On Vertical Integration, Regulation and Non-Price Discrimination in German Electricity Markets

I. Introduction

Vertical separation is a key issue in European energy markets, in particular since the DG Competition has initiated a sector inquiry in 2005. While the European Commission (EC) argues that vertical separation of electricity networks from other activities increases the consumer surplus,1 opponents argue that vertical integration enables cost savings due to economies of scope.2 In a number of speeches European Competition Commissioner Kroes provides mainly three reasons why a disadvantage of vertical integration in energy markets exists for retail customers: (1) market concentration, (2) lack of cross-border integration and (3) insufficient unbundling of network and supply activities.3 Following Haucap (2007) the first two concerns focus on national market situations and international competition whereas the last “already addresses a potential policy solution (unbundling) and the lack of its implementation”.4

The common tenor of a multiplicity of recent studies on vertical integration is that unbundling reduces a grid owner’s incentive to discriminate between own units and competitors but that unbundling increases the double mark-up problem if a dominant provider exists in the downstream market (Pollitt, 2007, Davies and Waddams Price, 2007, Haucap, 2007).

In this paper we consider on the household retail and distribution level and analyze how vertical integration affects retail prices and network access prices (distribution charges) in German electricity markets. We employ cross-sectional data for about 850 German markets, each served by one distribution system operator (DSO), one downstream incumbent and a number of new energy providers, and consider how alternative vertical structures, comprising full vertical integration, legal unbundling and ownership unbundling, affect retail prices and distribution charges. Using a structural model approach we find significantly higher distribution charges for markets with legally unbundled operators whereas in markets with fully separated operators and in markets with fully integrated operators distribution charges are at a similar level. Considering incumbents’ retail prices, we find significantly lower prices with ownership unbundling.

II. The German Electricity Sector

Electricity sectors consist of the four layers production, transportation, distribution and retail. In Germany four fully vertically integrated electricity providers, EnBW, E.on, RWE and Vattenfall keep about 85 percent of the production capacities and nearly 100 percent of the transmission grid. The remaining 15 percent of production capacities are either in the hands of local producers (which are mainly also retailers) or foreign companies. The transmission grid areas cover the following regions: The EnBW area is located in South-Western Germany, the Vattenfall area covers Eastern Germany, the RWE region is in Western Germany and covers mainly the territory of Nord-Rhine Westfalia and Rhineland Palatinate. The remaining territory which reaches from Northern Germany to Bavaria belongs to E.on.

2 ERGEG...
3 Examples are: Neelie Kroes: Improving Europe's energy markets through more competition SPEECH/07/115), Neelie Kroes: More Competition and Greater Energy Security in the Single European Market for Electricity and Gas (SPEECH/07/212)
4 Haucap (2007), p. 302
The distribution layer covers more than 850 regionally separated markets. Figure 1 provides an overview over the distribution markets in Germany.

**Figure 1: Regional separation of the German Electricity Distribution Market**

![Map of Germany showing regional separation](image)

The largest electricity supplier in each market in terms of household customers is obliged to offer one so-called standard contract. This contract is a “fall-back” option for those customers who decided to switch to an alternative contract. They automatically return to the standard contract either if their new provider leaves the market or if their contract is deleted and customers did not decide where to switch (§§ 36 – 38, Energiewirtschaftsgesetz (EnWG)). Until today, former monopolists are the providers of these standard contracts. All customers who haven’t switched yet (more than 60 percent on average) are served by this contract type.

Besides the standard contract former monopolists offer alternative contracts to keep more price-sensitive customers. About 34 percent of customers chose an alternative incumbent contract, whereas the rest turned to alternative suppliers.

In line with the 2005 Energy Act (EnWG) the German regulatory agency (NRA) Federal Network Agency started the regulation of the grid access charge, the so-called distribution charge. If a supplier serves a customer it has to pay the regional distribution charge of the customer’s region. Besides price regulation the Energy Act requires the regulation of grid-owners and retail operators and distinguishes the following types of vertical separation/integration: Vertical separation or **ownership unbundling** requires independence of producers, grid operators and retail providers. In contrast, **legal unbundling** describes the functional separation of DSOs and retail providers in terms of management, information flows and accounting. Grid operators with more than 100,000 customers are obliged to legally separate activities since 2007. Operators which have not reached this threshold need not
separate up upstream from downstream activities and are, thus, allowed to remain **vertical integrated**. About 19 percent of the German distribution operators are legally unbundled including voluntary separations whereas 75 percent are vertically integrated and 6 percent are fully separated.

### III. Related Literature

A large number of theoretical studies consider vertical integration of an upstream monopolist offering an essential input to a competitive downstream market. Without any regulation the upstream monopolist favors its own downstream unit either with price-privileges or quality-privileges. Including upstream price regulation into these models non-price discrimination becomes an issue as the upstream provider seeks new approaches to benefit its downstream unit over its competitors. Vickers (1995) shows that the standard raising rivals’ costs challenge (Salop et al. (1983)) continues to exist even with upstream regulation due to information asymmetries between the vertically integrated company and its downstream competitors. While the raising rivals’ costs theory considers the manipulation of the input price, “sabotage” is an alternative strategy to influence competitors’ downstream costs (Economides (1998), Beard et al. (2001)) which could hardly be detected and legally prohibited. The literature on non-price discrimination differentiates between several types to affect downstream rivals. In the following we try to shed some light on the alternative approaches including raising rivals’ costs or reducing rivals’ quality.

Vickers (1995) analyses welfare effects of vertical integration by assuming a regulated upstream monopolist which is the provider of an essential facility being integrated with a downstream company in a competitive retail market. Vickers assumes the regulator to be imperfectly informed about upstream costs what allows the upstream monopolist to select its wholesale price from a set of prices. Following Vickers’ analysis, regulation hampers upstream price adjustments to affect downstream competition. However, due to information asymmetries regulation cannot completely absorb the incentive. Sappington (2006) extends Vickers’ setup by including economies of scope and sabotage and confirms Vickers’ results concerning higher retail prices due to vertical integration. He specifies the outcome in the sense that the link between higher retail prices and vertical integration depends on the level of relative cost efficiencies among downstream competitors and the level of economies of scope which could be passed on to customers. The comparison of Vickers’ and Sappington’s approach show that the outcome of a raising rivals’ costs strategy does not dependent on the type of downstream competition.5

Mandy and Sappington (2006) consider an alternative approach where the upstream provider is able to influence the demand for the downstream rivals’ products by reducing their quality. By comparing the outcome of their approach with that of previous work the authors show that both cost-increasing discrimination and demand-reducing discrimination are profitable under Cournot competition. However, only cost-increasing discrimination is profitable under Bertrand competition.

With a focus on network industries the literature provides alternative regulatory approaches to overcome the challenge of vertical integration and discrimination by the provider of the essential downstream input. While ownership unbundling requires the strict separation of upstream and downstream providers, legal unbundling is discussed as a weaker instrument.

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5 Alternative studies which analyze non-price discrimination assuming Cournot competition or Bertrand competition are the following:

- Bertrand competition: Beard et al., 2001; Sappington 2006; Weisman, 1995.
Legal unbundling as an intermediate approach between ownership unbundling and vertical integration describes a particular type of separation in network based markets where the grid unit and the retail unit are operated by *de iure* independent managements deciding on prices and investments. Cremer et al. (2006) and also Bolle and Breitmoser (2006) show that the stronger unbundling is enforced by law the more network operators try to benefit from higher distribution charges whereas downstream competition is reduced resulting in higher retail prices.

