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Abstract: We analyze vertical structures where a regulated network operator serves n network users, and the network users compete in quantities for customers. We distinguish two cases: (i) none of the network users are related to the network operator (ownership unbundling), (ii) one of the network users is partially integrated with the operator and the others are disintegrated (legal unbundling). We seek to understand when ownership unbundling leads to lower customer prices, and formalize necessary conditions. In general, legal unbundling implies a less effective regulation, but it reduces the degree of market distortion caused by the difference between marginal costs and average costs (= regulated prices of network usage). We find that the necessary condition is not satisfied for realistic values of the relevant parameters, i.e. legal unbundling leads to lower costumer prices than ownership unbundling in most relevant markets.

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I. Introduction

Gas, electricity, railway, and other networks exhibit strong economies of scale and scope. Such networks are the prototypes of natural monopolies, and it is widely agreed that splitting up such networks is connected with higher costs than maintaining a regulated monopoly (in a certain region and depending on whether they are for transmission/transportation or retail, see e.g. Leautier, 2001). The regulation is to ensure that the network users are offered access at "competitive" prices and without discrimination (neither with respect to price nor to availability).

Historically, the networks have been vertically integrated; they are owned, for example, by the producers (importers) of electricity (gas). Hence, a prerequisite for regulated common access to the network is unbundling the network services from other business fields. Unbundling may come in three (or four) degrees:

1. *Accounting/functional unbundling:* The firm remains integrated but re-organises its book-keeping so that the costs of the network services can be identified.
2. *Legal unbundling:* The network services are provided by a separate firm. It is still connected with the production and trade activities of the previous integrated firm via a holding structure (see Figure 1).
3. *Ownership unbundling:* In addition to legal unbundling, the holding company has to sell either its network or both its production and trade arm.

Legal unbundling is the minimal requirement in most (EU) countries with respect to energy networks. Accounting unbundling is reserved for small utilities (<100.000 customers in Germany), and only a few countries have (thus far) passed legislation requiring ownership unbundling (as England and Austria have for transmission networks). In a number of countries, it is discussed, however, whether the minimal requirement should be increased to ownership unbundling (e.g. in the Netherlands and in Germany). Amongst others, the European Commission supports such a transition and argues (Energy Sector Enquiry-Issues Paper, DG Competition 15/11/2005, clause 28) that "The UK market experience of full ownership unbundling suggests that it significantly changes the behaviour of the transport undertaking: a

fully unbundled TSO will focus on optimizing the use of its network." Recently, also the EU commissioner for competition, Neelie Kroes (2006), explicitly required ownership unbundling.

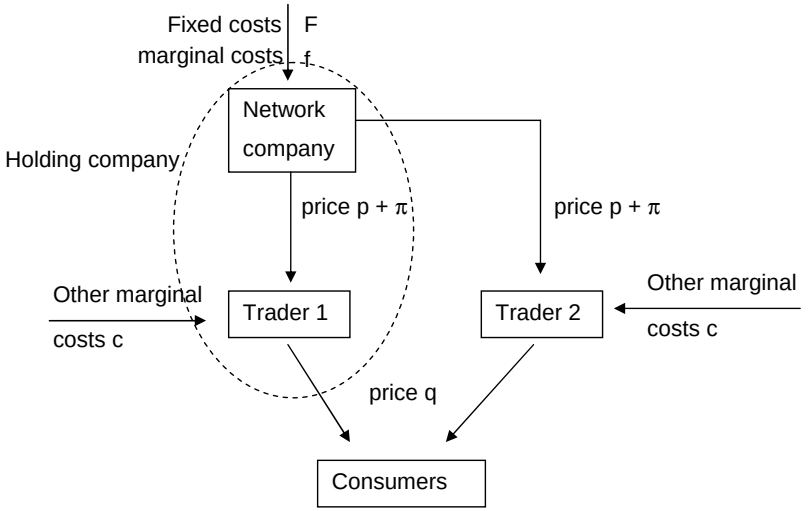

Figure 1: A legally unbundled energy provider (Network company, Trader 1) and a competitor (Trader 2).

