) is transformed into a demand function with a specified set of demand realizations k:

$$D_k = \alpha - \gamma p_k - \Delta_k \tag{4}$$

The intercept of the demand level is chosen such that when the shock is zero, either 95% of the observations in the German market are below the demand function or a maximum price of 200 €/MWh is obtained.[7]

Marginal generation costs of each oligopolist are based on the each player's generation portfolio (VGE, 2006). Plant capacities are decreased by seasonal availability factors following Hoster (1996). Marginal cost functions are estimated for each month separately, based on the plants efficiency and monthly fuel prices calculated as the average monthly cross-border prices for gas, oil and coal from Bafa (2006). The step-wise marginal cost functions of the generators are simplified to a cubic function where the parameters of the function (λ) are found by minimizing the weighted squared difference of

[5] Due to ramping constraints, start-up restrictions, and start-up costs market prices during off-peak periods can fall below marginal generation costs (see Abrell et al., 2008).

[6] δ_z is a vector of time dummies (day of week) for all hours t in the peak period. A two-stage least squares estimator is used to address the endogeneity of the German price p_G with respect to imports. As instruments the total demand level in Germany and German wind production is used.

[7] The second condition became necessary as in July 2006 a large fraction of peak hours was exceptionally high resulting in unrealistic imports as the import estimation neglects transmission capacities.

the parameterized function and the true cost function subject to the condition that marginal cost should be upward sloping:

$$c_{ik} = \lambda_{i0} + \lambda_{i1} q_{ik} + \lambda_{i2} q_{ik}^{\ 2} + \lambda_{i3} q_{ik}^{\ 3} \tag{5}$$

Following Anderson and Hu (2008), the continuity of the bid supply function is imposed specifying a piece-wise linear supply function, with $0 < \xi_{ik} < 1$:

$$q_{ik+1} - q_{ik} = (p_{k+1} - p_k)\left[(1 - \xi_{ik})\beta_{ik} + \xi_{ik}\beta_{ik+1}\right] \tag{6}$$

The first order conditions of each player *i* for each demand shock *k* requiring that each player's marginal revenue and marginal cost be equal:

$$(q_{ik} - F_{ik})\frac{dp_{ik}^{R}}{dq_{ik}} = p_k - c_{ik} \tag{7}$$

with F_i as the amount of contracts signed in equilibrium by firm *i*, and $\frac{dp_{ik}^{R}}{dq_{ik}}$ as the slope of its inverse residual demand function. Firms are allowed to sign fixed-capacity contracts F_i specified as a quantity (in MW) depending on the contracting factor *f* and the installed capacity cap_i by firm *i*: $F_i = f \cdot cap_i$.

The pricing equation differs for the two models. In the Cournot equilibrium, each strategic player assumes the production of the other players as given, and therefore the slope of the residual inverse demand function depends only on the slope of the demand function (γ):

$$q_{ik} - F_i = (p_k - c_{ik})\gamma \qquad i \in \{\text{Strategic Firms}\} \tag{8}$$

For the SFE model, the slope of the residual demand function depends on the slope of the demand function and the slope of the supply functions of the competitors (β_j):

$$q_{ik} - F_i = (p_k - c_{ik})\left(\sum_{j \neq i} \beta_{jk} + \gamma\right) \qquad i \in \{\text{Strategic Firms}\} \tag{9}$$

Beside the import elasticity, oligopolists face competitive production by several smaller firms forming the so called competitive fringe. The pricing behavior of competitive firms guarantees that marginal costs are equal to the market clearing price:[8]

$$p_k - c_{ik} = 0 \qquad i \in \{\text{Competitive Firms}\} \tag{10}$$

The Cournot equilibrium is a solution of equations (4), (5), (8), (10) and a market clearing condition, and the SFE is a solution of equations (4), (5), (6), (9),(10) and a market clearing condition. The models are solved in GAMS using the CoinIpopt solver with a MATLAB interface to call up the GAMS code for different months and different contract covers f.

