Temporary Bottlenecks, Hydropower and Acquisitions[1]

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JEL classification: D43, L13, L41, L94
Keywords: Hydropower, acquisition, oligopoly, transmission

Fist version: December 2003
This version: November 2004

Discussion Paper 28/2004

Abstract: The purpose of this article is to study the effects of an acquisition in a hydro power system with temporary bottlenecks. We apply a model with four markets: two regions and two time periods. It is shown that an acquisition has an ambiguous effect on welfare. In some instances it would lead to larger differences in prices between different markets, which would lead to an increase in the dead weight loss. In other instances an acquisition would lead to a reduction in price differences between different markets. This may happen if the dominant firm acquires a firm that is active in the market where the dominant firm used to dump its production before the acquisition took place.

[1]We are indebted to Nils-Henrik M. von der Fehr and seminar participants at Institute for Research in Economics and Business Administration (SNF), the Nordic Energy Research conference in Copenhagen November 15, 2002, and at The Research Institute of Industrial Economics (IUI) in Stockholm November 27, 2002 for valuable comments on an earlier draft. The research has been partly financed by Statkraft through Institute for Research in Economics and Business Administration (SNF). The views expressed here are the authors' own and are not necessarily shared by the Norwegian Competition Authority.

1 Introduction

During the last decade many countries have liberalized their electricity industry. There are several studies that analyse how well competition works in such an industry.[2] These studies are typically using one-period models with increasing marginal costs. Such models are well suited to analyse a system with thermal production. However, in several countries hydropower has a dominant position.[3] The purpose of this article is to show that the idiosyncratic characteristics of the hydropower system may reverse some of the existing results in the literature. In particular, we claim that recommendations concerning merger policy in hydro power systems can be misguided if one does not take into account the producers' ability to shift production between different periods.

In 2001 Statkraft was prohibited by the Norwegian Competition Authority (NCA) from acquiring Agder Energi.[4] NCA was worried about Statkraft's behaviour in Southern Norway, where Statkraft's market share would have increased from 40 to 50 %. It might reduce production in periods when Southern Norway was already a deficit area (import capacity fully utilised) or was about to become one, and increase production with the same amount in later periods when there were no bottlenecks on transmission lines. Then we see that the fear of strategic reshuffling of production between periods was decisive for their intervention.[5] The decision triggered

[2] Green and Newbery (1992), von der Fehr and Harbord (1993), Green (1996), Newbery (1998) and Wolfram (1999) are all studies that analyse the British electricity market, while Borenstein and Bushnell (1999) and Borenstein, Bushnell and Wolak (2000) are examples of studies of the Californian electricity industry. Two recent studies of competition in the Nordic electricity market are Hjalmarsson (1999) and Amundsen and Bergman (2000). Scott and Read (1997), Crampes and Moreaux (2001) and Bushnell (2000) all model a mixed system with hydropower and thermal production. None of them analyses the effects of a more concentrated industry, for example due to acquisitions. von der Fehr and Johnsen (2002a) analyse a pure hydropower system, and they compare perfect competition with a situation with market power. In contrast, our main focus is on the effects of an acquisition in a situation where we have imperfect competition both before and after the acquisition.

[3] In New Zealand 80% of production is from hydro, in Chile 70%, Brazil 97% and Norway close to 100%.

[4] See Konkurransetilsynet (2002a). Later on the Ministry of Labour and Government Administration permitted the acquisition, conditional on Statkraft's sale of shares in some other hydro power producers in Southern Norway (see Arbeids- og Adm. Dep., 2002).