The main advantages of stricter unbundling are (see Tönjes, 2005):

(i) Less incentives/opportunities for discrimination.
(ii) Less incentives/opportunities for cross-subsidising.
(iii) A more effective and efficient regulator.

Points (i) and (ii), in particular, constitute opportunities to cheat and decrease the effectiveness of the network regulation. In contrast to accounting unbundling, legal unbundling diminishes these opportunities, but a transition to ownership unbundling would remove them altogether. In this paper, we model the transition from legal to ownership unbundling, and based on the formal results, we discuss the relative merits of these regimes. In the model, we concentrate on analyzing the impacts of cross-subsidisation (point ii) and regulation effectiveness (point iii). That is, the model

neglects the potential impact of explicit customer discrimination. On the other hand, we also neglect the following disadvantages of ownership unbundling (Tönjes, 2005):

(iv) one-time costs related to ownership change,
(v) reduced credit ratings of the resulting smaller firms,
(vi) buyers outside the electricity (gas) business can be reluctant to buy such a network (resulting in a unsatisfactory market price).

A final point is that legal unbundling improves the information flow between the network operator and its users (see e.g. Newbery, 1997). A model related to this is presented in Gilbert and Riordan (1995) and will be discussed below.

The effectiveness of the network regulation varies with a parameter π. Its value is zero for ownership unbundling and positive for legal unbundling; and it represents the price increment (for network access) that results from the reduced regulation effectiveness under legal unbundling. That is, the profit transfers that are possible under legal unbundling imply that the costs of network access are $p+\pi$ per unit, but only p per unit under ownership unbundling. (Profit transfers can be made, for instance, by renting overpriced office space from another company of the holding firm.) The question that we address is: Does the improved effectiveness of regulation under ownership unbundling imply that the consumers are better off? The answer to this question is not a clear yes, as the possibility of profit transfers under legal unbundling implies a certain degree of vertical integration, and thus it reduces the implications of a phenomenon known as double marginalisation (Spengler, 1950). In double marginalization as well as in "average costs" regulation, allocative decisions are based on costs which are above marginal costs.

In principle, the existence of this trade-off (effective regulation vs. double marginalization) between legal and ownership unbundling is understood. In this paper, we model the transition from legal to ownership unbundling formally, to make the specific aspects of this trade off more transparent. Our model extends existing models in that we allow that a regulated network operator sells network access to network users competing in a Cournot fashion. That is, our study differs from existing studies in at least one of the following two dimensions. On the one hand, the network

operator cannot negotiate bilaterally with the network users about the price of network access, and there is no explicit market mechanism that balances supply and demand of network access. For general studies of market mechanisms and negotiations in vertical structures see e.g. Abiru et al. (1998), Baake et al. (2004), and the references cited therein, and for applications to network competition see e.g. Joskow and Tirole (2000), and Leautier (2001). Thus, we assume "regulated third party access" (see Newbery, 2002), i.e. a regulator sets a "fair" price (rate of return regulation) or defines a "fair" price setting procedure (cap regulation) which, however, has to be colibrated after several years by "rate-of-return considerations". Deviations from the "fair" price are possible by means of (secret) profit transfers. In our case, such deviations are possible only under legal unbundling for the network user that belongs to the same holding as the network operator.

On the other hand, we assume that the network users compete in quantities for customers, not in prices (see e.g. Laffont et al., 1998). In the spirit of Kreps and Scheinkman (1983), and related literature, we think of the equilibrium quantities as capacities, and thus we model the emerging market structure rather than the short-term equilibrium prices. It will be clear that a Cournot model captures equilibrium capacities only in a stylized way, but as we shall see, even such a simple model will be able to provide significant insights into the relative merits of legal and ownership unbundling.