Höffler and Kranz (2007a) compare the effects of legal unbundling with ownership unbundling and vertical integration and find lower retail prices (higher consumer surplus) with legal unbundling than with ownership unbundling and vertical integration. As a legally separated, price-regulated network operator maximizes only its own profit by maximizing the upstream output there is no incentive to discriminate between downstream competitors. Thus, retail prices are lower than under vertical integration. However, in the case of ownership separation the outcome seems to be the same as the upstream firm has no incentive to discriminate anymore. In Höffler and Kranz’ setup the only difference between legal unbundling and ownership separation is that the downstream firm that owns the upstream monopolist maximizes its profits in both markets. Therefore, legal unbundling seems to be preferable since it yields (weakly) higher consumer surplus and lower retail prices. By assuming informal interdependence between the legally unbundled upstream and downstream unit Höffler and Kranz (2007b) show that discrimination might again occur. If the regulator employs stricter regulatory rules to separate the upstream from the downstream and the adequate adoption of such rules the outcome tends towards the outcome of perfect legal unbundling.

In a nutshell, the literature provides a broad range of recommendations how vertical integration affects retail prices and upstream prices. The consideration of legal unbundling as an intermediate approach between ownership unbundling and vertical integration has highlighted some alternative approaches to alleviate the discrimination challenge of vertical integration.

In the liberalised electricity market non-price discrimination could be delaying customers’ switching activity from the integrated downstream operator to a downstream competitor. Alternatively, a grid operator could deter information about grid characteristics and customer characteristics.

IV. Theoretical Model

Based on this theoretical background we compare alternative types of non-price discrimination with alternative forms of vertical integration.

a. Vertical Integration

Consider a Hotelling game with two firms located at the ends of a line, with uniformly distributed potential customers dependent on their loyalty.\(^6\) Firms offer differentiated products which means electricity contracts with a given amount of electricity demand per contract. Without loss of generality, we assume the incumbent to be located at 0 and the entrant to be located at 1. The incumbent is vertically integrated with the DSO which provides a common input, “access” to the distribution grid, at a cost-based regulated per unit price. The DSO faces constant per unit costs \(c_u\) with \(d(c_u) \geq c_u\). Besides distribution charges, both firms

\(^6\) We assume the household electricity demand to be highly price-inelastic in the short run.
bear constant marginal costs per contract $c_i$, $i = d, e$ and fixed costs $F_i$, $i = d, e$, for serving customers. Each downstream firm demands one unit of network access per contract and each customer $x$, $x \in [0, 1]$, buys one contract from the incumbent or the entrant at prices $p_i$ or $p_e$, respectively. Household electricity demand is assumed to be very price inelastic (at least in the short run).

$v$ denotes a common reservation price with $v \geq p_i^0$, $i = d, e$ and each customer pays $\tau_e$ if he buys from the incumbent and $\tau_d$ otherwise. Transportation costs represent the customer preferences for a particular supplier. The utility function of customer $x$ is defined as follows:

$$U(x) = \begin{cases} v - p_d - \tau_d x & \text{if the customer buys from the incumbent} \\ v - p_e - \tau_e (1-x) & \text{otherwise.} \end{cases}$$

As input prices are regulated the DSO might be interested in favoring its downstream unit over its competitors using non-price discriminating activities. We distinguish two alternative approaches which are cost-increasing, $s_j$, and demand reducing, $d_j$, discrimination. Cost-increasing discrimination might be due to lacking information provision on infrastructure availability or quality whereas demand-reducing discrimination is due to delays in the contract switching process. While cost-increasing discrimination directly reduces the entrant’s price-cost mark-up demand-decreasing investments, simultaneously increase the loyalty to the incumbent but decrease the loyalty to the entrant, $\frac{\partial \tau_d}{\partial s_d} < 0$, $\frac{\partial \tau_e}{\partial s_d} > 0$.

Discrimination induces costs $C(s_i, s_j)$ to the DSO, with $C'(s_i) > 0$, $C'(s_j) > 0$, $\frac{\partial C^2}{\partial s_i \partial s_j} = 0$, $i, j = c, d$, $i \neq j$.

As usual in Hotelling models, the demand split is defined by the marginal consumer $x_i$ who is indifferent between the incumbent’s contract and the competitor’s contract. Thus, we get the incumbent’s demand $D_i = x_i$ as:

$$D_i = x_i = \frac{p_e - p_d + \tau_e}{\tau_d + \tau_e}.$$ 

and the demand for competitor’s contract as $D_e = 1 - x_i$, with $D_i(\tau_e) \leq 0$ and $D_i(\tau_d) \geq 0$ for $i, j = d, e$.

Thus, we can derive the profit functions for the entrant $\pi_e$, the incumbent’s downstream unit $\pi_d$ and the incumbent’s upstream unit $\pi_u$:

$$\pi_e = (p_e - c_e - d - s_e)D_e - F_e$$
$$\pi_d = \pi_{du} + \pi_{de} \text{ with}$$
$$\pi_{du} = (p_d - c_d - d)D_d - F_d$$
$$\pi_{de} = (d - c_e)(D_e + D_d) - F_{de} - C(s_e, s_d),$$

5
We assume a two stage game where, first, the vertically integrated incumbent chooses the discrimination strategy \( S^* = S(s^*_d, s^*_c) \) and, second, downstream units engage in Bertrand competition. Let us begin with vertical integration where the incumbent maximizes its total profits, that is \( \pi = \max(\pi_d, \pi_c) \). By backward induction, we get for the best reply functions:

\[
p_d^* = \frac{1}{2}(d + c_d + p_o + \tau_c) \quad \text{and} \quad p_c^* = \frac{1}{2}(d + c_c + p_d + \tau_c + s_c).
\]

Cost-increasing discrimination increases the entrant’s price as \( p_c^*(s_c) > 0 \) what confirms the findings of previous studies such as Economides (1998). In contrast, demand reducing discrimination shifts the entrant’s best-reply curve inwards and the incumbent’s best-reply curve outwards. The results are ambiguous: First, both equilibrium prices may be higher if the (positive) effect on the competitor’s transportation costs outweighs the (negative) effect on the incumbent’s transportation costs. Second, demand reducing discrimination induces the competitor to respond aggressively by reducing its price what is also shown in Mandy & Sappington (2006).

**Lemma 1:**

(i) Cost-increasing discrimination raises both equilibrium downstream prices. The competitor’s price rises more than the incumbent’s price, \( \frac{\partial p^*_c}{\partial s_c} = \frac{2}{3} \) and \( \frac{\partial p^*_d}{\partial s_c} = \frac{1}{3} \).

(ii) Cost-increasing discrimination raises the incumbent’s demand by \( \frac{\partial D^*_d}{\partial s_c} = \frac{1}{3(\tau_d + \tau_c)} \) and decreases the competitor’s demand by \( \frac{\partial D^*_e}{\partial s_c} = -\frac{1}{3(\tau_d + \tau_c)} \).

As cost-increasing discrimination induces the competitor to choose a higher price than without discrimination he loses a fraction of its customers. These customers turn to the incumbent so that he can also charge a higher price.

**Lemma 2:**

(i) Demand-decreasing sabotage raises the incumbent’s downstream price and decreases the competitor’s downstream price if \( \frac{\partial \tau_d}{\partial s_c} < \frac{\partial \tau_c}{\partial s_c} < \frac{2}{3} \frac{\partial \tau_c}{\partial s_c} \).

(ii) Demand-decreasing sabotage raises the incumbent’s equilibrium demand \( \frac{dD^*_d}{ds_c} > 0 \) and decreases the competitor’s equilibrium demand \( \frac{dD^*_e}{ds_c} < 0 \) as long as

\[
(c_d - c_c - s_c + \tau_c) \frac{\partial \tau_d}{\partial s_c} > (c_c + s_c + \tau_c + \tau_c) \frac{\partial \tau_c}{\partial s_c}.
\]

This inequality holds for \( c_d = c_c \), \( \tau_d > s_c \) and \( \frac{\partial \tau_d}{\partial s_c} = \frac{\partial \tau_c}{\partial s_c} \).