[5] The same argument was decisive for the ban of Statkraft's acquisition of Trondheim Energiverk later on in 2002 (see Konkurransetilsynet, 2002b). The decision was confirmed by the Ministry of Labour and Governmental Affairs (see Arb. og Adm. Dep., 2003).

a debate in Norway about the effects of M&A's in a hydropower system.[6]

As shown in Borenstein, Bushnell and Stoft (2000), a power producer might reduce production in a time period in such a way that it induces a constraint on the transmission line.[7] It then exploits its dominant position in the period with a bottleneck in the transmission network. However, Borenstein *et al.* (2000) applied a static model with only thermal production. It implies that they do not take into account the fact that the production a hydro power producer withdraws in one period to create or strenghten a bottleneck must be sold in a later period.

To capture such an idiosyncratic characteristic of a hydro power system, we allow for two different regions and two different time periods in our model. This implies that there is a potential for four separate sub-markets. Each hydropower producer has a total fixed energy capacity, determined by water available in its reservoirs, and allocates its total capacity between the sub-markets. Each producer can shift production in time by storing water in its reservoir, and shift production in space by exporting through a transmission line to another region.[8] We focus on the case with temporary bottlenecks, where transmission lines can be capacity constrained only in one of the two time periods.

We can use our model to replicate the result first shown in Borenstein, Bushnell and Stoft (2000). This is done by allowing a large hydro power producer with production in both regions to acquire a competitive fringe in one of the regions. After the acquisition the large producer withdraws production in that particular region in one period to create a bottleneck on the transmission lines, and it achieves a high price. It sells the withheld quantity in the next period when there is no capacity constraint on the transmission lines between the two regions, and the price reduction in that period is limited since the market is large (regions are integrated).

But given that such an acquisition results in price differences between

[6] See Mathiesen, Skaar and Sørgard (2002) and von der Fehr and Johnsen (2002b).

[7] Schmalensee and Golub (1984) pointed at the potential problems associated with congestion on transmission lines. Schweppe *et al.* (1988) develop a spot pricing theory where the special features of electric networks are considered. Later we have seen several studies of the problems associated with congested transmission lines, such as the pricing of transmission and incentives for investing in transmission lines. See for example Hogan (1992), Oren *et al.* (1995), Bushnell and Stoft (1996), Chao and Peck (1996) and Cardell *et al.* (1997) for analysis of energy systems as networks.

[8] The transmission lines are owned by an independent operator, who acts as an arbitrage player between regions and always exports to the high price region. Our approach is consistent with the institutional setting in the Nordic market, and it is also in line with the "nodal pricing" system first introduced in Schweppe *et al.* (1988).

markets, how would an additional acquisition influence the large producer's behaviour? It turns out that with price differences at the outset, an additional acquisition might lead to a *reduction* in price differences between sub-markets. The decisive factor is the producer's location of its sales. If the acquired firm's sale is located in the market where the dominant producer sells at a low price ('dumps' some of its production), then it can be rational for the dominant firm to act in such a way that the price differences are reduced. By doing so it can increase the price in the 'dumping' market and thereby the revenues generated from the acquired firm's sales.

In our model location of sales is interpreted as geographic location. For example, the acquiring producer has production in both regions, and it acquires a producer that has production only in the low price region. However, the basic intuition in our model is of relevance in other situations as well. Concerning the hydro power market, location can be given a temporal interpretation. For example, one producer has multiyear reservoirs, whereas another producer cannot store water from one year to another.[9] They are located in the same region. In a year with heavy rainfall and large amounts of water in the reservoirs, the producer with no flexibility has to produce in that year despite a low price. The other producer, with large flexiblity concerning storage, can dump some of the water in the year with a low price and store the remaining water for production the next year. After an acqusition, the producer with a multiyear reservoir might dump less production in the year with large water inflow, the year the inflexible producer has to produce a large quantity. By doing so, the revenues from the acquired firm will increase.

Our result can also be of relevance for other markets, for example a market for a durable good.[10] A dominant firm can find it profitable to charge a high price to high valuation customers in the first period and a low price to the remaining low valuation customers in the second period. If this firm faces a competitor only in the second period, for example due to a technological laggard, this would probably lead to an even more aggressive pricing policy in the second period. In that case an acquisition would imply that the dominant firm would find less price discrimination rational, since after the acquisition it would have more sales in the second period. It would then reshuffle some of its original sales from the second to the first period.