The answer to the initial question ("Does ownership unbundling imply smaller consumer prices?") depends on π as discussed above, and on the fixed costs of the network operator (labelled F in the following). In general, the larger π and the smaller F is, the more appropriate ownership unbundling is. The fixed costs F are relevant, since they define the difference between p (=average costs plus allowed return on capital) and f (=marginal costs of the network operator). The implied difference of p and f is relevant, in turn, as the profit of the network user integrated with the network operator (under legal unbundling) is not a function of the price set by the regulator, $p+\pi$, but a function of the marginal costs f. The basic trade-off consists of the following two elements. (A) under legal unbundling, the integrated network user faces a price $f<p$, and therefore, it supplies a larger quantity than the

corresponding firm would under ownership unbundling. (B) the competitors face a price $p+\pi > p$ under legal unbundling, and therefore provide lower quantities under legal unbundling than under ownership unbundling. It depends on the relative values of f, p, and π as to whether (A) or (B) dominates.

In Section II, we analyze two models to determine when ownership unbundling implies lower prices, i.e. when effect (B) dominates. The first model is the outlined Cournot model, and the second model concerns a medium-term perspective of the transition from legal to ownership unbundling. In the second model, the incumbent has a dominant position and the market entrants constitute a competitive fringe. In Section III, we discuss the formal results with an eye on several existing networks. We argue that, in relation to p, the values of f and π are rather small in most cases, which implies that the consumers would usually be better off under legal unbundling. Section IV relates our results to the literature and offers a conclusion.

II. Two models of legal vs. ownership unbundling

II.1. General assumptions

We assume that consumer demand is described by

(1) $p = P(x)$ with x as the total quantity provided.

$P(x)$ is assumed to be decreasing until $P(x_0) = 0$ for a certain x_0, or to satisfy $P(x) \to 0$ for $x \to \infty$. $xP(x)$ is assumed to be a concave function, i.e.

(2) $xP''(x) + 2P'(x) < 0$.

Eq. (2) implies that monopoly and equilibrium oligopoly prices exist. It is fulfilled for a fairly general set of demand functions, e.g. for linear demand functions and for $P(x) = x^{\alpha}$ with $-1 < \alpha < 0$. In turn, for $\alpha < -1$, $xP(x) \to \infty$ for $x \to 0$ would result, i.e. a monopoly could realize arbitrarily large profits by supplying almost zero quantities.

A single network operator serves the market (region). Under legal unbundling, it provides its service at the price $p+\pi$, under ownership unbundling at price p. Its costs are $F + f \cdot x$, where x denotes the aggregate quantity of network services. The transportation of one unit of the good to a consumer requires one unit of network service.

There are traders $1,\ldots,n$ who are interested in using the network (e.g. in railway transportation, or to distribute gas or electricity) with marginal costs of c per unit. Under *legal unbundling,* Trader 1 and the network company belong to the same holding company, and due to this he makes decisions as if his costs of purchasing network services were f. Under *ownership unbundling,* the market structure is symmetric, i.e. Trader 1 faces marginal costs p when using network services.

II.2. An oligopoly model

This subsection is concerned with a model where the incumbent trader (i.e. Trader 1) does not have a predominant position in the market. The traders $2,\ldots,n$ face prices equal to $p+\pi$ in the case of legal unbundling, and p in the case of ownership unbundling (as indicated above, Trader 1 has costs f and p, respectively). The marginal production costs of the firms $1,\ldots,n$ are symmetric and equal to c.

Firm i's profit from supplying x_i to the market is

(3) $G_i = x_i \cdot P(x) - a_i x_i$

with $a_i = \begin{cases} p + c & \text{under ownership unbundling} \\ p + \pi + c & \text{for } i \neq 1 \text{ under legal unbundling} \\ f + c & \text{for } i = 1 \text{ under legal unbundling} \end{cases}$

The best reply of i is the solution of

(4) $\frac{\partial G_i}{\partial x_i} = P(x) + x_i \cdot P'(x) - a_i = 0$

provided

(5) $\frac{\partial^2 G_i}{\partial x_i} = 2P'(x) + x_i P''(x) < 0$.

Eq. (5) is fulfilled because of Eq. (2) and the fact that $P'(x) < 0$ and $x_i < x$. This implies that $P(x) + x_i P'(x)$ is decreasing in x_i, and thus, using $x_{-i} = \Sigma_{j \neq i} x_j$, if $P(x_{-i}) - a_i > 0$, then there exists an x_i which satisfies Eq. (4).