In contrast to cost-increasing discrimination, the effects of demand-decreasing discrimination are ambiguous and depend on additional assumptions.
We assume that the firms are comparably efficient, i.e. they have the same unit costs, \( c_d = c_e \), and the impact of demand-decreasing discrimination on the competitor’s transportation costs is larger than the impact on the incumbent’s transportation costs, \( \frac{\partial \tau_\text{e}}{\partial s_d} > \frac{\partial \tau_\text{d}}{\partial s_d} \). With these assumptions the incumbent’s price increases with demand-decreasing discrimination (Lemma 2 (i)).

Following Lemma 1 cost-increasing discrimination is profitable for the incumbent as this action increases both the incumbent’s price and also its demand. However, taking into account the impact on the incumbent’s grid unit, cost-increasing discrimination decreases the competitor’s quantity and, thus, the incumbent’s upstream profit. In consequence, the incumbent reaches the optimum discrimination level with \( \pi_{\text{d}}'(s_d^*) + \pi_{\text{de}}'(s_d^*) = 0 \), i.e. where the marginal revenues of discrimination equals its marginal costs. If price regulation is implemented in a very strict way which means \( d(c_u) = c_u \), the incumbent neglects the discrimination effect on wholesale profits and, therefore, prefers cost-increasing discrimination over no discrimination as \( \pi_{\text{d}}(s_d^*) \geq \pi_{\text{d}}(0) \).

For the singular effect of demand-decreasing discrimination we can derive similar conditions: We know from Lemma 2 (i) that the incumbent’s retail price increases and the competitor’s price decreases with discrimination. Furthermore, the optimal discrimination level is determined by \( \pi_{\text{d}}'(s_d^*) + \pi_{\text{de}}'(s_d^*) = 0 \) and therefore the incumbent engages in demand-decreasing discrimination as \( \pi_{\text{d}}(s_d^*) \geq \pi_{\text{d}}(0) \) holds. As the competitor’s transportation costs and, simultaneously, the incumbent’s own transportation costs decrease more customers turn from the entrant and the incumbent can charge a higher retail price. The incumbent will, therefore, discriminate more until the marginal revenue of an additional “unit” of discrimination exceeds the marginal costs. In contrast, the competitor reduces its price to enhance switching what reduces its profit.

We know from Lemma 1 that the level of cost-increasing discrimination also affects the profitability of demand-decreasing discrimination and, therefore, consider the joint outcome in the next step. The previous findings, \( \pi_{\text{d}}(s_d^*) \geq \pi_{\text{d}}(0) \) and \( \pi_{\text{d}}(s_d^*) \geq \pi_{\text{d}}(0) \), show that non-price discrimination is always a preferable strategy for the vertically integrated incumbent. With Lemma 2(ii), \( \tau_d \geq s_c \), discrimination increases the demand for the incumbent’s contract, \( \frac{dD^\ast_d}{ds_d} > 0 \) and \( \frac{d^2D^\ast_d}{ds_d s_c} > 0 \), 2 and allows the incumbent to choose higher retail prices \( \frac{\partial p^\ast_d}{\partial s_d} > 0 \) and \( \frac{\partial^2 p^\ast_d}{\partial s_d s_c} > 0 \). While the second derivatives of demand with respect to non-price discrimination are negative \( \frac{d^2 D^\ast_d}{ds_c s_c} = \frac{d^2 D^\ast_c}{ds_c s_c} < 0 \) the incumbent’s profit increases as with \( \tau_d \geq s_c \) the positive price effect outweighs the demand effect. \( \frac{d^2 \pi^\ast_d}{ds_c s_c} = \frac{d^2 \pi^\ast_c}{ds_c s_c} > 0 \). Employing both types of discrimination the boundary condition \( \tau_d \geq s_c \) is reached faster than with singular discrimination as demand-decreasing discrimination reduces \( \tau_d \) and \( s_c \) is positive. Thus, the

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2 Incumbent’s incremental demand with respect to DDS is increasing as long as

\[ s_c \leq \tau_d < \frac{\tau_d \tau_e [s_d] - \tau_e \tau_d [s_d]}{\tau_e [s_d] + \tau_d [s_d]} \] holds.
higher the maximum level of cost-increasing discrimination the lower the maximum level of demand-decreasing discrimination and vice versa. With the positive second derivatives and the further intermediate results we know that also \( \pi_d(s^*_d, \tau_d) \geq \pi_d(0,0) \) holds, i.e. employing the optimum combination of both types of discrimination results in a higher total profit than no discrimination.

Proposition 1: With \( \pi_d(s^*_d) \geq \pi_d(0) \), \( \pi_d(s^*_d) \geq \pi_d(0) \) and \( \pi_d(s^*_d, s^*_d) \geq \pi_d(0,0) \) non-price discrimination is a preferable strategy for the incumbent as long as \( \tau_d \geq s^*_d \).

The discussion in line with Proposition 1 provides theoretical evidence that the incumbent’s price is lower without non-price discrimination independent of the discrimination strategy. On the other hand, the competitors’ price choice depends on the magnitude of demand-decreasing discrimination and customers’ loyalty, i.e. the transportation costs.

Hypothesis 1: In markets with vertically integrated companies, non-price discrimination results in higher retail prices of the incumbent.

b. Legal unbundling

Let us next turn to legal unbundling. We adopt the ideas of Cremer et al. (2006) and Höfler and Kranz (2007a) and assume that the legally unbundled grid operator considers only its grid activity whereas the downstream incumbent fully or partially owns the grid operator, \( \lambda \in [0,1] \), and aims at maximizing the overall profit.

With perfect legal unbundling the overall profit is given by:

\[
\pi_d = \pi_u + \lambda \pi_u = (p_t - c_d - d) D_d - F_{\text{op}} + \lambda \left((d - c_v)(D_v + D_d) - F_{\text{op}} - C(s, s_d)\right)
\]

As distribution charges are regulated the only instrument to affect upstream competition is to change the demand. However, the grid operator earns the same profit independent of downstream market shares. Therefore, discrimination does not affect its profits and – with perfect legal unbundling – the grid operator has no incentive to discriminate. This outcome strongly corresponds to the findings of Höfler and Kranz (2007a).

A fraction \( \lambda \) of upstream gains is transferred to the downstream incumbent. In the next step it is thus necessary to check whether the partial consideration of grid profits affects the retail providers’ profit maximization strategies. Deriving the incumbent’s optimum retail price strategy brings us to \( p_d^* = \frac{1}{3}(3d + s_v + \tau_d + 2\tau_v) \) which is independent of the ownership share.

Proposition 2: With perfect legal unbundling the grid operator maximizes its upstream profit.

No incentives for discrimination exist and, therefore, \( S^*(0,0) \) is the equilibrium strategy.

Downstream prices are unaffected by the ownership share \( \lambda \).

Hypothesis 2: Perfect legal unbundling provides the same results as total separation (ownership unbundling). Therefore, incumbents’ prices in markets with legal unbundling do not significantly differ from incumbents’ prices in markets with ownership separation.

