Finnish Economic Papers – Volume 16 – Number 2 – Autumn 2003

QUANTITY VERSUS PRICE COMPETITION IN THE DEREGULATED FINNISH ELECTRICITY MARKETS*

MARIA KOPSAKANGAS-SAVOLAINEN

Department of Economics, University of Oulu,
P.O. Box 4600, 90014 University of Oulu, Finland

The main motivation to deregulate Finnish electricity markets and introduce competition to the industry was to improve efficiency and obtain lower prices. In this paper we use a numerical simulation model in order to analyse the impact of market structure to the wholesale price of electricity. We solve Cournot equilibrium and Bertrand equilibrium. The results indicate that in some circumstances deregulation might actually lead to higher prices instead of lower ones. This happens if Cournot competition is realised and consumers do not react to the competition by becoming more price sensitive. If, however, price elasticity of demand increases deregulation will lead to the lower prices and higher production regardless of the market structure. (JEL: D43, L11, L94)

1. Introduction

The new Finnish Electricity Market Act went into effect in November 1995. At that time the production and supply of electricity was deregulated and competition was introduced to the industry. The main aim of the law was to improve efficiency and to provide opportunities for the Finnish electricity companies to compete successfully in the emerging international markets. According to the law production, supply and network services have to be vertically separated. Supply and production were opened to free competition, but network services[1] have retained their position as a natural monopoly and they are still regulated. In addition, network prices have to be equal for all energy suppliers.

The purpose of this paper is to study the consequences of the deregulation for the wholesale price of electricity and the market structure of the industry.[2] In particular, it is interesting to study whether it is possible that deregulation in some circumstances may actually lead to higher prices instead of lower ones. Similar kinds of studies have been conducted in Britain by Green and Newbery (1992) and in Sweden by Andersson and Bergman (1995). Green and Newbery focus on the symmetric duopoly situation prevailing in England and in Wales. They

* *This paper is based on the fourth chapter of my dissertation (Kopsakangas-Savolainen, 2002). I wish to thank Erkki Koskela, Mikko Puhakka, Matti Tuomala, Rauli Svento, the editor and two anonymous referees for very helpful comments and suggestion. Financial support from the Nordic Energy Research Program is gratefully acknowledged.*

[1] *Including transmission and distribution.*

[2] *The market structures considered are the Cournot market structure and Bertrand market structure.*

use a supply-function equilibrium approach suggested by Klemperer and Meyer (1989).[3] Andersson and Bergman concentrate on an asymmetric oligopoly, where one firm has a very large market share. Quantity decisions play a major role in their model because of the strong dependence on hydropower in Sweden. Our study follows closely the approach adopted by Andersson and Bergman. We use this approach since the production structure in Finland is much closer to that prevailing in Sweden than the one in the United Kingdom. Sulamaa (2001) has also utilised the model of Andersson and Bergman. His approach, however, differs in some respects. The main differences are connected to the data and to the value of the price elasticity of demand. We have excluded from our data those producers who are not operating actively in the market, i.e., those who consume all the electricity they produce, whereas Sulamaa has treated them as active operators. Furthermore, we have not taken gross ownership into account, contrary to Sulamaa, since according to our view each producer operates in the market as an independent competitor. In simulations we used the elasticity value of –0.35, while Sulamaa used the value of –0.6. The value –0.35 is well supported by earlier studies (see, e.g., Filippini, 1999, Törmä, 1985, and Willner, 1996). The findings of Sulamaa are in any case similar to ours. The major difference is that the changes in price and quantity resulting from the change in the market structure are clearly bigger according to Sulamaa.[4]

Green and Newbery (1992) found that in Britain the electricity production markets are far too concentrated if the target of lower prices is to be reached through deregulation and free competition. They argue that since the British electricity production is characterised by a strongly duopolistic situation, achieving welfare[5] improvements requires strict price regulation. Andersson and Bergman (1995) concluded that deregulation is not a sufficient condition to improve welfare. In the Swedish electricity markets it is necessary to have at least five electricity-producing firms of equal size in order to have lower prices and higher production.