[8] In Willems et al. (2009) the fringe generator is assumed to be representable by a linear supply function, here we allow for a more flexible formulation.

3.2 Calibration

Given the underlying dataset of the German electricity market in 2006 the Cournot and SFE models are simulated varying the contract coverage f of the oligopolists from 0% up to 100% of their installed generation capacities. The four large oligopolists (EON; RWE, Vattenfall, and EnBW) are assumed to behave strategically while the remaining generation capacities are clustered in a fringe firm which is bidding competitively. The resulting supply curves are then analyzed to obtain the optimal contract cover f using the observed price-demand results at the EEX spot market as a benchmark:

$$\min_{f} \sum_{t} \left(P_t^{obs} - P_t^{\mathrm{mod}}(f) \right)^2 \qquad \text{Squared error mimization} \qquad (11)$$

with P_t^{obs} the observed prices at the EEX and $P_t^{\mathrm{mod}}(f)$ the modeled prices given the contract cover f *at period* t. The results are reported in Table 1. The Cournot model has on average a twice as high coverage than the SFE model. The optimal contract cover in 2006 for the Cournot model is 48% whereas the SFE model only has 22%. However, the variance of the SFE model is higher than Cournot model. The reason is that the results of the SFE-model are less sensitive to the contract factor, and hence the estimates for the contract factor are harder to calculate. Nevertheless, both models predict the observed market data reasonable well with an R^2 close to 0.8.

Given these calibrated values for 2006, divestiture cases will be calculated. In order to do so, we assume that the amount of contracts is constant. We are therefore likely to either underestimate or overestimate the results depending on the change in contracting after the divestiture. For Cournot models Bushnell (2007) shows the relation between the price mark-up and contracting. In a simple setting with constant marginal costs the impact of contracts on the markup is similar to squaring the number of firms in the market. A divestiture from 2 to 4 firms with endogenous contracts will have the same effect as increasing the number of firms from 2 to 16 in a situation with fixed contracts. The situation becomes more complex with non constant marginal costs (this requires numerical simulations as in Bushnell), risk aversion (which leads to higher contacting positions, Hughes, 1997), with multiple contracting rounds (with 2 contracting rounds, the introduction of contracts will have a similar effect as taking the cube of the number of firms), and (un)observability of contracting positions (contract unobservability reduces the strategic value of contract). Van Eijkel and Moraga-González (2009) analyze the impact of observability in a Cournot setting of a natural gas market. They show that in case of pure risk-hedging the level of contracts increases with the number of firms whereas in case of strategic incentives the impact varies with the observability. By contrast for SFE models the impact of contracts and the number of firms is unclear.

Given the difficulties in determining the level of contracts endogenously, we will, in our basic analysis, keep the contract level after the divestiture constant. Instead we will perform a sensitivity study of the results, by varying the contract levels. We simulate a range of possible market outcomes

by varying the contract position with one standard deviation from the contract positions from our regression.

Table 1: Optimal contract covers, pre-divestiture calibration, 2006

	Contract Cover	Variance	Std Dev Error	R^2	Number of Observations
Cournot	47.7	0.082	10.4	0.7888	4521
SFE	22.4	0.2401	10.9	0.7702	4521

Source: Own calculation

4 Scenarios, results and discussion

4.1 Scenarios

Given the pre-divesture results of 2006, two divestiture cases are modeled to obtain predictions for 2006 under different market structures. The first divestiture case (*6 Strategic Firms Case*) resembles a breaking up of the dominant duopoly of EON and RWE into four separate companies which each own a half of the pre-divested company, respectively. This divestiture could either be realized by forcing EON and RWE to split up their assets into separate companies (similar to unbundling) or to sell the separated companies to interested investors (e.g. foreign companies, or financial investors). The resulting market structure would be a six-firm oligopoly were each firm owns about 10GW generation capacity and thus has no more than 15% market share.