Assuming perfect legal unbundling eliminates the grid operator’s legal dependence of the retail incumbent. Consequently, the grid operator ignores the downstream effect of its strategic decisions and, thus, has no incentive to act in favor of its retail mother firm. However, according to the Sondergutachten (2009) of the German Monopolies Commission
on issues in German energy markets, the dependence of former vertically integrated operators remains to be strong even with legal unbundling. In particular, it is stated that upstream management decisions seem to be influenced by requirements of the retail incumbent. We take this imperfect legal unbundling situation into account by adjusting our model as follows:

Modeling this internal dependence we assume that the downstream firm owning the network, but forced to legal unbundling, might lease the network to upstream subsidiary by charging a particular leasing rate $r_u$ that rises with increasing network costs. In addition, assume that this leasing rate is also affected by the sabotage strategy of the upstream, $r_u = \tilde{r}(\epsilon_u, S(s_u, s_d))$, but in contrast to regular costs that emerge from operating the network, sabotage lowers the leasing rate, $\frac{\partial r_u}{\partial s_d} < 0$ with $i = c, d$, and $r_u \in \left[ \tilde{r}_0(\epsilon_u, S(s_u, s_d)), \tilde{r}_0(\epsilon_u, 0) \right]$. On the other hand the optimal sabotage strategy of the upstream affiliate depends on the leasing rate $r_u$ to be paid to downstream, $s_i(r_u)$ with $i = c, d$. This setting or the internal structure is based on principal-agent problem with the landlord (incumbent) as the principal and the tenant (DSO) as the agent. In contrast to Höffler and Kranz (2007b) where they assume that the upstream receives a fraction of downstream profits and therefore has the incentive to sabotage, our setting might better fit the observations in German electricity market since the internal structure of the legally unbundled firms is not regulated.

In addition, assume that the incumbent first set the boundaries for the leasing rate $r_u \in [\tilde{r}_u, \bar{r}_u]$ and afterwards the upstream affiliate chooses the sabotage level and the corresponding leasing rate, respectively. Given our assumptions this setting enables the incumbent to influence decisions in upstream even though the upstream firm is legally separated. Now, we slightly change the profit functions faced by the downstream incumbent and its upstream subsidiary.

$$
\pi_u = \pi_u + \lambda \pi_u = (p_u - c_d - d)D_u - F_u + (r_u - c_u)(D_u + D_d) + \lambda \pi_{du},
$$

$$
\pi_{du} = (d - r_u)(D_u + D_d) - C(s_u, s_d)
$$

In the equilibrium the affiliate will always set the sabotage level that corresponds to the lower bound of the leasing rate since the lower the leasing rate the higher the profit, $\pi_{du}(S'(s_u, s_d) = \bar{s}_u, r_u) \geq \pi_{du}(\tilde{S}(s_u, s_d) = \tilde{s}_u, \tilde{r}_u)$. Deviation to lower sabotage level would induce higher leasing rate and is therefore not the optimal decision.

In case we have the limit $\lambda \rightarrow 1$ incumbent’s overall profit collapses to:

$$
\pi_u + \lambda \pi_u = (p_u - c_d - d)D_u - F_u + (d - c_u)(D_u + D_d) - C(s_u, s_d)
$$

that is exactly our initial objective profit function. Moreover, in this case $r_u$ acts as steering tool for upstream affiliate but has no direct impact on upstream profit in incumbent’s objective function.

Proposition 3.: Incentive to sabotage increases in ownership share $\lambda$ of downstream incumbent on upstream affiliate. The DSO will undertake sabotage since there exist a subgame-perfect equilibrium with $r_u^*, S'$, $\pi_u^* \geq \pi_u(\tilde{r}_u, \tilde{s}_u, s_d) \geq \pi_u(\bar{r}_u, S(0, 0))$ and
The upstream profit increases with a lower leasing rate and higher sabotage level. This result implies that sabotage is increasing in ownership share.

\[ \pi_u(S^*(s, s_d), r^*_u) \geq \pi_u(S(0,0), r^*_u) \] that maximize firms’ objective functions.

Proof: In this case, the outcome is obvious since \( S^*(s, s_d) \) with \( s_c \land s_d \neq 0 \) maximizes the incumbent’s profit function as already derived in prop 1. This implies that the downstream incumbent will set the corresponding lower bound for the leasing rate to \( r^*_u = \Delta \leq r^*_u \).

Accordingly, the upstream firm maximizes the profit by undertaking sabotage as long as the gain from lowering leasing rate corresponding to sabotage level exceeds sabotage costs so that

\[ \pi_u(S^*(s, s_d), r^*_u) \geq \pi_u(S(0,0), r^*_u) \] with \( s_c \land s_d \neq 0 \).

Consider two different ownership shares \( \lambda_a \) and \( \lambda_b \) with \( \lambda_a < \lambda_b \), whereas \( p^*_a \) and \( r^*_a \) (\( p^*_b \) and \( r^*_b \)) denote downstream incumbent’s optimal choice given \( \lambda_a \) and \( \lambda_b \). \( S \) denotes the optimal sabotage strategy given the market share. DSO’s optimal choice implies:

\[
\begin{align*}
  \pi_u(p^*_a, r^*_a, S^a) + \lambda_a \pi_u(p^*_b, r^*_b, S^b) &\geq \pi_u(p^*_a, r^*_a, S^a) + \lambda_a \pi_u(p^*_b, r^*_b, S^b) \\
  \pi_u(p^*_a, r^*_a, S^a) + \lambda_b \pi_u(p^*_b, r^*_b, S^b) &\geq \pi_u(p^*_a, r^*_a, S^a) + \lambda_b \pi_u(p^*_b, r^*_b, S^b) 
\end{align*}
\]

Adding the two inequalities and dividing by \((\lambda_b - \lambda_a)\) we find that \( \pi_u(S^a, r^*_a) \geq \pi_u(S^a, r^*_a) \).

Since upstream profit increases with lower leasing rate and higher sabotage level this result implies that sabotage is increasing in ownership share.

**Hypothesis 3:** With imperfect legal unbundling, incentives for non-price discrimination exist which initiate higher retail prices than with total separation.

### V. Empirical analysis

Hier muss noch rein, dass wir das theoretische Modell so nicht schätzen können. Vielmehr vergleichen wir die Ergebnisse für unterschiedliche Ownership structures zur Analyse der theoretischen Ergebnisse.

**Data Sources**

For the analysis of our hypotheses we use data from multiple sources to cover the vertical ownership structure, retail prices, distribution charges and customer characteristics. We employ a cross-sectional approach using information as of August 2008 which is aggregated on distribution grid.\(^8\) Quantity and price data are selected for an average household consumption level of 4000 kWh per year (3 to 4 persons).

\(^8\) According to the Federal Cartel Office (Bundeskartellamt) the relevant market for a customer without real-time-metering is the low-voltage grid area where the customer obtains electricity.
Ownership information is provided by Creditreform, the largest German wholesale commercial credit agency. Price and contract information aggregated on the zip code level stems from the internet platform Verivox which collects information on electricity contract offers. Low-voltage grid information and grid-related information is provided by E’net. Aggregated information about customer characteristics are taken from the Acxiom database.

**Data Adjustments**

Because of the particular aggregation level of consideration we adjust our data set to the grid level. Moreover, some additional calculations are necessary to get the ownership relation of the grid owner and the retail provider.

The most comprehensive calculations concern the calculation of ownership shares. The Creditreform database offers information about the ownership structure of each company in our sample. Please note that this information comprises both the direct owners of the retail company and the grid operator and also the network of owners to the ultimate owner. With these data we break down the individual share of an ultimate owner for each electricity company. However, we needed to calculate the direct and the indirect ownership link of intermediate owners as we consider (only) the structure between the retail provider and the grid owner what we consider here.\(^9\) Total ownership of a grid owner by an electricity provider and vice versa are calculated independently of the number of intermediate owners and of other owners on a higher ownership level. While the link between any grid owner and any electricity provider is undeterred by this approach, one has to keep in mind that the information for higher level owners of one of them might be deterred due to the consideration of a spot of the whole structure.\(^10\) Please note that we consider markets individually, i.e. we ignore cross-ownerships between alternative incumbents and alternative grid owners. We have tested this cross-market ownership structure and found it to be negligible due to the very low number of existence. However, what cannot be taken into account in this study, is the aspect of common owners on a higher level.