Even though we closely follow the approach adopted by Andersson and Bergman, there are some differences. The structure of the Finnish electricity markets is not as concentrated as that in Sweden. The largest and the second largest producers in Sweden have a market share of 50% and 25% respectively (see Sørgard, 1997). The corresponding figures are 28% and 19% in Finland (1995). Moreover, 95% of the production in Sweden is based on hydropower and nuclear power. In Finland backpressure power and condensing power also play important roles. Because they are easier to adjust than nuclear power, the Finnish electricity markets can be viewed as perhaps more flexible than the Swedish markets.[6]

In this paper we use a numerical model to analyse the output and the prices of electricity in high voltage electricity markets. The relationship between the Cournot equilibrium and the Bertrand equilibrium will be quantitatively explored. The paper is organised as follows. In section 2 we discuss the suitability of quantity versus price oligopoly models to characterise the electricity industry. Section 3 introduces the model utilised. In section 4 we present the data. Section 5 provides the results and section 6 concludes.

2. *Price versus quantity models and electricity markets*

Whether price or quantity is more suitable as a strategic variable depends strongly on the nature of the industry. Some authors (see, e.g., Kreps and Scheinkman, 1983, and Maggi,

[3] See also Bolle (1992) for an application of supply-function equilibrium approach.

[4] For a further explanation of the differences in results see chapter 5.

[5] The term welfare is used throughout this study to refer to consumer and producer surpluses.

[6] We have not connected this study to the Nordic Power markets because deregulation occurred at different times in different Nordic countries and this caused problems with the availability and comparability of the data. In addition, the fact that the model we use in this study does not take transmission congestion possibility into account, as clearly should in the integrated market model, motivated us to concentrate to the Finnish markets solely.

1996) have stressed that the mode of competition is usually determined endogenously in the market. This means that firms cannot exogenously determine whether they want to compete by price or by quantity. The form of competition, and thus the determination of the endogenous mode of competition, is determined mainly by the importance of capacity constraints. Kreps and Scheinkman (1983) did not model the capacity commitment of the firms as an inflexible constraint. Firms can produce under circumstances of excess capacity, but at a higher marginal cost. In particular, it is this additional cost of producing above capacity which captures the importance of capacity constraints. Firms first set their capacity and then compete with prices given the cost curves generated by their choice of capacity. The equilibrium outcome ranges from the Bertrand to the Cournot outcome, as capacity constraints become more binding. In this respect the mode of competition is a continuous variable rather than a binary variable. The mode of competition hinges on how much a firm can affect the price competition through its choice of capacity. Consequently, intermediate situations between the pure Bertrand and Cournot cases may also be realised.

In the electricity industry capacity constraints are strongly binding when using nuclear or hydropower. In fossil fuel plants the magnitude of the capacity constraint is strongly dependent on the plant scale and on the technology used. For example some small-scale oil or gas turbines are quite flexible, their fixed costs are relative small while their variable costs are quite high. These power plants are thus used at peak load times in balancing demand and supply. On the other hand large-scale fossil power plants are quite inelastic. Most of the time demand is on an average level and then the large-scale fossil fuel plants are the main determinants of the price of electricity and thus also the cost structure of the firm. Even though the capacity constraint is not binding there can be quantity competition. As Tirole (1988, pp. 217–18) stated "in most cases, firms do not face rigid capacity constraints. … More generally, what we mean by quantity competition is really a choice of scale that determines the firm's cost functions and thus determines the conditions of price competition". He as well as Kreps and Scheinkman (1983) argue that through capacity commitment it is possible to mitigate the next period's price competition.

Electricity markets are special in the sense that the product is, with some exceptions, not storable and short-run demand is relatively inelastic. This means that even though the firm that is going to reduce its output may be small at a given demand level, it may be the case that no other firm is able to replace that supply because of capacity or transmission constraints (see Borenstein et al., 1999).

Because of this special nature of electricity industry, and because the Bertrand equilibrium approach assumes that any firm can capture the entire market by pricing below others and can expand output to meet such demand, the Cournot model seems more appropriate. Also the studies by Kreps and Scheinkman (1983) and Davidson and Deneckere (1986) suggest that even though firms first choose their capacities and then compete via the price, the Cournot model may closely approximate the outcome. The centralized price mechanism, acting like an auctioneer, also supports the Cournot model. In this paper we solve both the Cournot equilibrium and Bertrand equilibrium from which the latter can be seen as a benchmark case.