For the second divestiture case (*Large Fringe Case*) the duopoly of EON and RWE is also broken by forcing them to divest half of their capacities. However, the divested assets are sold to a lot of small companies and interested parties while enforcing that no buyer can obtain a significant market share. Thus, the divested plants become part of the competitive fringe and are no longer strategic companies. The resulting market structure would be a four-firm oligopoly like in the pre-divestiture case but with significantly reduced market shares (and an increase fringe size).

Table 2 summarizes the changes in market structure before and after divestiture. Thus the C_4 concentration ratio, based on installed capacity, would decrease from about 80% before to about 50% after the divestiture with no firm having a capacity share above 15%. The HHI index for the German market based on installed capacities is also decreasing from an uncompetitive level of 2150 before the divestiture to a level of 1050 in the *6 Firm Case* and to 700 in the *Large Fringe Case.* Thus the post-divested market should provide market outcomes close to the competitive levels.

Table 2: Concentration indicators: before and after divestitures

	Pre-divestiture	6 Firms	Large Fringe
C4	78%	54%	53%
HHI	2150	1050	700

The supply curves of the divested firms are obtained by splitting up the power plant portfolio of EON and RWE into two identical subsets which are then transformed into cubic cost functions following the methodology described in Section 2. This symmetric divestiture guarantees that the resulting firm cost curves add up exactly to the pre-divestiture oligopoly cost curve.

For both cases the monthly bidding curves are estimated using the calibrated contract cover to obtain hourly prices, overall welfare, and profit estimates. By keeping the contract factors constant, we may underestimate the effect of a divestiture, as divestitures would normally lead to an increase in the contract position. Afterwards two additional scenarios are simulated with a reduced and an increased contract coverage given by the obtained standard deviation for contracting in the calibration (see Table 1).

4.2 Results

As the divestitures increase the number of firms and reduce the market share of the strategic companies, prices decrease. With four oligopolists the German electricity market has a relatively "low" market concentration given the European context; thus, France and Belgium are dominated by a single firm. One could therefore conjecture that a further concentration reduction may only result in small price effects, particularly if the divested assets are bought by other strategic firms. The simulation results do not confirm this hypothesis. For both models the divestiture of EON and RWE significantly reduces the equilibrium supply curves. For high demand levels, the bids are partially lower, whereas for lower demand levels the changes are less pronounced. As expected, the Large Fringe case produces a more competitive outcome than the 6 Firm case. The divestitures bring the bid curves closer to the market's marginal costs curve (Figure 1).

Overall, the average peak prices can be reduced by about 6 €/MWh in the 6 Firm Case and by an additional 2 €/MWh in the Large Fringe Case which brings them significantly closer to the competitive level (Table 3). The lower prices lead to an increase in consumer surplus and a reduction of producer surplus. In sum the first effect exceeds the second leading to an overall welfare increase for Germany.[9] However, revenues for importers decline as both the amount they import as the price at which they sell, is reduced. Welfare abroad is therefore negatively affected by the divestitures. Combining German and foreign effects still leads to an overall welfare increase of about 200 million € per year. Although the German welfare increase in the Large Fringe case is higher, this is offset by a larger welfare reduction abroad leading to nearly similar overall welfare effects in both cases.

The difference between the Cournot and the SFE model are relatively small. Both models predict similar results for the effect of a change in market structure (Table 3).

[9] This is not obvious as production efficiency might be negatively impacted by the divestiture.