The grid access charge consists of a fix part, the sum of a fix usage charge and the meter charge, and a variable part which depends on the usage level. Thus, the grid access charge for a particular usage level is the sum of these components.

Grid regions are not identical with zip code regions, the level of customer information. Moreover, they range over multiple zip code regions and adjoin each other within zip code regions. As customer information covers all regional markets we calculate weights using 3- and-more-person households as they are the corresponding level of consideration in this study for the aggregation of customer information to the grid level.

**Data Description of the Key Variables**

The descriptive information is summarized in Table 1 in the appendix. The information used in the estimations covers about 770 regionally separated electricity markets.

6 percent of electricity companies are fully separated network operators and retail incumbents (ownership unbundling), in 19 percent of all markets under scrutiny companies are legally unbundled but they are not vertically integrated with the other. In 18 percent of markets retail incumbents partially or fully own the distribution grid operator whereas in 1 percent of markets the ownership structure is the opposite (52 percent of legally unbundled firms hold a 100 percent share of their subsidiaries). In 75 percent of markets retail incumbents and distribution grid operators are one company, i.e they are fully integrated and not legally

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\(^9\) We appreciate inexhaustible support by our colleague Thorsten Doherr.

\(^10\) A magnitude of approaches exist how to calculate ownership shares if one considers more than the first level. Our calculation is based on the actual share values due to even more complex calculation requirements with additional threshold requirements.
separated. Thus, in these regions the standard contract provider has a strong information advantage over its competitors as it knows the quantities provided by competitors and, moreover, it knows exactly the customers served by competitors.

We find that the standard price is on average 44 Euros more expensive than the lowest price incumbent offer. However, the lowest price offer of competitors which is comparable to the incumbent offers is more than 120 Euros less expensive than the standard contract. Taking into account pre-payment offers the reduction is about 170 Euros for household customers.

In line with the explanations in the Monitoring Report of the Federal Network Agency (Bundesnetzagentur) the distribution charge share in the standard contract price is on average 26.0 percent within our sample.

VI. Econometric Model

Nikosyan and Veith (2009) have shown that the standard contract price and the distribution charge are strategic instruments to affect competition in terms of the number of offered contracts and providers in regional electricity markets in Germany. In the current paper we want to specify the impact of vertical integration on the distribution charge and the retail price. Due to missing information about company specific incentive schemes and internal information on vertical relations between the grid owner and the retail incumbent, we cannot fully specify the explanatory equations. However, these drivers should affect both distribution charges and retail prices as described in the theoretical model. We therefore employ a structural estimation approach where the distribution charge enters the standard contract price equation, the incumbent’s most competitive contract price equation and the competitors’ lowest price equation. Ownership variables are used as explanatory variables for both the distribution charge equation and the price equations.

So we end up with the following specification:

\[
\log(dc_i) = \text{ownervec}_i ' + \beta_{\text{ownervec}} ' + \text{grid characteristics}_i ' + \beta_{\text{grid}} ' + \text{reg. characteristics}_i ' + \beta_{\text{reg}} ' + \alpha_i ' + \epsilon_i ' \]

\[
\log(price_{it}) = \text{ownervec}_i ' + \beta_{\text{ownervec}} ' + \text{reg. characteristics}_i ' + \beta_{\text{reg}} ' + \beta_{\text{dc log}} ' \log(dc_i) + \alpha_i ' + \epsilon_i ' \]

\[
\log(price_{it}^{\text{almost}}) = \text{ownervec}_i ' + \beta_{\text{ownervec}} ' + \text{reg. characteristics}_i ' + \beta_{\text{reg}} ' + \beta_{\text{dc log}} ' \log(dc_i) + \beta_{\text{num competitors}} ' \log(\text{num. competitors}) + \beta_i ' \log(price_{it}) + \alpha_i ' + \epsilon_i ' \]

\[
\log(price_{it}^{\text{lowest}}) = \text{ownervec}_i ' + \beta_{\text{ownervec}} ' + \text{reg. characteristics}_i ' + \beta_{\text{reg}} ' + \beta_{\text{dc log}} ' \log(dc_i) + \beta_i ' \log(price_{it}) + \alpha_i ' + \epsilon_i ' \]

We include control variables for grid characteristics and regional characteristics into the distribution charge equation and control variables to characterize regional markets into the price equations. Grid characteristics are proxied by grid length, the size of the distribution region, supply intensity (total power distributed in a region over the number of tapping points) and population density. Regional characteristics include information about customers such as total population and regional purchasing power.

For reasons of comparison we employ alternative ownership measures. First, we estimate the model including dummy variables for markets with fully separated, fully integrated and legally unbundled incumbents. Second, we distinguish between the ownership directions, i.e.
whether the retail incumbent or the DSO is the subsidiary. In the last specification we use threshold variables for ownership shares below 25.0 percent between 25.0 and <50.0 percent, between 50.0 and <75.0 percent and between 75.0 and 100.0 percent. A 100-percent ownership dummy distinguishes full vertical integration from legal unbundling. We have double-checked the robustness of our results controlling for alternative specifications of ownership structures and thresholds but find no significant differences to the specifications presented here.

Furthermore, we assume that the lowest-price equation and the incumbent’s lowest-price equation both depend also on the standard contract price whereas the standard contract price is not affected the other way round. This specification has been proven to be a sufficient approach as the Monitoring Report of the Bundesnetzagentur (2009) finds the majority of household customers (53 percent) to be still served by the standard contract. Moreover, in our previous study the standard contract price classified to be a key driver of competition. In contrast, the incumbent’s lowest-price contract additionally depends on alternative competition measures like the number of competitors and their offers (which are also endogenous). We distinguish contracts with and without prepayments, i.e. contracts which have to be completely paid in advance, and estimate our model twice including contracts without prepayment \( price_{i}^{\text{lowest}} \) and contracts with prepayment \( price_{i}^{\text{lowest,pp}} \) as we assume both types of contracts to address alternative customer groups. However, we take both of them into account in the other price-specification, respectively.

VII. Estimation Results and Discussion

The results of the alternative estimation specifications are displayed in Tables 2 and 3 in the appendix. In specification A we examine the vertical structure ignoring the direction of ownership. Specification B explicitly takes into account the ownership direction whereas specification C covers the size of vertical integration. Full vertical integration is the reference category.

Following the theoretical model, incumbent contract prices are expected to be lower with vertical separation of the monopolistic upstream provider. The empirical results support the expectations of the theoretical model as all model specification provide evidence for significantly lower standard contract prices in markets with ownership unbundling. Our findings provide evidence that vertical separation Unexpectedly we do not observe any significant direct effects on lowest-price-contracts \textit{price with prepayment}. In contrast, the estimation shows significant negative \textit{standard contract} prices in markets where the retail incumbent is totally separated (ownership unbundling). We obtain the same result, with lower coefficient, in the equation for the \textit{incumbent’s low-priced contract}. This findings suggest that in markets where the incumbent and DSO are either fully integrated or legally separated, but are still (partially) owned by incumbent, prices for contracts offered by incumbent are on average higher than in markets with fully separated incumbents. Since standard contract prices strongly affect the other prices in the market vertical integration might also affect prices for competitive contracts indirectly. Furthermore, we do not find significant differences in prices in markets with full integrated and legally unbundled incumbents. However, we unexpectedly observe lower prices for \textit{lowest-price-contract without prepayment} in markets with legally unbundled companies.