Adding up Eq. (4) for all i leads to

(6) $xP'(x) + nP(x) = \sum_i a_i$

Eq. (2) implies that the left hand side of Eq. (6) is a decreasing function of x. In addition, we know that $P(x)$ approaches 0 for large x. Therefore, if the average a_i is less than $P(x)$ for small x, e.g. less than $P(0)$ if $P(0)$ exists, then Eq. (6) has a unique solution x^*. If a firm i exists with a_i greater than $P(x^*)$, then we obtain a corner solution where this i supplies zero quantity. In this case, the number of players and Eq. (6) would have to be adjusted accordingly, and the average a_i would decrease. The market price $P(x^*)$ would also decrease, and the equilibrium x^* would increase. We can see this after rearranging Eq. (6).

(7) $x \cdot P'(x) + (n-1)P(x) = \sum_{i=1}^{n-1} a_i + a_n - P(x)$.

Assume that $a_1 \leq a_2 \leq \cdots \leq a_n$ and $a_n > P(x)$, i.e. Trader n does not appear in the market. Eq. (2) implies that the left hand side of Eq. (7) is a decreasing function of x, and thus, after omitting $a_n - P(x)$ on the right hand side, x^* has to increase.

Based on this general discussion, we can compare ownership unbundling and legal unbundling. In the case of ownership unbundling, we have $a_i = p + c$ for all firms, i.e.

$\Sigma_i a_i = n \cdot (p + c)$. In the case of legal unbundling, $\Sigma_i a_i = nc + (n-1)(p + \pi) + f$, or $\Sigma_i a_i = a_1 = c + f$ if $p + \pi + c > P(x)$. In the latter case, $c + f < P(x) < c + p + \pi$.

As the left hand side of Eq. (6) is a decreasing function of x, the equilibrium quantity decreases if $\Sigma_i a_i$ increases. Hence, the equilibrium price increases if $\Sigma_i a_i$ increases. The following statement exploits this to characterise the relationship between the equilibrium prices for legal unbundling and ownership unbundling.

Proposition 1: Legal unbundling implies smaller consumer prices q than ownership unbundling if

(8) $p - f > (n-1) \cdot \pi$

Proof: If Eq. (8) is satisfied, then $\Sigma_i a_i$ is smaller in the case of legal unbundling than in the case of ownership unbundling.■

Verbally, legal unbundling tends to imply more favourable market prices than ownership unbundling,

- the smaller the regulatory ineffectiveness π is,
- the smaller the number of potential competitors $n-1$ is, and
- the larger the difference between the regulatory price p (including fixed costs and profits of the network company) and the marginal costs f of the network company are.

In particular, legal unbundling is preferable if $\pi = 0$.

II.3. A model with a competitive fringe

In most cases where private firms have obtained access to networks of previous state monopolies, the incumbents remain to be the dominant actors. At least, it appears fair to say that for rather lengthy transition phases, market entrants would gain only small market shares. This is most significant in France, see Glachant and

Finon (2005), but applies also in Germany where, until 2004, only 6% of the small German industrial costumers (though 35% of the large industry) have changed their supplier of electricity (Commission of the European Communities, 2005)**.** Similarly small percentages are reported for other European contries. Exceptions are UK and Norway where more than half of the industrial customers changed their supplier. Therefore, we complement the long-term perspective provided above, the case of an oligopoly, with the medium-term perspective in this subsection, i.e. with the case that the non-incumbent firms constitute a "competitive fringe." Note that a similar approach to distinguishing the "mature phase" from a "transition phase" of network industries can be found in Laffont et al. (1998), although for a different context of network competition.

We model the aggregate behaviour of the non-incumbent firms through the supply function $S(q-c-r)$ with q as the market price and $r=p$ or $r=p+\pi$, depending on the type of unbundling (see above). The incumbent Trader 1 charges the monopoly price for the residual demand $P^{-1}(q)-S(q-c-r)$, considering his respective marginal network costs $a=p$ or $a=f$ (as above).