Figure 1: Cournot and SFE supply curves, January 2006

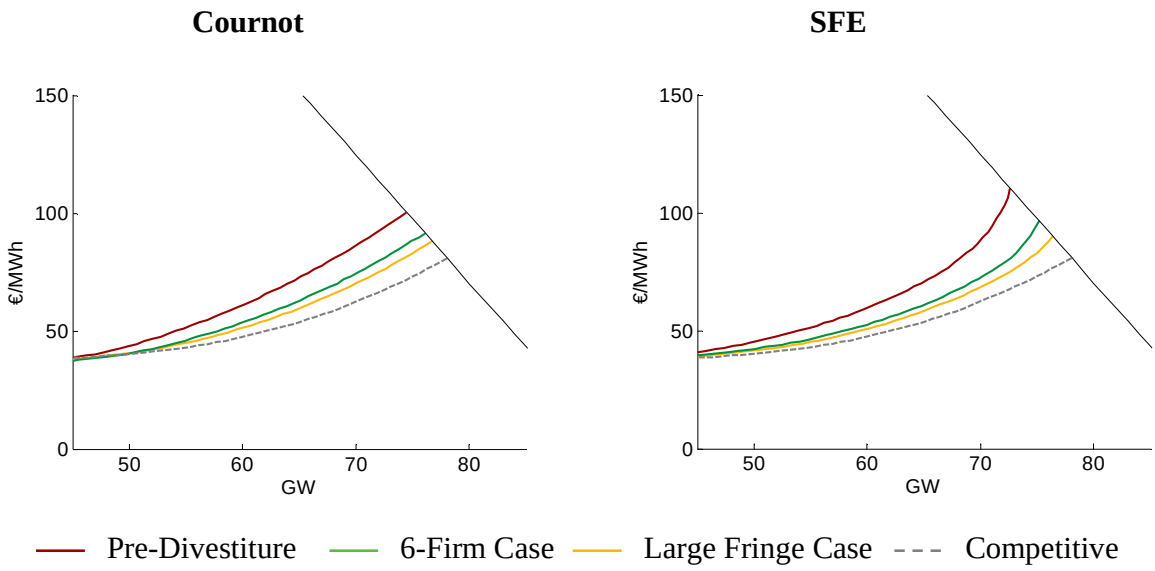

Table 3: Price and welfare results for peak hours compared to pre-divestiture, 2006

	Competitive	Pre-Divestiture		6 Firm		Large Fringe	
		(C)	(SFE)	(C)	(SFE)	(C)	(SFE)
Avg. peak price [€/MWh]	48.3	58.2	58.7	52.4 -10%	52.5 -11%	50.8 -13%	50.6 -14%
Avg. dom. generation [GW]	59.1	57.2	57.2	58.3 +1.9%	58.3 +1.9%	58.6 +2.4%	58.6 +2.4%
Avg. imports [GW]	8.9	10.7	10.8	9.6 -10%	9.6 -11%	9.3 -13%	9.3 -14%
Dom. consumer expenses [bn €/a]	15.32	18.60	18.77	16.71 -10%	16.74 -11%	16.16 -14%	16.08 -14%
Dom. producer surplus [bn €/a]	6.32	8.97	9.08	7.58 -16%	7.61 -16%	7.11 -21%	7.05 -22%
Dom. welfare gain [bn €/a]				0.50	0.56	0.58	0.66
Productive inefficiency [bn €/a][10]		0.076	0.083	0.033 -57%	0.019 -77%	0.026 -66%	0.018 -78%
Foreign welfare effect [bn €/a]				-0.29	-0.32	-0.37	-0.42
Total welfare effect [bn €/a]				+0.20	+0.23	+0.21	+0.24

Source: Own calculation

The estimations of the contract positions were subject to some uncertainty. The uncertainty was larger for SFEs than in the Cournot case, as contract positions have a smaller effect in the SFE model, and therefore harder to recover empirically. To test the sensitivity of our results to the contract position, we vary in a second part of the analysis the contract coverage with one standard deviation of our estimation quality. With a higher contract position the companies will bid more aggressively in the spot market leading to a further reduction of prices and corresponding surplus and quantity effects.

[10] Productive inefficiency is measured by comparing production costs in the Cournot/SFE solution with a competitive counterfactual industry supply the same level of domestic demand and the same level of export as in the divested oligopoly model. Note that this is a different simulation than the competitive scenario (where both demand and import levels are higher).