3. The model

The model we use is a numerical, static and short-term model developed by Andersson and Bergman (1995). Its objective is to determine the market-clearing price of high voltage electricity. Because of the short time horizon the production capacity is assumed to be exogenous and thus determined outside the model. The market price is solved endogenously.

The model distinguishes between two categories of production capacity. The first category consists of nuclear and hydropower capacity, which together constitute approximately 51% of total production. The second category is composed as an aggregate of backpressure, condensing and other fossil fuel and renewable fuel capacity. The model is structured so that it does not distinguish between different technologies competing with each other. Instead, it distinguishes between individual firms, which in turn could be described as portfolios of different production units using different technologies.

The hydro and nuclear plants are denoted by i while the backpressure, condensing and other plants are denoted by j. The output of the firm f using plant type i is denoted by X_{fi}, while that of the other types of plants is denoted by X_{fj} . F refers to the total number of firms.

Because the model is assumed to be a short-term model, output is constrained by the predetermined capacity denoted by K_{fi} and already existing production units denoted by K_{fj}.

The total output for an individual firm is given by:

$$(1) \quad X_f = \sum_{i=1}^{2} X_{fi} + X_{fj} \qquad ; f = 1,2,\ldots\ldots\ldots F.$$

The total output is thus an aggregate of two types of production units, which use different power technologies. Firms are assumed to take different types of plant units into operation by using cost minimisation as the crucial criterion.[7] Thereby the marginal cost function has an essential role in the model. Marginal costs depend on the type of production units and they are determined as follows.

The marginal cost of type i production units is:

$$(2) \quad \frac{\partial C_{fi}}{\partial X_{fi}} = c_i + \lambda_{fi} \quad ; i = 1,2. \qquad ; f = 1,2,\ldots\ldots\ldots F.$$

c_i denotes the firm-specific unit cost of operation. Variable costs, including c_i, are mainly composed of fuel costs, variable labour costs and maintenance of production equipment. It is notable that especially hydroelectric generation has very low variable costs. However, hydroelectric plants require large reservoirs to regulate the flow of water between wet and dry periods. Thus, computing generation costs requires computing the shadow price of stored water (see, e.g., Johnsen et al., 1999).[8] The term λ denotes firm-specific scarcity rent, or in other words the shadow price, of the firm's production when using the capacity of type i. The following inequalities and equalities define the properties of λ:

$$(3) \quad \lambda_{fi} : X_{fi} - K_{fi} \leq 0; \quad \lambda_{fi}(X_{fi} - K_{fi}) = 0; \quad \lambda_{fi} \geq 0.$$

This has basically two implications. First the constraint, $X_{fi} - K_{fi} \leq 0$, means that the production cannot exceed the existing capacity. The second constraint, $\lambda_{fi}(X_{fi} - K_{fi}) = 0$, means that if the capacity is fully utilised, i.e. $X_{fi} - K_{fi} = 0$, then λ_{fi} can deviate from 0, but if there is excessive capacity, i.e. $X_{fi} - K_{fi} < 0$, the scarcity rent λ_{fi} is equal to zero. Hence, when we operate on a moderate capacity level the marginal costs of production units of type i are simply equal to c_i. However, when the production reaches the maximum capacity, marginal costs exceed the unit cost of operation c_i.

The marginal cost of type j production unit is:

$$(4) \quad \frac{\partial C_{fj}}{\partial X_{fj}} = a_j + b_j \left(\frac{X_{fj}}{K_{fj}}\right)^{\sigma} \qquad ; f = 1,2,\ldots\ldots\ldots F.$$

Here, a_j is the cost per unit of output in the cheapest production units that belong to the group j. The cost per unit includes the purchase costs of fuel[9] and other operating costs, which are basically caused by the same factors as in the case of the unit type i. Because the marginal costs of fossil fuel plants depend strictly on the type of fuel used, the marginal cost has to be different if we use more costly production units[10] than combined heat and power units. The expression $a_j + b_j$ is used to determine the marginal costs for these costly units.