The profit function of Trader 1 is

(9) $$G_1(q)=(q-a)\left(P^{-1}(q)-S(q-c-r)\right)$$

The market price q is the solution of

(10) $$\frac{dG_1}{dq}=P^{-1}(q)-S(q-c-r)+(q-a)(P^{-1'}(q)-S'(q-c-r))=0\,.$$

To simplify the notation, let us assume that S is the linear function $S(z)=bz$ with $b>0$. Using $q:=P(x)$, $P^{-1}(q)=:x$, and $\frac{dP^{-1}(x)}{dx}=\frac{1}{P'(x)}$ we obtain

(11) $$x+\frac{P^{-1}(x)}{P'(x)}-2bP^{-1}(x)+bc=a\cdot\left[\frac{1}{P'(x)}-b\right]-br\,.$$

The left hand side of Eq. (11) is an increasing function of x, as $P^{-1}(x)$ is a decreasing function of x, and $P'(x)<0$. Thus, the larger the term on the right-hand side of Eq. (11), the larger the x that solves Eq. (11) will be, and the smaller the market price q.

Proposition 2: In the case of a competitive fringe, legal unbundling leads to larger quantities and lower consumer prices if

(12) (p – f) $$\left(b-\frac{1}{P'(x)}\right)>b\pi$$

Proof: Compare the right hand sides of (11) for (a, r) = (p, p) and (a, r) = (f, p + π). ■

Finally, note that $P'(x)<0$ implies that Eq. (12) is fulfilled if

(13) $$p-f>\pi\,.$$

Thus, Eq. (8) implies Eq. (13), and thus it also implies Eq. (12): if legal unbundling leads to preferable consumer prices in the long-term perspective (in the oligopoly), then ownership unbundling cannot be preferable in the transition phase. In other words, legal unbundling is preferable in the long term only if it would be preferable in the medium term, and Eq. (13) is a formal representation of the latter necessary condition.

III. Application of the model

Legal unbundling implies smaller consumer prices than ownership unbundling (i) in the long term if Eq. (8) is satisfied, and (ii) in the medium-term transition phase if Eq.

(13) is satisfied. Moreover, Eq. (13) is a necessary condition for Eq. (8), and they coincide if $n=2$. In this section, we discuss under which conditions one would expect that the necessary condition Eq. (13) is satisfied. This discussion extends to the long-term scenario if the expected number of players n with significant market shares would not be too large, but it extends also if the transition phase is rather long and the consumers (or, perhaps the government considering the transition) are sufficiently impatient. Unfortunately, there is not enough experience with networks that are deregulated for a sufficiently long term in order for a true oligopoly market to have been established (as mentioned, most networks are still in the transition phase). Therefore, such a discussion would be speculative at this point. In the rest of this section, we shall concentrate on discussing Eq. (13).

III.1. Costs and regulated prices

First, we want to emphasise that π does not measure inefficiency of producing the network service – in fact there is no such inefficiency in our model (only allocative inefficiency) – but ineffectiveness of regulation. It will be clear that the provision of network services is rarely completely efficient (in particular in the case of retail networks), but such inefficiencies are not necessarily associated with the unbundling regime. Ideally, a scheme of incentive regulation is chosen such that the market operates efficiently and, theoretically, this can be achieved independently of the unbundling regime.

In our model, the costs of network services can be separated into fixed costs and variable costs. In the case of rate-of-return regulation, the rate base K (= "used and useful" capital) and the variable costs v ("prudent" outlays) would have to be determined. Then, the network customers would have to pay $\frac{(1+\rho)K}{x}+v$ with x as the total quantity and ρ as the allowed rate of return. Thus, $f=v$ and $p-f=\frac{(1+\rho)K}{x}$, and therefore ownership unbundling is preferable to legal unbundling in the sense of Eq. (13) if

(14) $p-f=\frac{(1+\rho)K}{x}<\pi$.

Capital costs are dominant in networks – 80% is a rough but adequate estimate (they are larger in high voltage/high pressure networks for distance transportation and lower in retail networks). Hence, ownership unbundling is preferable only if π is larger than 80% of p. To illustrate this, ownership unbundling would be preferable only if its increased effectiveness implies that the price drops by 44% (from $p+\pi=1.8p$ to p). We assume that this would be the exception rather than the rule.