The opposite is true if the contract position decreases. Table 4 summarized the simulated results. For all cases the price reduction and surplus change directions of the divestiture remain stable. However, for the reduced contracting cases the differences to the pre-divestiture situation are significantly reduced. The resulting predictions show that price will drop from 58.2 to somewhere in the range between 48.5 and 56.6 in the 6 firm Cournot case with an approximate 60% certainty, and from 58.7 to in the range 50.9 to 54.4 in the 6 firm SFE model. In the Large Fringe case the upper price levels are further reduced whereas the lower boundary remains on a relatively similar level as in the 6 Firm case and is close to the competitive benchmark.

Table 4: Impact of varying contract coverage (+/-one standard deviation)

Scenario	6 Firm Case				Large Fringe Case			
Model	Cournot		SFE		Cournot		SFE	
Contracts	Less	More	Less	More	Less	More	Less	More
Average peak price [€/MWh]	56.6 €	48.5 €	54.4 €	50.9 €	53.5 €	48.4 €	51.5 €	49.6 €
Average German generation [GW]	57.5	59.0	57.9	58.6	58.1	59.0	58.5	58.8
Average imports [GW]	10.4	8.9	10.0	9.3	9.8	8.9	9.5	9.1
Consumer expenses [bn €/a]	18.00	15.51	17.34	16.20	17.01	15.42	16.40	15.77
Producer surplus [bn €/a]	7.78	6.57	7.32	7.16	7.78	6.50	7.30	6.80

Source: Own calculation

4.3 Discussion

Comparing the pre- and post-divestiture market results shows clear price and surplus effects of the proposed divestiture cases. As prices significantly decrease, the consumer expenses decrease as well, leading to a consumers' surplus gain. This is accompanied by a decrease in domestic producers' surplus. The net effect for consumers and generators is a surplus of more than 500 million € per year for Germany (Table 3).

Note that domestic demand is assumed to be perfectly inelastic. Hence, a lower price does not lead to a reduction of consumer dead weight loss within Germany. The 500 million € benefit comes from three sources: (1) production efficiency in Germany increases, (2) electricity is bought more cheaply abroad, (a terms of trade effect) (3) a reduction of congestion rents on cross-border flows (this is a transfer from network operators to network users). However, lower prices in Germany will also have an effect on other countries. It will hurt foreign producers and benefit foreign consumers. Both the net import levels and the prices at which it is traded decline. In sum foreign markets face a welfare reduction of 300 to 400 million € per year (Table 3). Counterweighing domestic and foreign effects a net surplus of about 200 million € can be obtained.

Furthermore, the productive inefficiency due to capacity withholding can be reduced by divesting the two larger companies from about 80 million € per year to about 30 million € in the Cournot setting and less than 20 million € in the SFE setting.

Table 5 shows that in the pre-divestiture situation the oligopolists' surplus is significantly higher than under pure competitive conditions. Also fringe firms, acting as price takers, profit from the oligopolistic price setting, as they can free ride on the capacity withholding of the strategic firms and the resulting higher prices.

By divesting the two larger German companies, the surplus of the oligopolists and the fringe firms can be greatly reduced. In the *6 Firm Case* revenues drop by about 15% for strategic companies.[11] In contrast, all competitive fringe firms combined face a significant larger surplus reduction (of more than 20%) highlighting the impact of capacity withholding by the strategic companies.

In the *Large Fringe Case* the average company surplus drops by about 20%. The surplus generated by the divested assets that are sold to fringe companies (see Table 5, EON2 and RWE2) are slightly higher than the remaining assets that are modeled as strategic companies (as those firms do not withhold capacity, but obtain the same price as the strategic firms). As in the *Base Line Case*, fringe generators benefit from the oligopolistic players withholding capacity and driving up prices.

As the German companies own a mixed power plant fleet of base and peak units consisting partly of depreciated plants it is hard to derive an assessment whether the surplus is beyond the necessary margin for fixed cost recovery and what impact the divestiture will have in the long run on investment signals. The average return per MW is about 60.000 € per year in the competitive benchmark and about 90.000 € per year for the strategic firms in the pre-divestiture setting. Assuming a life time of 20 years and an interest rate of 6% the fixed costs of a power plant range between 44.000 and 130.000 € per MW per year for overnight costs of 500 €/kW and 1500 €/kW respectively. Thus given a mixed portfolio of less cost intensive peakers and more costly base load units the obtained revenue values seem reasonable to assure cost recovery.