---

[7] *Because of the low marginal costs of hydro power it is the first in the merit order and it is worthwhile to put all possible hydro power to use. However, in practice some hydro power is left in reserve in order to adjust supply and demand (see, e.g., Lehto, 1995).*

[8] *This can be done by solving the generator's intertemporal profit maximisation problem.*

[9] *These are primarily based on import prices in Finland.*

[10] *E.g., oil fired condensing power plants.*

Because of the different cost structure of power plants of unit type *j*, the final marginal cost function also depends on capacity. If the production exceeds the capacity of the cheapest type of power plant, more expensive types of plants have to be put into operation, which increases the marginal costs. The expression (X_{fj}/K_{fj}) describes how quickly this shift takes place. If the amount of electricity produced by fossil fuel plants is quite small, the marginal cost will be close to a_j. In the situation when production is equal to the capacity in use, the marginal cost is $a_j + b_j$. The value of parameter σ is greater than one and thus if the production exceeds the already existing capacity of unit type *j* the marginal costs increase very rapidly. In practice, this means that gas turbines with high variable costs have to be put into operation.

Total demand for electricity is assumed to be of the following form:

$$(5) \qquad D_E = D_0 \left(\frac{P_E}{P_0}\right)^{\varepsilon}$$

where D_E is the market demand of high voltage electricity, P_E is the market price of high-voltage electricity, ε is the price elasticity of demand and subscript *0* denotes the pre-reform value of the variable in question.

Total supply is:

$$(6) \qquad S_E = \sum_{f=1}^{F} X_f + M$$

where $\Sigma_{f=1}^{F} X_f$ is the aggregate of domestic production and M is imports of electricity.

Solving for the market equilibrium, i.e. $D_E = S_E$, with respect to the market price gives us the inverse demand function

$$(7) \qquad P_E = P_0 \left(\frac{\Sigma X_f + M}{E_0}\right)^{\frac{1}{\varepsilon}}$$

where E_0 is total electricity consumption in initial year[11] (1995).

Each electricity company is assumed to maximise its profits given the quantity chosen by other firms. The profit function is given as:

$$(8) \qquad \pi^f = X_f P_E - C_f(X_f)$$

where X_f is the production of firm *f* and C_f denotes the costs of firm *f*.

Solving the first order condition with respect to quantity yields to the following equation:

$$(9) \qquad \frac{\partial \pi^f}{\partial X_f} = P_E + \frac{\partial P_E}{\partial X_f} X_f - \frac{\partial C_f}{\partial X_f} = 0$$

If we dispense with the assumption of rivals' fixed output and introduce Hicks's (1935) conjectural derivative approach, equation (9) can be rewritten as

$$(10) \qquad P_E + X_f \frac{\partial P_E}{\partial X_f}\left(1 + \frac{\partial X_{-f}}{\partial X_f}\right) = \frac{\partial C_f}{\partial X_f} \qquad f = 1,2,\ldots\ldots\ldots F.$$

Where X_{-f} is the total output of all other firms except for firm *f*. Term $\frac{\partial X_{-f}}{\partial X_f}$ is a conjectural variation term in competitive equilibrium. We assume here that the conjectural variation term is either 0 or –1.

If the conjectural variation term is assumed to be –1, we end up with the standard competitive market model

$$(11) \qquad P_E = \frac{\partial C_f}{\partial X_f} \qquad f = 1,2,\ldots\ldots\ldots F.$$

The resulting outcome is the Bertrand equilibrium. If one firm changes its output in this situation, other firms react so that the total output of the market remains unchanged. Alternatively, the conjectural-variation term can be equal to 0. This implies monopolistic pricing and the solution is the Cournot equilibrium. In this situation a firm takes the output of the other firms as given. In other words the company thinks that even if it changes its supply, there would be no reaction whatsoever from the other firms in the market.

The paper continues as follows: in section 4 we introduce the data and then in section 5 we simulate the model assuming first the Bertrand market structure and then the Cournot market structure.

[11] *I.e., domestic production and imports together.*

Table 1. Active firms and electricity production (TWh) by production type, 1995.