The next step of our investigation is to analyse if the \textit{ownership direction}, according to our theoretical findings and also to Cremer et al. (2006) and Höfler & Kranz (2007) matters in price setting behaviour. As we have shown vertical integration indeed affects the prices and
hence the question is whether this finding is induced by the ownership direction. In this estimation (Table 1 and 2, estimation B) we distinguish between the DSO (partially or fully) owned by the retail incumbent and the DSO that (partially or fully) owns the retail incumbent. However, this distinction is done for markets with legally unbundled companies, since firms that are vertically integrated but are not legally unbundled are in fact departments for network management and retail activities within one firm. Therefore the question of ownership direction can be analysed when the companies are legally separated. The estimation confirms the estimation results above and shows the significant negative effect of legal unbundling on lowest price without prepayment, however, the ownership direction does not matter. The same goes for the distribution charge equation, where both dummy variables are significant positive.

**Hypothesis 1** cannot be rejected since we find higher incumbent retail prices in markets with vertically integrated incumbents. Lowest-price-contracts (with prepayment) of competitors are affected by the standard contract price rather than the vertical structure. In contrast, prices of lowest-price-contracts without prepayment are significantly lower in markets with legally unbundled firms but they are also significantly affected by the level of the standard contract price. Moreover, we find positive significant effect of standard contract price on other contract prices. Therefore, we conclude that the standard contract takes the price leadership, however, not only due to its significance but also due to its high demand (in average about 60 percent of household customers). Consequently, vertical integration of the retail incumbent and DSO has not only direct impact on the standard contract price but also indirect effect on other prices in the market. However, observing this estimation results one might conclude that higher prices in vertical integrated markets indicate non-price discrimination.

In contrast, **Hypotheses 2** (lower prices in markets with perfectly working legal unbundling) can be partially rejected since we find no evidence for (reversed) legal unbundling to be favorable for customers’ surplus. The prices for the standard contract and for the low-priced competitive contracts that are offered by the incumbent are not affected by any regulative unbundling options. One reason might be that major vertical integrated firms which were obliged to legally separate their distribution activities but still own the network might now lease the network to affiliated DSO by charging sabotage conform leasing rate, as has been shown in our theoretical model.11 The German regulator and the Monopolies Commission also complain about the insufficient realization of operational separation of the network activities. In sum, we conclude that legal unbundling does not work perfectly so that stricter regulation is required.

The last **Hypothesis 3** (the ownership share has impact on pricing behavior if legal unbundling does not work perfectly) cannot be rejected for the distribution charge equation since only in cases with 100 percent share and legal unbundling, the distribution charges are higher. As mentioned above this observation might be caused by one-off costs that arise from required legal separation. In contrast, we do not observe any difference in distribution charges in markets with shares under 100 percent to markets with fully integrated incumbents. This might be an indication that these firms were separated before the unbundling law was implemented. Regarding the retail pricing behavior we only observe share effects on competitors’ lowest-price-contract without prepayment. If these effects were driven by non-price discrimination we could not reject our hypothesis.

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First, considering the **distribution charges** and the impact of vertical integration we confirm the results reported for example by Kwoka (2005) or by Growitsch et al. (2009)\(^\text{12}\) showing **economies of scale** in distribution network. We find that marginal increase in supply density, defined as population divided by distribution area, marginally decreases the distribution charges for household customers. Distribution charges also decrease with increasing total energy supplied in the geographical market. These findings suggest that there are indeed economies of scale driven by supply density and by total supplied energy in a network. In contrast, the density of tapping points (tapping points divided by distribution area) and consumption intensity (supplied energy in the low-voltage area divided by the number of tapping points) have positive impact at the distribution charge. The vertical structure and regulatory unbundling options, among others, are also used to examine the factors that determine the distribution charges. As we expected a positive effect of vertical integration on distribution charges due to potential **economies of scope** (retail activity and distribution), we find no support for this argument.\(^\text{13}\) In contrast, in markets with legally unbundled retail incumbent and DSO we find significant higher distribution charges for household customers compared with full integration and ownership unbundling. This might be driven by additional costs from restructuring the vertical agreements between retail and distribution. However, the coefficient is relatively small (but significant). Comparing the distribution charges in four high voltage zones we find that the highest distribution charges are invoiced in the Vattenfall-zone that is located in East Germany. The reason for this major difference in distribution charges is caused by higher depreciation for the network investments that raise the costs in this high voltage area and consequently in distribution networks located in this area.

In our previous study (Nikogosian & Veith 2009) we have shown that distribution charges have a significant effect on standard contract price. Unsurprisingly, the same result is derived in this estimation. The validation of the previous results shows weighty impact of distribution charge on standard contract price. As we have extended the estimation on the price for incumbent’s low-priced competitive contract, we find also strong impact of distribution charge on price. The same result appears in regard to **lowest-price-contract without prepayment** offered in the market. Surprisingly, we find, in contrast to incumbent’s contracts, negative small but significant effect of distribution charges on the **lowest-price-contract price with prepayment** in the market offered by an alternative supplier. Since the elasticity of the price with respect to distribution charge is about \(-0.0954\) a marginal increase in distribution charge would even lower the price for the lowest-price-contract. However, the effects of distribution charge increase on lowest market price are ambiguous since there are also mediate effects from the standard contract price. Since incumbent’s standard contract price can be seen as market price leader that has significant positive effect on competitive contracts and that itself is strongly determined by the distribution charge, an increase in distribution charge might lead to higher contract price for the lowest-price-contract if the impact of standard contract price outweighs the direct distribution charge effect on lowest-price-contract. Consequently, although distribution charges have significant negative direct impact on lowest-price-contract, the overall effect depends on the magnitude of mediate effects.

Comparing the direct effects of pricing behaviour of competitors or the cross-price elasticity of the different contract types we observe that contracts with prepayment are strongly affected

\(^{12}\) See also Filipini (1996) and Piacenza et al. (2009).

\(^{13}\) A limitation of the study is that we only consider the distribution charges for household customers and disregard distribution charges for industrial customers with real-time metering which are also indispensable for analyzing economies of scope.
by the standard contract, \( \frac{\partial \text{price}^{\text{lowestpp}}}{\partial \text{price}^{\text{std}}} > \frac{\partial \text{price}^{\text{lowestpp}}}{\partial \text{price}^{\text{lowest}}} \), whereas contracts without prepayment are rather affected by contracts with prepayment, \( \frac{\partial \text{price}^{\text{lowestpp}}}{\partial \text{price}^{\text{lowest}}} < \frac{\partial \text{price}^{\text{lowestpp}}}{\partial \text{price}^{\text{lowest}}} \). In contrast, incumbent’s low-price contract significantly reacts only to changes in standard contract price. Consequently, the standard contract is acting as a price leader strongly affecting all other prices in the market. That is not very surprising since the majority of the customers, who are potential customers for alternative supplier, are with the standard contract.

In order to detect possible impact of conflict of strategic interests between stake that owned by the network operator or by the retail incumbent and other stakeholder, for example financial investors, we consider the effect of number of ultimate owner on prices and distribution charge. As the estimation result shows, the coefficients for the number of ultimate owner in the standard contract price equation and in distribution charge equation are positive and significant (but small). This result holds also for incumbent’s lower-priced contract but is weaker, since the standard contract is the main profit driver. However, the coefficients for the number of ultimate owner are very small e.g. near zero.