The article is organised as follows. In the next section we introduce

[9] This example is analysed in detail in an earlier version of the paper, see Skaar and Sørgard (2003).

[10] We are grateful to one referee for this example.

our model. In section 3 we analyse the effects of acquisitions, and discuss how asymmetries on location and the number of producers may change our results. In section 4 we offer some concluding remarks. All the proofs are given in the Appendix.

2 The model

Let us consider a market with two different geographical regions, called East (E) and West (W). In addition there are two time periods, called 1 and 2. The combination of geography and time implies that we have four different sub-markets. Note that we discuss allocation of water stored in reservoirs. A producer must then decide whether it shall produce in one season, for example summer, or wait and rather produce in a later season. If a producer has a one year reservoir, it can shift production between summer and winter. A producer with multiyear reservoirs has even more flexibility, and can shift production from one year to another.

There are four different hydropower producers, $j = S, S_E, F_W, F_E$.[11] Except for producer S, each producer has plants in only one region. While we assume that both S and S_E are single producers, we interpret F_W and F_E as competitive fringes. Each of them consists of a number of small producers, behaving as price takers. F_W is located in region W, while F_E is located in region E. In principle, though, each producer can sell in all four sub-markets. First, reservoirs enable each producer to store water and thereby allocate its total production between the two time periods in the region where the reservoir is located. Second, transmission lines allow each producer to sell in the neighbouring region. The market structure is described in Figure 1.

Each hydropower plant is able to produce all the available energy at that site in one time period (no binding constraint on effect capacity). However, total production in one region is constrained by the available energy capacity (water in the reservoir). Then each producer has the following constraint on production in region i:

$$\sum_{t=1}^{2} q_{it}^{j} \leqslant \overline{q}_{i}^{j}, \text{ where } i = W, E \text{ and } j = S, S_E, F_W, F_E \qquad (1)$$

$\overline{q}_{i}^{j}$ denotes the total energy capacity available to producer j for produc-

[11] Later on we allow for more hydropower producers. In an earlier version of the paper we have shown that the same mechanism will be present also in a mixed system with both hydro power and thermal production (see Skaar and Sørgard, 2003).

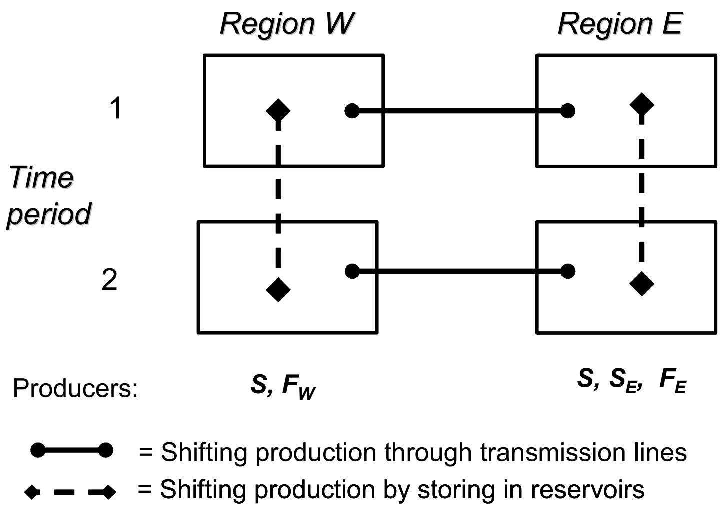

Figure 1: The market structure

tion in region i while q_{it}^{j} denotes production by producer j in region i at time t. All available water is used for production of energy, so that there is no spill of water.[12] Then the energy constraint in (1) holds with equality.