As a divestiture can be seen as a reversed merger it is interesting to assess whether the profit changes are in line with standard theory on mergers. In a standard Cournot game with constant marginal costs, a merger will lead to a reduction of overall profit of the merging firms, unless the merging firms own a large fraction of total demand, or the merger creates large cost reductions (Salant et al. 1983). In our case, the firms have upward sloping marginal cost functions, and this result is therefore no longer valid (Fauli-Oller, 1997). Here a merged firm (the pre-divestiture firms) may have a higher profit level than the sum of the profits of the separate firms (the post-divestiture firms). We also see in our simulations that mergers are more profitable in the SFE model than in the Cournot model.

The results of our simulations are subject to some restrictions. First, the contract coverage obtained during the calibration may not be the one applied in the post-divested market. In the Cournot model, firms have an incentive to increase their contract coverage in response to a merger. In the SFE model, the strategic effects of contracts are less clear cut. Second, the cubic cost function assumption neglects

capacity constraints which may lead to higher prices. This is also true for imports as the constant import elasticity may overestimate competition from abroad. And finally the characteristics of electricity markets can lead to situations not captured by the model, e.g. strategic behavior by small firms in peak times with little capacity reserves.

Table 5: Company surplus, in bn € per year

	Competitive Benchmark	Pre-Divestiture		6 Firm Case		4 Firm Case	
		Cournot	SFE	Cournot	SFE	Cournot	SFE
EON 1				1.033	1.035	0.974	0.966
EON 2				1.033	1.035	0.982	0.974
EON TOT	1.769	2.380	2.405	2.065	2.071	1.957	1.939
				-13.2%	-13.9%	-17.7%	-19.4%
RWE 1				0.970	0.975	0.902	0.894
RWE 2				0.970	0.975	0.921	0.910
RWE TOT	1.624	2.295	2.282	1.941	1.950	1.823	1.804
				-15.4%	-14.5%	-20.6%	-20.9%
Vattenfall	0.989	1.423	1.464	1.234	1.244	1.155	1.151
				-13.3%	-15.0%	-18.8%	-21.4%
EnBW	0.957	1.295	1.321	1.106	1.109	1.047	1.039
				-14.6%	-16.0%	-19.2%	-21.3%
Fringe	0.985	1.575	1.606	1.233	1.232	1.134	1.116
				-21.7%	-23.3%	-28.0%	-30.5%

Source: Own calculation

5 Conclusion

In this paper competition policy and divestiture in electricity markets are analyzed. Based on the case of Germany it is shown that a reduced market concentration can provide welfare benefits. Applying a Cournot and SFE model two divestiture cases are analyzed that both lead to a similar peak-price reduction and welfare gains. Although foreign markets face a welfare reduction due to the price decrease and reduced imports from Germany, the overall impact counterweighing domestic and foreign effects shows a positive welfare gain.

The results also show that in the case of Germany divested assets should be sold to independent and small firms, preventing the emergence of further strategic players. Providing this setting a reduction of consumer expenses of more than 2 bn € per year, and a peak price reduction of up to 8 €/MWh can be achieved taking 2006 as reference year.

Even though this paper highlights that divestures can increase the competitiveness of oligopolistic electricity markets the question whether it is the best fitted instrument for that task is not answered. Divestiture is generally considered a “hard” instrument of competition policy and thus may result in significant opposition by the concerned companies that delay its implementation. An acceptable alternative may be provided by virtual divestures with a limited duration. Whether other measurements like the increase in cross-border transmission capacity and the further integration of congestion

[11] The two non-divested firms (Vattenfall and EnBW) face similar changes as the two divested firms (EON and RWE).

management schemes may provide a similar or higher benefit is subject to further research. In addition a translation of the result for the German case to other markets is not advisable given the large divergence in the market structures among European electricity markets.

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