Firm	Hydro	Nuclear	Backpressure	Condensing	Other	Total Production	Share of production
Imatran Voima Oy	3.795	6.449	3.188	3.425	–0.0017	16.855	0,279
Teollisuuden Voima Oy	0	11.679	0	0	0	11.679	0,193
Kemijoki Oy	3.675	0	0	0	0	3.675	0,061
Helsingin Energia	0	0	3.096	0.438	0.0003	3.534	0,058
PVO-lämpövoima Oy	0	0	0	1.588	0.0012	1.589	0,026
Mussalon Voima Oy	0	0	0.300	1.171	0.0002	1.471	0,024
Iijoen Voima Oy	1.467	0	0	0	0	1.467	0,024
Vaskiluodon Voima Oy	0	0	0.479	0.945	0	1.424	0,024
Tampereen kaup. sl.	0.046	0	1.180	0.048	0	1.274	0,021
Oulun Energia	0.185	0	0.518	0.134	0	0.837	0,014
Other	3.621	0	11.957	1.148	0.0089	16.735	0,276
TOTAL	12.789	18.128	20.718	8.897	0.0089	60.540	1

Note: The first column lists the firms treated as active competitors. The next five columns indicate the generation of electricity by the type of production. The last column gives the firm's market share. The data is from Sähkömarkkinakeskus: Electricity Statistics for Finland 1995.

4. *Empirical background*

In 1995 the total production of electricity in Finland was 60.539 TWh. The demand was 68.944 TWh. The excess demand was satisfied by imports of 8.501 TWh mainly from Russia and Sweden. The largest consumer group was the refining industry with an annual demand of 36.951 TWh. The second largest consumers were the private sector and the service industry. The smallest consumer group was agriculture with an annual demand of 2.358 TWh (see Sähkötarkastuskeskus, 1996).

In the simulation the ten biggest producers of electricity are treated as active competitors. However, although they are significant producers, UPM-Kymmene Ltd. and Enso Gutzeit Ltd. were excluded from this group because they use all the electricity they produce themselves. The biggest producer was (1995) Imatran Voima Ltd. with a yearly production of 16.855 TWh. The smallest of the ten active firms was Oulun Energia with its 0.836 TWh yearly production. The smaller producers are treated as an aggregated group and their production together amounted to 16.734 TWh in 1995. The reference year production and respective market shares are shown in Table1.

In the simulation we have specified five different categories of power generation plants. These are nuclear power, hydropower, backpressure power, conventional condensing power and other types of power plants. The primary fuel used in the plant will be considerably reflected in the costs of the electricity-producing firm.

The variable costs of electricity generation consist of the primary fuel costs and of the other variable operating costs.[12] The fuel prices and fossil fuel taxes used were as follows:

Table 2. Primary fuel costs and fossil fuel taxes, 1995.

Primary fuel	Fuel price	Fossil fuel taxes, p/kWh
Nuclear	2176 FIM/t	
Coal	191 FIM/t	0.96
Gas	413 FIM/1000 m^3	0.64
Oil	438 FIM/t	1.04

Note: FIM refers to the Finnish mark (1 FIM is 0.168187 Euros), p refers to the Finnish penni (1 penni is 0,168187 cents), t refers to the unit of weight, ton, and m^3 to the unit of cubic contents. Sources: KTM (1997) and Kosunen and Leino (1995).

Taking into account also the other variable costs, the approximation of the variable unit costs of operation are shown in Figure 1:

[12] *These include maintenance costs, hour-based salaries and fuel taxes.*

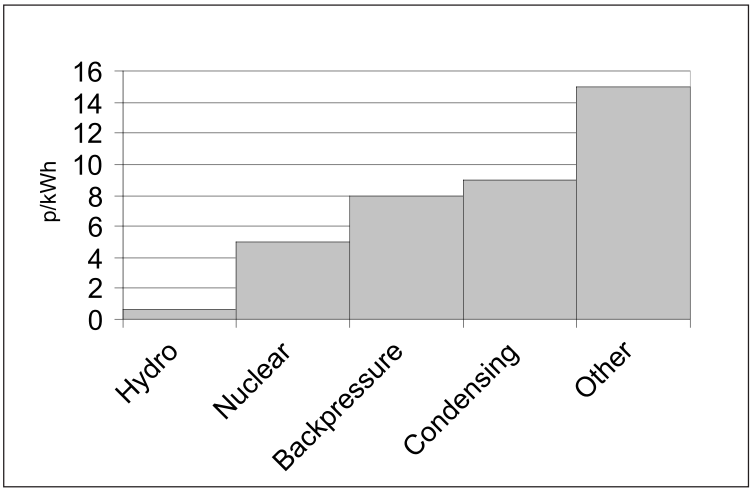

Figure 1. Variable costs of electricity generation.
Sources: Electricity Statistics of Finland 1995, KTM (1997) and Kosunen and Leino (1995).