In line with the institutional arrangement in the Nordic market, we assume that the transmission lines between regions are operated by independent grid operators. At times of congestion the market is divided into different market regions where demand equals supply in each region. When lines are congested the price difference between two regions corresponds to the cost of transmission or the congestion rent. This rent is collected by the grid operator.[13]

[12] Whether this assumption is realistic or not is an open question. However, it is often used in the literature (see Johnsen, Verma and Wolfram, 1999, and Crampes and Moreaux, 2001). The Norwegian Competition Authority wrote as follows in its decision concerning Statkraft AS's acquisition of shares in Agder Energi (see Konkurransetilsynet, 2002a):

"The producers do not need to forsake production (i.e. let water run past turbines that are free to be operated) in order to utilise market power. The low production costs of a hydro power producer may mean that it is not likely that waste of water will take place, but a producer with market power might behave in a way that increases the risk of waste."

[13] We might say that the grid operator acts as a competitive arbitrage agent between regions. If we think of the regions as market nodes, we can describe the pricing by the term "nodal pricing". It refers to the term used by Schweppe *et al.* (1988). This pricing regime implies that a seller located in region i will receive the market price in that region, even if its production is exported to the neighbouring region.

The transmission line between the regions has a capacity of $\overline{K}$ and an actual flow of K in each period. Prices in the two regions can only differ when the capacity is fully utilized. In this case we would have that $K = \overline{K}$.

Let D_{it} denote the demand in region i in period t. We can then state the equilibrium condition for the two regions as:

$$D_{Wt} = q^S_{Wt} + q^{F_W}_{Wt} + K \text{ and } D_{Et} = q^S_{Et} + q^{S_E}_{Et} + q^{F_E}_{Et} - K \tag{2}$$

If $K > 0$ and transmission has reached the capacity limit, we have that electricity flows from region E to W and the price in region W can exceed the price in region E.

We are concerned about the situations where a transmission line becomes a bottleneck. However, the extreme case where transmission lines are binding in both time periods is not of interest. In such a case the two regions are separated, and we could analyse each region in isolation. On the other hand, nor is the case with no binding transmission constraint in any of the two time periods of interest. In this case the two markets can be seen as one integrated market, and the questions concerning bottlenecks are ruled out. More interestingly, we focus on a situation where the lines are congested in just one of the two periods. In such a case the regions are partially integrated or, put another way, the transmission line is temporarily congested (temporary bottlenecks).

We assume that in period 2 the regions are integrated with a common price and no congestion on the transmission line. Even if the price is the same in both regions we might have transmission on the line between them. However, actual flows (K) have to be less than capacity ($\overline{K}$). We can now state the equilibrium condition for our new market:

$$D_{W2} + D_{E2} = q^S_{W2} + q^{F_W}_{W2} + K_2 + q^S_{E2} + q^{S_E}_{E2} + q^{F_E}_{E2} - K \tag{3}$$

Let us specify a more detailed model with the following linear inverse-demand functions[14]:

$$p_{it} = \alpha_{it} - \beta_{it} D_{it},\ i = E, W;\ t = 1, 2 \tag{4}$$

where:

$$\alpha_{W1} = 1,\ \alpha_{W2} = \alpha_{E1} = \alpha_{E2} = V \text{ and } \beta_{W1} = \beta_{W2} = 1,\ \beta_{E1} = \beta_{E2} = 1/b$$

[14] In most electricity markets the short-run price elasticity of demand is close to zero. Note, though, that short run is often interpreted as one hour. As explained above, the two periods in our model can be interpreted as two different seasons. Due to this it is natural to apply a model with a positive absolute price elasticity of demand, as we do.

If $V = b = 1$, demand in all four sub-markets is identical. To allow for any possible asymmetry between sub-markets, we assume that both V and b can differ from 1. If $V < 1$, the willingness to pay in region W in period 1 is higher than in all the three other sub–markets. If $Vb > 1$, the two sub-markets in region E are of larger size than the two submarkets in region W.