Under cap regulation and under yardstick competition, the network operator is provided with incentives to operate efficiently. However, under cap regulation he would generally not be motivated to remove the ineffectiveness π. The price p would regularly be readjusted, and if the regulated company succeeds in substituting its efficiency gains through increased ineffectiveness π, then it does not need to fear stricter cost saving requirements in the next cap period. The incentive to keep π high in yardstick competition is lower than in cap regulation, but again it would be higher than 0.

Thus, if combined with a sufficiently ineffective variant of rate-of-return regulation or cap regulation, ownership unbundling might be preferable to legal unbundling. In combination with an effective (i.e. incentive compatible) variant of regulation however, legal unbundling would generally be preferable.

Finally, let us consider the case that the network capacity is exhausted (e.g. in peak periods). Then Trader 1 would not consider the short-term marginal costs of the network operator (under legal unbundling), but he would consider the (long-term) variable costs, i.e. marginal costs close to p. Then, and depending on how often peaks reach the capacity constraint, the advantages of legal unbundling would cease to exist. In such cases, the regulator would demand capacity expansions, regardless of which unbundling scheme had been chosen (and in general, it is well understood that scarcity of network capacity is one of the main obstacles to competition among the network users, see Leautier, 2001, for a formal discussion and a review of the

literature, and also Newbery, 2002). In addition to such external motivation, however, the network operator would be more interested in extending the capacity under legal unbundling than under ownership, because Trader 1 has a stronger effect on competition under legal unbundling. Hence, the frequency of peaks reaching the capacity constraint is lower under legal unbundling.

In the following subsections, we discuss specific networks in more detail, to give an impression of the actual magnitude of π in relation to $p - f$. We will conclude that π is typically less than $p - f$ by an order of magnitude which suggests that legal unbundling is preferable in both the medium term, Eq. (13), and the long term, Eq. (8).

III.2. Railway transportation in Germany and Europe

Germany has witnessed several years of fierce discussions about the privatization scheme that would be applied to the state-owned DB (Deutsche Bahn). The management of DB and the dominant unions are vigorously in favour of legal unbundling, while the German monopoly commission (Monopolkommission, 2006) clearly favours ownership unbundling (to keep the rail as public property and privatise the rest of DB). The argument of those favouring legal unbundling is the "loss of economics of scope," but their main fears appear to be the loss of market power and laying off of staff of the disintegrated network and transportation companies. In the following discussion, we concentrate on the situation in Germany, but the arguments and the conclusion apply more or less to most other European countries.

The railway services in less densely populated regions have to be subsidised heavily. So extending the network is not an issue. Even the usage of the rails between the two largest German cities, Berlin and Hamburg, is far from being exhaustive. Moreover, in contrast to pipeline transportation the adjustment of capacity can be made only in discrete steps. The maximum speed that a track allows is a qualitative attribute and can not easy be used to fine-tune capacity.

This suggests that f is negligible in relation to p in the case of railway transportations. Furthermore, competition is not yet existent and will continue to constitute a competitive fringe for years to come. Both of these facts strongly support the case for legal unbundling, while the regulator should concentrate on the task of keeping π low.

III.3. Electricity in Germany and in Europe

Electricity is the sector with the most significant progress in unbundling and competition. Nonetheless, even in the most competitive segment, of large industrial customers, only in 7 of the EU-25 counties the incumbents defended less than 2/3 of the market (Commission of the European Communities, 2005). So, in most countries, the competitive fringe model seems to be justified.

The German regulator Bundesnetzagentur recently published cost comparisons, based on data submitted by the regulated networks. The data had been classified according to the voltage of the lines, customer density, and with respect to the location (former GDR or not). The cost differences within these classes are huge. The ratio of max cost/min cost ranged from 2.64 to 31.07 for low voltage networks and from 1.53 to 33.22 for high voltage networks (the ratios for three categories of medium voltages are similar). This suggests that the productive efficiencies differ a lot, and also that there are significant differences with respect to the networks' attempts to establish ineffectiveness π. Bundesnetzagentur reacted in 2006 by preventing price increases for network services and, in a number of cases, by requiring price reductions of up to 20%. On average, the network fees in Germany are nearly twice as high as in Great Britain or in Sweden; but based only on the above report, it is difficult to gauge to what degree this results from inefficiency or from ineffectiveness of regulation. In addition, the large German variance implies that many German utilities have costs and require network fees not above those in England or Sweden.