5. *Simulation results*

The simulation was done by using the calibration method. This means that parameters and exogenous variables were chosen so that the model replicates the base year outcome. In the pre-deregulation case the equilibrium price of electricity was 21.1 p/kWh and the corresponding output was 60.539 TWh. Historically it has been assumed that the demand is quite inelastic and hence we have first simulated the model by using the elasticity value of –0.35.[13] Because according to economic theory demand should become more elastic as the level of the competition increases, we have simulated the model also by using the elasticity value of –0.8. Andersson and Bergman (1995) and Sulamaa (2001) have also used a value for elasticity of the same magnitude in order to test the sensitivity of the model.

The base case has an important role since it will act as a calibration point in this study. The main aim of the new electricity law and deregulated electricity markets is to give incentives for more efficient production through competition. Consequently, the ultimate goal is lower market prices and improved welfare.

If the deregulation leads to price competition or at least to the real threat of a Bertrand type of competition, the market price will be considerably lower than in the base case (see table 3). In the model above such a situation occurs if the conjectural variation term is fixed at –1 and equation (10) reduces to the normal price-equal-to-cost condition (see equation 11). By solving this equation[14] the resulting Bertrand equilibrium price is 17.82 p/kWh and the corresponding output is 66.03 TWh/year. The difference between the Bertrand price and the base case price is quite significant, referring to possible pre-deregulation inefficiency of the markets.

If there is a situation where no competition occurs despite the deregulation[15] the simulation results are quite the opposite. The market prices will then be distinctly higher than in the base case. This happens if the conjectural variation term in the model is zero for each active firm and minus unity for the aggregate of the smaller firms. Every active firm is assumed to know the market demand and take the output of the

[13] *According to the estimation results by Törmä (1985) the price elasticity of demand was approximately –0.35 in the beginning of the 1980s. The results by Andersson and Damsgaard (1999) also support the assumption of inelastic demand. See also Willner (1996) for an international summary of price elasticities of electricity demand.*

[14] *The Bertrand and Cournot equilibrium is reach by solving so called Mixed Complementarity Problem by using the GAMS/MILES solver.*

[15] *This can happen if the biggest producers are able to exploit their market power.*

Table 3. Production and equilibrium prices.

	Production, TWh	price, p/kWh	% of pre-deregulation case
Pre-deregulation case	60.54	21.1	100
Bertrand equilibrium	66.03	17.82	84.5
Cournot equilibrium	56.30	24.26	114.9

Table 4. Cournot equilibrium if the two biggest producers are split.

	Production, TWh	Equilibrium price, p/kWh	% of pre-deregulation case
Pre-deregulation case	60.54	21.1	100
Cournot equilibrium	64.83	18.33	86.9

other firms as exogenous. This leads to monopolistic pricing and the so-called Cournot equilibrium. The production of electricity is then 56.30 TWh/year and the equilibrium price is 24.26 p/kWh.

As can be seen above it is very important to identify which kind of a market structure emerges as a consequence of deregulation. If the biggest producers act as under the Cournot equilibrium, the deregulation will lead to higher prices and lower production than would be the case without liberalisation of the markets. If they take the threat of either national or international competition seriously, the deregulation may lead to considerable welfare improvements. This is because, as the number of Cournot players increases the Cournot equilibrium converges toward the competitive equilibrium. Our results are supported by Sulamaa (2001).[16]

The two biggest producers, Imatran Voima Ltd. and Teollisuuden Voima Ltd., generate almost half of the total electricity produced in Finland. It would be interesting to consider how the market price and the total production would change if we split both of these companies into two. On the other hand, if the two biggest companies co-operated or even merged the results would also be different. Next the resulting prices and outputs are computed in both cases, first if the two biggest producers are split, and second if they merge.

As can be seen from the Table 4 the consequences of the splitting of the two biggest producers has a considerable effect on the equilibrium market price. The production would increase from 60.54 TWh/year to 64.83 TWh/year and the market price would decrease from 21.1 p/kWh to 18.33 p/kWh even in the case of Cournot competition. However, in the other extreme, where the two biggest producers merge, the outcome is the opposite.