The two sub-markets in period 2 are by assumption integrated (see above). The aggregated linear inverse-demand function for this integrated market becomes[15]:

$$p_{WE2} = V - \frac{1}{1+b}(D_{W2} + D_{E2}) \tag{5}$$

S can now use capacity in both regions when supplying the market in period 2. The new constraint in period 2 becomes:

$$\sum_i q_{i2}^S \leqslant \sum_i \overline{q}_i^S, \text{ where } i = E, W \tag{6}$$

In period 1, where we have the potential for two separate markets, producer S is now able to produce all the available energy capacity within a region in this period;

$$q_{i1}^S \leqslant \overline{q}_i^S \tag{7}$$

and still be able to sell in the same region in period 2 by the use of energy capacity located in the other region. However, these new constraints can not bind at the same time for positive production levels in both periods and regions. This would result in overall production in excess of available energy capacity. The following must therefore hold:

$$\sum_i \sum_t q_{it}^S \leqslant \sum_i \overline{q}_i^S, \text{ where } i = E, W;\ t = 1, 2 \tag{8}$$

Producer S can de facto move production from period 1 in region E to period 1 in region W *without* using the transmission line between the two regions in period 1. The reason is that the producer is able to reshuffle its sale in period 2, when regions are integrated.

However, we still may have three different sub-markets: region W in period 1, region E in period 1, and the integrated market consisting of both

[15] One reason why the transmission lines are only congested in one of the two periods could be that $V < 1$. This implies, at least as far as region W is concerned, that demand in period 2 is lower than demand in period 1. Given the same transmission capacity in the two periods, less transmission is needed to equate prices in period 2.

regions in period 2. However, note that we have one competitive fringe in region E and one in region W. Given that the competitive fringes are sufficiently large, they will ensure that there are no price differences between periods 1 and 2. For example, let us consider region E. If producer S_E reduces sales in one of the two periods in order to increase the price, the competitive fringe F_E would immediately increase sales in this period, giving producer S_E no room for such strategic behavior.

3 The effect of acquisitions

The starting point is, as described, that all four sub-markets are integrated. However, there is a potential for the transmission line in period 1 to be congested. Then we ask the question of how an acquisition may change the equilibrium outcome. First, we let S acquire the competitive fringe F_W. Given such an acquisition, we next consider what happens when S acquires S_E.

3.1 An endogenous bottleneck?

If S acquires F_W, there will no longer be any players present to guarantee identical prices in region W in periods 1 and 2. Producer S then has three alternatives.

One alternative is that producer S after the acquisition acts so that prices in all four sub-markets are identical, as was the case before the acquisition. Alternatively, producer S might reduce its production in region W in time period 1 in order to cause the line to be congested with full *imports* to the region. By doing so it could achieve a higher price in that sub-market than in the three other integrated sub-markets. There will then be two separate markets, as illustrated in Figure 2.

The third alternative would be to increase production in region W in period 1, causing congestion and full *exports* from region W to region E. Then there will also be two sub-markets, as illustrated in Figure 2.

If we focus on the situation where producer S finds it profitable to charge a higher price in market $W1$ after the acquisition, we can now state our proposition 1:

Proposition 1 *If S acquires F_W and if the profit maximation level of q_{W1}^S is positive but low enough to cause congestion on the line between the two regions ($0 < q_{W1}^S < \frac{1}{2+2b}Q - (V-1)(\frac{1+2b}{2+2b}) - \overline{K}$), then after the acquisition we have that $p_{W1} - p_2 > 0$.*