The most efficient network class appears to be the part of the high voltage transmission system that is run by the four big producers E.ON, RWE, Vattenfall, and

EnBW (EdF). In addition to possibly differing π, cost differences amongst these lines stem from the location (there are more new lines in the East, which implies a larger capital stock/rate base), and from the more difficult management of wind energy from northern Germany which requires more ancillary services than electricity from classical power plants. On average, however, the cost structure should be comparable with that of the UK, which has a similar customer density and also large north-south flows in the network. Moreover, the transmission prices in the UK are rather similar to those in Germany (etso, 2005). Hence, the difference of regulated transmission fees under ownership unbundling (England) and legal unbundling (Germany) is negligible. By definition, a measure of this difference is π. We conclude that π is small (if not close to 0), and that legal unbundling would be preferable for transmission.

III.4. The Gas Industry in Germany and England

Competition in the gas industry has yet to develop in Germany. Although there are nine importing pipelines and 20% domestic production, there is restricted competition even for large industrial customers (7% changed their supplier until 2004, see Commission of the European Communities, 2005)) and practically non-existing competition in the household sector. In England, the respective numbers are $>50\%$ and 47% (Commission of the European Communities, 2005)**,** but that seems to be an exception. In only four of the EU-25 countries entrants succeeded in conquering more than a third of the market. This suggests again that (at this stage) the competitive fringe model seems most appropriate.

Similar to electricity transmission, there are large cost differences between the networks in Germany. The ratio between maximum and minimum costs in different classes lies between 2.5 and 15.6.

In the past, the gas sector was far less regulated than the electricity sector. It was assumed that interfuel competition against oil and coal would keep the gas prices down. Gas to gas competition has hardly developed, however. The most important contract forms are the long-term (from several years up to 30 or 40 years) Take or

Pay contracts which dominate import deliveries as well as deliveries between pipelines and retailers. Meanwhile, in Germany, the duration of contracts with retailers is restricted to 2 – 4 years, but further measures are required to stimulate competition. With respect to import contracts, release auctions might be used to increase the number of traders in the market. Currently, for instance, DONG (in Denmark) and Ruhrgas (in Germany) are obliged to offer considerable quantities in such auctions (see also Bolle and Breitmoser, 2006). For 2002, the regulator Bundesnetzagentur established a new regulatory framework, and thus, it appears advisable to postpone the (practically irreversible) transition to ownership unbundling until the implications of the stricter regulation can be observed. It is interesting, however, that for large customers, network fees do not seem to differ much in European countries (European Commission, 2005). The prices in Germany display a rather large variance, but the smallest prices in Germany are comparable to the smallest ones in Europe, including England. The comparison with England (with ownership unbundling and auction prices for the transportation of large quantities) is most remarkable, as it suggests again that ownership unbundling is not a prerequisite for a small π.

IV Discussion and Conclusion

We compared the implications of ownership unbundling and legal unbundling in regulated networks, with an eye on the implied consumer prices. We have seen that ownership unbundling does not generally imply lower consumer prices. For realistic values of our model parameters (i.e. of p and π), legal unbundling would actually imply more preferable consumer prices.

This contradicts a widely held belief that ownership unbundling is preferable. One of its main advocates is the European Commission who regularly refers to the successful British example in the Electricity and Gas industry when requiring ownership unbundling. At this point, however, one should note that the success of the British example is not necessarily a result of full disintegration. For instance, SERIS (2006) credits improvements in the gas network usage mainly to regulatory developments and not to disintegration.

Kwoka (2002) shows that disintegrated (American) utilities bear higher costs. Partly, this may be a result of double marginalization: the production/purchasing costs of highly integrated utilities (exporters of electricity) are only half of those of the least integrated utilities (importing more than 50% of their supply). To a large degree, these cost differences (due to unbundling production and retail) can be expected to carry over to cases of unbundling production and transportation. With respect to the electricity sector, Newbery and Pollitt (1997) showed that from 1990 to 1996, the restructured sector became more efficient, but also that these efficiency gains did not lead to falling prices. In the period from 1996 to 2001 prices decreased in GB and from 1998 on also in Germany.