The effects on the market price and quantity would be quite remarkable in the hypothetical situation where the biggest producers merge. The price would increase from 21.1 p/kWh to 27.91 p/kWh. Correspondingly quantities would decrease considerably. The potential welfare effects of this kind of a market solution can be quite considerable. Thus it is important to ensure in one way or another that the deregulation leads to a rather high degree of competition. One way of improving the possibilities for a high degree of competition is the integration of the Nordic electricity markets, which increases the number of active players in the market.

[16] *According to the results of Sulamaa, however, the changes in prices and quantities are clearly larger. While our simulations indicates that as a result of Cournot competition the price will increase by 15% and the quantity decrease by 7% the respective values of Sulamaa are 37% and 27%. In a Bertrand type of competition according to our results the price will decline by 16% and the quantity increase by 9% while the respective values obtained by Sulamaa are 38% and 27%. The explanation of differences in Cournot results is that while Sulamaa accounts for gross ownership the market shares of biggest producers are clearly higher in his simulations than those we have used. The explanation for the differences in Bertrand equilbrium results is mainly due to the fact that Sulamaa has used a higher elasticity value (–0.6) than we have used (–035).*

Table 5. Cournot equilibrium if the two biggest producers merge.

	Production, TWh	Equilibrium price, p/kWh	% of pre-deregulation case
Pre-deregulation case	60.54	21.1	100
Cournot equilibrium	53.30	27.91	132.27

Table 6. Equilibrium price and price elasticity of demand in Cournot equilibrium.

	Production, TWh	Equilibrium price, p/kWh	% of pre-deregulation case
Pre-deregulation case	60.54	21.1	100
Cournot equilibrium, price elasticity –0.35	56.30	24.26	114.9
Cournot equilibrium, price elasticity –0.8	62.76	20.07	95.1

Up until now we have assumed that the price elasticity of electricity demand is –0.35. However, the demand may and should become more elastic as markets become more competitive.[17] If we assume that the price elasticity of demand rises to –0.8, and other factors remain unchanged (no splitting and no merging) the above results will change considerably as can be seen from Table 6.

If the price elasticity of electricity demand rises to –0.8 the market price of electricity will decrease even in the Cournot equilibrium and without splitting. Hence deregulation may lead to welfare improvements even if the markets are not perfectly competitive as far as the price elasticity increases. This can result, for instance, if the threat of entry is factual or if the opening of international markets is a real option to the prevalent market structure. The experience of the few first years after deregulation supports the view that demand elasticity towards the wholesale price of electricity has increased (see NordPool 2002). Hence the assumption of more elastic demand seems quite plausible. Further, it indicates that introducing competition to the wholesale market of electricity has been quite successful and at least part of the objectives of the deregulation has been reached.[18] It is however notable that the demand seems to remained quite inelastic towards the retail price.

[17] *This should be true at least according to economic theory.*

[18] *There have emerged some problems connected to the wholesale market (e.g., volatile prices and market power exploitation) which are not, however, connected to the price elasticity of demand.*

6. *Conclusions*

In a similar kind of study made with Swedish data Andersson and Bergman (1995) have shown that deregulation may not be a sufficient condition to improve welfare and lower prices in the Swedish electricity markets. Even though the situation is similar in Finland we have perhaps better possibilities to succeed in promoting competition even though we consider the autarky situation.[19] This is mainly due to the fact that in Finland the biggest producer, Imatran Voima Ltd., produces approximately 28% of the total output while in Sweden the biggest producer, Vattenfall, produces over 50% of the total electricity output.

Our results indicate that the impact of deregulation may be negative in the sense that prices may increase and production decrease if the Cournot type of competition takes place. However, it should be noted that the result is very sensitive as regards the value of the price elasticity of demand. Consequently, if demand becomes more elastic as the electricity markets become more competitive, deregulation may lead to lower prices and higher output also in the case of Cournot competition.

[19] *I.e., we do not consider integrated Nordic power markets.*

In any case, the integration of the Nordic power markets, and thus the increase in the number of eminent players in the market, is supported since it clearly makes the market more competitive and hence also increase the price elasticity of demand. However, it should be ensured that no substantial number of mergers takes place, since they may re-establish the market power that has been abolished through the integration.