Considering the outcome for variables representing the demand side in submarkets we find that the purchasing power in a market, as proxy for the willingness to pay for electricity, significantly affects only the lowest-price-contract prices with and without prepayment in both estimations. Interestingly, the price for the lowest-price-contract with prepayment is decreasing with increasing purchasing power in the market, what we rather would expect inversely. One possible explanation could be the more intensive price competition for prepayment contracts since customers in these regions might afford to pay the electricity for one year in advance. In contrast, we observe the reversed effect for lowest-price-contract without prepayment, which meets our expectations. The coefficient is positive and significant, though, near zero. Furthermore, there is no significant effect on the standard contract price induced by purchasing power but rather by the population in a market i.e. proxy for market demand. Growing population in a market leads to higher price for standard contract and, in addition, it leads to higher lowest-price-contract without prepayment price. However, this effect appears reversely in the lowest-price-contract with prepayment price equation, suggesting that in larger markets the lowest-price-contract price is relatively low.

A further question that is related to our investigation is whether the share of legally unbundled companies influences the price setting behaviour as derived in our theoretical model. One may conjecture that 5 percent share of the retail incumbent on the DSO would not have that strategic impact compared with 90 percent share. In contrast, in our previous estimation we defined the legal unbundled dummy that values 1 if either the retail incumbent holds any share on DSO or the DSO holds any share on retail incumbent. Considering the shares for the integrated firms, the estimation (Table 1 and 2, estimation C) confirms again, our finds in the first estimation and gives further information about strategic use of vertical structure. The results show that the coefficients for legal unbundling in lowest-price-contract equation (without prepayment) become significant in case of shares greater than 75 percent. Moreover, distribution charges are significantly affected only in markets where the firms were fully (100 percent) integrated but, due to legislation, had to separate the network legally. In all other markets with legally separated firms the differences in distribution charges vanishes, compared with markets with fully integrated firms.
To sum up, we find a significant impact of the vertical structure on both incumbents’ retail contract prices and cost-based regulated distribution charges, so that, our findings confirm to a far extent the results of our theoretical model.

In addition, our results show that in case of perfectly informed regulator, potential economies of scope do not decrease the distribution charges. The implications are: 1) vertical integration does not provide economies of scope, thus, the distribution charges remain unaffected regardless the vertical structure 2) the regulator is not perfectly informed about actual costs, thus, existing economies of scope enable to some extent to set higher distribution charges than actual costs that is caused by cost shifting from downstream to upstream. Compoundedly, if economies of scope exist this outcome provides evidence for raising rivals’ costs, according to Vickers (1995). „Economies of scale [scope] are frequently cited as the major reason to allow shared services and sharing of personnel. In 80% of responding countries, shared services, i.e. services performed by the integrated company for the DSO, are permitted and regulators have access to the underlying contracts. However, in about 4 out of 5 [European] Member States it has not been demonstrated that sharing services leads to lowering costs. It might be interesting for regulators to investigate this area in order to have a clear idea on the benefits of shared services.” According to responses to ERGEG (2009) questionnaire common shared services are IT, legal services, communication, and human resources, accounting and financial services. However, sharing the services apparently does not lead to economies of scope. Observing our estimation results we recommend to quantify potential economies of scope that arise from shared services. Similarly, ERGEG(2009) argues “that shared services could lead to cross-subsidization and indicates the need to further investigate this issue.”

VIII. Concluding Remarks

This paper considers the impact of vertical relations on retail and distribution prices in the German electricity sector. According to a recent strand of literature, standard wholesale price regulation in markets with an essential input can only partially hamper the influence of the input provider on downstream competition.

In a theoretical model we show that upstream monopolists could use non-price discrimination with regulated wholesale prices to increase downstream costs or to decrease downstream competitors’ demand and, thus, to affect downstream prices. Legal unbundling is sometimes brought forward in the literature as a regulatory option which is less restrictive than ownership unbundling but which also prohibits discriminatory interventions of a vertically integrated company on downstream competition. However, we show that a less restrictive implementation of legal unbundling still provides incentives for non-price discrimination.

We test the findings of our theoretical model using data for more than 770 regional German electricity markets and find central differences in the wholesale and the retail pricing behavior based on alternative vertical ownership structures. In markets with fully separated incumbents (ownership unbundling), retail prices for incumbents’ contracts are lower than in markets with fully integrated incumbents. In contrast, controlling for full vertical integration provides no statistical differences to the case of legal separation in standard contract prices. These results

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14 Note that we consider only distribution charges for customers without real-time metering which are commonly used in industry.
15 ERGEG 2009 p.9. In this status report of ERGEG economies of scale are defined as synergies that arise from sharing services between retail activities and electricity distribution. However, we define these synergies as economies of scope, since retail and distribution are entirely different “products”.
16 ERGEG 2009 p.15
underline the findings of our theoretical model that legal separation might not work perfectly since firms might elude the rules that ensure the independence.

Our findings show a mixed picture for vertical integration as we find no statistical difference between legal unbundled and vertically integrated providers. In consequence, these results raise the question whether legal unbundling as it is implemented in European electricity markets meets the aims which were originally intended to this regulatory instrument. However, one should not ignore that we only focus on pricing aspects in our analysis. In particular, we cannot consider any cost or investment aspects which have been brought forward in a range of theoretical papers due to missing data. Nevertheless, our results provide a first empirical indication about the role alternative forms of vertical ownership unbundling regulations and their impact on downstream competition.

References:


Höffler, F., and S. Kranz (2007b): Imperfect Legal Unbundling of Monopo-


## Appendix

### Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observations</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ownership structure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully integrated</td>
<td>772</td>
<td>0.75</td>
<td>0.43</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Fully separated</td>
<td>772</td>
<td>0.06</td>
<td>0.23</td>
<td>0</td>
<td>1</td>
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<td>Legally unbundled</td>
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<td>0.19</td>
<td>0.39</td>
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<tr>
<td>Retail Incumbent owns the DSO</td>
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<td>0.18</td>
<td>0.38</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>DSO owns the Retail Incumbent</td>
<td>772</td>
<td>0.1</td>
<td>0.11</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Share [0, 25]</td>
<td>772</td>
<td>0.06</td>
<td>0.24</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Share [25, 50]</td>
<td>772</td>
<td>0.01</td>
<td>0.09</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Share [50, 75]</td>
<td>772</td>
<td>0.01</td>
<td>0.07</td>
<td>0</td>
<td>1</td>
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<tr>
<td>Share [75, 99.99]</td>
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<td>0.01</td>
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<td>Share 100</td>
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<td>0</td>
<td>1</td>
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<tr>
<td><strong>Market prices (4000 kWh)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Incumbent standard price</td>
<td>771</td>
<td>877.68</td>
<td>41.89</td>
<td>732.56</td>
<td>999.61</td>
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<tr>
<td>Incumbent lowest price</td>
<td>771</td>
<td>833.71</td>
<td>39.95</td>
<td>680.00</td>
<td>958.44</td>
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<tr>
<td>Lowest price</td>
<td>772</td>
<td>754.61</td>
<td>26.51</td>
<td>574.53</td>
<td>824.00</td>
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<tr>
<td>Lowest price (prepayment)</td>
<td>772</td>
<td>705.85</td>
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<td>Distribution charge</td>
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<td>228.81</td>
<td>29.84</td>
<td>149.71</td>
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<td><strong>Market and network characteristics</strong></td>
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<td>Number competitors</td>
<td>772</td>
<td>43.91</td>
<td>6.75</td>
<td>12.00</td>
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<td>Population</td>
<td>688</td>
<td>115225.90</td>
<td>310824.90</td>
<td>570.00</td>
<td>3410000.00</td>
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<td>Density</td>
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<td>703.88</td>
<td>818.02</td>
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<td>Purchasing power</td>
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<td>101.74</td>
<td>80.98</td>
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<td>490.90</td>
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<td>Distributed area</td>
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<td>103.41</td>
<td>483.21</td>
<td>0.00</td>
<td>6737.16</td>
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<td>Area</td>
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<td>501.24</td>
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<td>Number tapping points</td>
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<td>65602.70</td>
<td>182375.50</td>
<td>0.00</td>
<td>2322236.00</td>
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<td>Annual electr. demand</td>
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<td>267255.30</td>
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<td>Underground cabel</td>
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<td>4725.86</td>
<td>1.17</td>
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<td>HV-Zone EnBW</td>
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<td>0.15</td>
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<td>HV-Zone Vattenfall</td>
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<td>0.37</td>
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## Table 2: Estimation Results (without prepayment)