Those observations do not constitute direct evidence for our model, as we compare ownership unbundling to legal unbundling (not to a fully integrated company), but they show that dissolving the vertical integration is not only theoretically problematic, but also empirically. In some sense, it may now appear that legal unbundling has the best of both worlds. It maintains a certain degree of vertical integration, but strengthens the competitive forces required for efficient production. This conclusion would, of course, be far too bold, given the simplicity of our model. In the following, we briefly discuss related findings from the literature to provide a more complete picture of the situation.

A large body of literature is concerned with the information asymmetries between the regulator and the regulated firms. In our case, the regulator is not informed about the costs of the network operator, but he has the task of setting a price for network access. A different model is presented in Gilbert and Riordan (1995) where, in a Principal-Agent model, a customer/regulator player is identified with the principal. They consider two models, in one case a vertically integrated monopolist (provided network access *and* electricity), and in the other case two disintegrated monopolists (one providing the network access and the other one providing electricity). There are no other firms in the model. The technical problem (of the principal) is to write optimal contracts under incomplete information about the costs of the firm(s). Gilbert and Riordan find that unbundling may (but not necessarily) be advantageous, based on an argument referring to double marginalization as in our model. The details of the argument differ, since the model differs (in a crucial way, as electricity generation is

not subject to regulation in our case), but the main reason as to why vertical unbundling threatens efficiency remains.

We assumed that the network capacity is not scarce. Leautier (2001) shows that “a transmission company also involved in generation would strategically plan [under-] expansion of the transmission network [i.e. underinvestment], or fail to maintain or upgrade portions of the grid, to increase its profits” (p. 47). A related result is provided by Joskow and Tirole (2000), who show that integrated firms may restrict access to transmission capacity in order to raise the profits of its production arm. This suggests that scarcity is inherent in legal unbundling, but the opposite conclusion is reached by Cremer et al. (2006). We do not want to go into the details of this aspect, but simply remind that maintaining an adequate network capacity is crucial for an effectively operating market (see Newbery, 2002), and ensuring this is one of the main tasks of the regulator. Apart from this, the incentives to maintain and extend the network capacity are larger (in our framework) under legal unbundling than under ownership unbundling (see above). Hence, the network capacity would not be lower under legal unbundling than under ownership unbundling (ceteris paribus). Therefore, even in cases where the capacity constraint is reached under legal unbundling (which would imply that the full potential of legal unbundling cannot be developed), the provided market quantity would not be less than under ownership unbundling (and hence the price would not be higher). Needless to say, this intuitive argument would have to be formalized in a corresponding framework, ideally in a dynamic model.

Our approach in modelling the transition from legal unbundling to ownership unbundling allows for two phases: a transition phase where the non-incumbent network users constitute a competitive fringe and a mature phase where an oligopoly has emerged. We argued that legal unbundling is likely to be preferable in both phases, and hence overall. This neglects the fact that the length of the transition phase may depend on the unbundling regime. Due to the asymmetric market structure induced under legal unbundling, the mature phase may be reached more quickly under ownership unbundling. Hence, for some intermediate discount factors (i.e. not too small and not too close to 1) ownership unbundling may imply a preferable discounted sum of consumer surpluses.

Finally, van Koten and Ortmann (2006) show that the degree of unbundling and the degree of corruption (measured by the Corruption Perception Index CPI of *Transparency International*) are negatively correlated. This suggests that lobbying is required to convince policy makers not to disintegrate the industry structure, and that the lobbyists (i.e. the incumbent firms) expect to benefit from higher degrees of vertical integration. This does not necessarily indicate that the consumers would lose out. Starting with Spengler (1950), a large body of literature seeks to explain when the commercial interests of firms are aligned with the interests of their customers. It has been shown that vertical integration does have positive aspects, and this study displays this result in the case of regulated networks with Cournot competition in the customer market. Further aspects remain to be analyzed, as discussed for instance in Newbery (1997), but at this point, it remains debatable whether and when ownership unbundling is preferable.

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