If we are able to keep the number of eminent players high enough in the Nordic power market, the integration may cause substantial benefits. Amundsen, Bergman and Andersson (1998) have studied the effects of deregulation and free trade on the electricity prices in the Nordic countries. According to their results free trade tends to equalise prices across countries and it also reduces the difference between Cournot prices and perfect competition prices. Free trade price is lower than the autarky price but the difference between them depends on the pre-integration market structure of the country. Of course the impact of integrated power markets is not so extensive if the pre-integration market structure is close to perfect competition.

References

Amundsen, E., L. Bergman, and B. Andersson (1998). Competition and Prices on the Emerging Nordic Electricity Market. Working Paper Series in Economics and Finance No. 217. Stockholm School of Economics.

Andersson, B., and L. Bergman (1995). "Market Structure and the Price of Electricity: An Ex Ante Analysis of the Deregulated Swedish Electricity Market." *The Energy Journal* 16, Issue 2, 97–109.

Andersson, B., and N. Damsgaard (1999). Residential Electricity Use – Demand Estimations Using Swedish Micro Data. Paper presented at the 22:nd IAEE Annual International Conference, Rome, 9–12 June 1999.

Bolle, F. (1992). "Supply Function Equilibria and the Danger of Tacit Collusion: The Case of Spot Markets for Electricity." *Energy Economics* 16, Issue 2, 94–102.

Borenstein, S., J. Bushnell, and C. Knittel (1999). "Market Power in Electricity Markets: Beyond Concentration Measures." *The Energy Journal* 20, Issue 4, 65–88.

Davidson, C., and R. Deneckere (1986). "Long-run Competition in Capacity, Short-run Competition in Price, and the Cournot Model." *Rand Journal of Economics* 17, 404–415.

Filippini, M. (1999). "Swiss Residential Demand for Electricity." *Applied Economic Letters* 6, 533.

Green, R., and D. Newbery (1992). "Competition in the British Electricity Spot Market." *Journal of Political Economy* 100, 929–953.

Hicks, J. (1935). "Annual Survey of Economic Theory: Monopoly." *Econometrica* 3.

Johnsen, T., S. Verma, and C. Wolfram (1999). Zonal Pricing and Demand-Side Bidding in the Norwegian Electricity Market. POWER, Working Paper, PWP-63, California, U.S.

KTM (1997). Sähköntuotantokustannukset. The Ministry of Trade and Industry, Energiaosasto, Energia-Ekono Oy.

Klemperer, P., and M. Meyer (1989). "Supply Function Equilibria in Oligopoly under Uncertainty." *Econometrica* 57, 1243–1277.

Kopsakangas-Savolainen, M. (2002). A Study on the Deregulation of the Finnish Electricity Markets. Acta Universitatis Ouluensis, Oeconomica G11. Oulu: Oulu University Press. Dissertation.

Kosunen, P., and P. Leino (1995). Biopolttoaineen kilpailukyky sähkön ja lämmön tuotannossa. Kauppa ja teollisuusministeriön tutkimuksia ja raportteja 99/1995. Helsinki.

Kreps, D., and J. Scheinkman (1983). "Quantity Precommitment and Bertrand competition yield Cournot Outcomes." *Bell Journal of Economics* 14, 326–337.

Lehto, E. (1995). Avautuvat sähkömarkkinat – Markkinoiden rakenne sekä viranomaisten tehtävät. Palkansaajien tutkimuslaitos, tutkimuksia 1995:57.

Maggi, G. (1996). "Strategic Trade Policies with Endogenous Mode of Competition." *The American Economic Review* 86, 237–258.

NordPool (2002). Nord Pool, Annual Report 2001. http://www.nordpool.no/organisation

Sulamaa, P. (2001). Essays in Deregulated Finnish and Nordic Electricity Markets. ETLA (The Research Institute of the Finnish Economy), A34 Series. Dissertation.

Sähkötarkastuskeskus (1996). Electricity statistics for Finland 1995. Sähkötarkastuskeskus, Helsinki.

Sørgard, L. (1997). "Domestic merger policy in an international oligopoly: The Nordic market for electricity." *Energy Economics* 19, 239–253.

Tirole, J. (1988). *The Theory of Industrial Organization*. Cambridge, MA: MIT Press.

Törmä, H. (1985). Industrial demand for energy in Finland 1960–1982. Discussion paper no. 9, University of Jyväskylä.

Willner, J. (1996). "A Comment on Bradburd: Privatisation of Natural Monopolies." *Review of Industrial Organization* 11, 869–882.