<table>
<thead>
<tr>
<th>without prepayment</th>
<th>log (lowest price)</th>
<th>log (lowest incum. price)</th>
<th>log (standard contr. price)</th>
<th>log (distribution charge)</th>
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<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A</td>
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Table 3: Estimation Results (with prepayment)

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<th>with prepayment</th>
<th>log (lowest price prepayment) A</th>
<th>B</th>
<th>C</th>
<th>log (lowest incumbent price) A</th>
<th>B</th>
<th>C</th>
<th>log (standard contr. price) A</th>
<th>B</th>
<th>C</th>
<th>log (distribution charge) A</th>
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<td>0.2638548***</td>
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<td>0.3282023***</td>
<td>0.3324393***</td>
<td>0.3251707***</td>
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<td>0.2638548***</td>
<td>0.2669903***</td>
<td>0.3282023***</td>
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<td>-0.0933403**</td>
<td>-0.0933403**</td>
<td>0.2570069***</td>
<td>0.2638548***</td>
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<td>0.3282023***</td>
<td>0.3324393***</td>
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<td>log(# competitors)</td>
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Kommentar [22]: Zahlen auf 3 Nachkommastellen anpassen, Überschriften zentrieren, Tabellenumrahmung und – unterteilung

IX. Unbundling experience from other countries

New Zealand is the first country that has legally implemented ownership separation of electricity distribution from other commercial activities such as generation or retail. The separation was introduced in 1998 after electricity market restructuring in 1992 resulted in no significant retail price reductions. Nillesen and Pollitt (2008) analyze the economic effects of unbundling employing a dataset between 1995 and 2007 and show that prices for commercial customers decreased whereas household prices increased after the unbundling intervention. On the other hand, liberalization caused a strong reduction in the number of competitors as energy producers acquired retailers. In their consideration of the unbundling effect on production and distribution costs, Nillesen and Pollitt find significant operational cost reductions. However, they were not passed on to customers in the form of lower distribution charges.

Currently, a political debate is going on in the Netherlands about ownership separation on the distribution level which will be legally implemented in 2011. Nooij and Baarsma (2008) summarize the arguments of a strand of literature that ownership separation positively affects competition. Among others, they show in a scenario analysis of the Dutch electricity sector that discriminatory activities and cross-subsidization of vertically related companies are prohibited. In contrast to this theory-based analysis, Mulder et al. (2005) find only little evidence for a price effect due to vertical separation with a broad cross-country – cross-market analysis of vertical integration strategies.

Incumbent’s profit in case of vertical integration is composed of downstream profit and upstream profit and is given by:

\[ \pi_d = (p_d - c_d - c_e)D_d + (d - c_d)D_e - F_{de} - F_{de} - C(s_d,s_e) \]

The demand for one contract offered by incumbent is characterized by the marginal consumer who is willing to by the contract from the incumbent:

\[ D_d = \frac{P_d}{\tau_d + \tau_e} \]

The demand for the competitor is then:

\[ D_e = 1 + \frac{P_e - P_d - \tau_e}{\tau_d + \tau_e} \]

Given this information we can calculate the equilibrium prices:

\[ p_d^* = \frac{1}{3}(3d + 2c_d + c_e + s_d + \tau_d + 2\tau_e) \]

\[ p_e^* = \frac{1}{3}(3d + c_d + 2c_e + 2s_e + 2\tau_d + \tau_e) \]

and the profit function before choosing the sabotage strategy:

\[ \pi = \pi_d + \pi_e \]

---

17 For commercial customer on average from NZS 18.99 to 13.72 cents, and for household customers from NZS 14.40 to 18.60 cents after ownership unbundling. The average overall price remained constant (see Nillesen and Pollitt 2007, p. 30f).
\[
\pi^*_d = \frac{1}{3} \left( \frac{(d - c_d)(c_d - c_e - s_e + 2\tau_d + \tau_e)}{\tau_d + \tau_e} + \frac{(c_e - c_d + s_e + \tau_d + 2\tau_e)(3d + c_e - c_d - 3c_e + s_e + \tau_d + 2\tau_e)}{3(\tau_d + \tau_e)} - F_{d0} - C[s_e, s_e] \right)
\]

Lemma 2 is derived from the derivatives of equilibrium prices and equilibrium demand with respect to demand-decreasing sabotage in the last stage (i.e. before the sabotage strategy is chosen):

\[
\frac{\partial p^*_e}{\partial s_d} = \frac{1}{3} \left( \frac{2 \partial \tau_d}{\partial s_d} + \frac{\partial \tau_e}{\partial s_d} \right)
\]

\[
\frac{\partial p^*_e}{\partial s_d} = \frac{1}{3} \left( \frac{\partial \tau_d}{\partial s_d} + 2 \frac{\partial \tau_e}{\partial s_d} \right)
\]

a. Demand-decreasing sabotage increases incumbent’s downstream price and at the same time decreases competitor’s downstream price given that our assumptions hold and if \[ \frac{1}{2} \frac{\partial \tau_d}{\partial s_d} < \frac{\partial \tau_e}{\partial s_d} < 2 \frac{\partial \tau_d}{\partial s_d} \].

b. increases both equilibrium downstream prices given that our assumptions hold and if \[ \frac{\partial \tau_e}{\partial s_d} > 2 \frac{\partial \tau_d}{\partial s_d} \], i.e. competitors price is very sensitive to changes in own transportation cost compared with the effect on incumbent’s transportation cost,

c. vice versa, decreases both equilibrium downstream prices given that our assumptions hold and if \[ \frac{\partial \tau_e}{\partial s_d} < \frac{1}{2} \frac{\partial \tau_d}{\partial s_d} \]

\[
\frac{\partial D^*_e}{\partial s_d} = \frac{(c_e - c_d + s_e + \tau_e) \frac{\partial \tau_d}{\partial s_d} + (c_e - c_d + s_e - \tau_e) \frac{\partial \tau_e}{\partial s_d}}{3(\tau_d + \tau_e)^2}
\]

\[
\frac{\partial D^*_e}{\partial s_d} = \frac{(c_e - c_d - s_e + \tau_e) \frac{\partial \tau_d}{\partial s_d} + (c_e - c_d - s_e + \tau_e) \frac{\partial \tau_e}{\partial s_d}}{3(\tau_d + \tau_e)^2}
\]

a. Demand-reducing sabotage increases incumbent’s equilibrium demand \[ \frac{dD^*_e}{ds_d} > 0 \] and decreases competitor’s equilibrium demand \[ \frac{dD^*_e}{ds_d} < 0 \] given that our assumptions hold and \[ (c_e - c_d - s_e + \tau_e) \frac{\partial \tau_d}{\partial s_d} + (c_e - c_d + s_e + \tau_e) \frac{\partial \tau_e}{\partial s_d} \]. This inequality is true when the companies are comparably efficient, \( c_d = c_e \), and
incumbent’s transportation cost is lower than the competitor’s sabotage cost, \( \tau_d \geq s_j \) (or \( \left| \frac{\partial \tau_d}{\partial s_j} \right| < \left| \frac{\partial \tau_j}{\partial s_j} \right| \)).