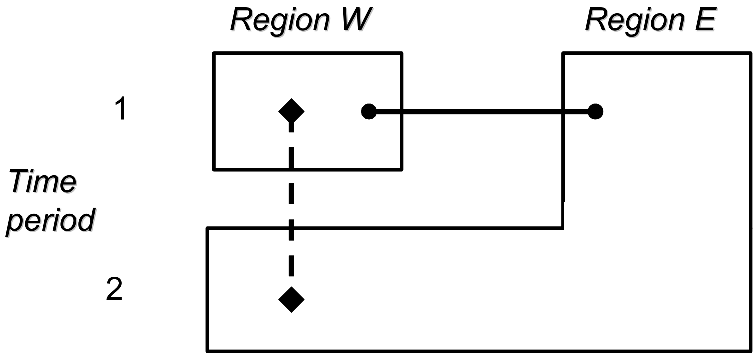

Figure 2: West a separate market in period 1

Proof. See Appendix A. ■

Our result replicates the result found in Borenstein, Bushnell and Stoft (2000). After the acquisition, the firm may find it profitable to induce a congestion on a transmission line. By reducing production in region W in period 1, producer S can become a de facto monopoly firm in region W in period 1 sub-market. It controls total demand in that sub-market, deducted the imports through the transmission line. Strategic behaviour has in such a case led to a temporary bottleneck on transmission.[16]

Assuming that $p_{W1} - p_2 > 0$, we can find the exact price difference after the acquisition of F_W by inserting the solution to producer S's maximation problem (q_{W1}^S) into the two inverse demand functions,

$$\Delta p \equiv p_{W1} - p_2 = \frac{1}{2} \frac{-(K_1 + V - 1)(1 + 2b) - \overline{K} + \overline{q}_E^{S_E} + \overline{q}_E^{F_E}}{1 + 2b}. \tag{9}$$

3.2 Asymmetry concerning location

Let us now assume that S has acquired F_W, and that this has led to the price difference reported in (9). What will happen to this price difference when producer S acquires producer S_E?

If producer S acquires S_E, it controls a larger share of the capacity located in region E. Production by S in market 2 can now be expressed as follows:

[16] In Appendix A we also provide a numerical example that illustrates our result.

$$q_2^S = \overline{q}_W^S + \overline{q}_E^S + \overline{q}_E^{S_E} - q_{W1}^S \tag{10}$$

Producer S maximises profit subject to the following constraints;

$$q_{W1}^S \leq \overline{q}_W^S \text{ and } q_2^S \leq \overline{q}_W^S + \overline{q}_E^S + \overline{q}_E^{S_E} \tag{11}$$

Note that producer S now has more energy available for production in market 2. It can use some of its energy available in region W for production in period 2, thus selling electricity in market 2. As long as production in region W in period 1 is positive as well, then we have an internal solution to our problem where none of the two constraints (11) above is binding. Unless otherwise stated, we assume that this is the case.[17]

From the producer's first order condition we can define the price difference between the two markets after the acquisition as

$$\Delta\widehat{p} \equiv \widehat{p}_{W1} - \widehat{p}_2 = \frac{1}{2}\frac{-(K+V-1)(1+2b) - \overline{K} + \overline{q}_E^{F_E}}{1+2b}. \tag{12}$$

We find that the acquisition results in a reduction in the price difference:

$$\Delta p - \Delta\widehat{p} = \frac{\overline{q}_E^{S_E}}{2(1+2b)} > 0. \tag{13}$$

This implies that the acquisition results in higher welfare, since sales are shifted from low valuation to high valuation consumers. The reduction in the price difference follows directly from the change in producer S's incentives following the acquisition. After the acquisition producer S takes into account revenues on sales of energy by producer S_E. This energy is located in region E and offered for sale in market 2. A reduction in sales in market 2 and thereby a higher price in that market would be beneficial simply because producer S now controls more of the energy sold in that market.

Our result can be illustated by Figure 3, where we have shown the effect of shifting one unit of sales from one market to another. Before the acquisition the dominant firm reshuffles production between the two sub-markets until there is no more to gain from reshuffling. When A = B + C in Figure 3 the dominant firm allocates sales between the two markets in an optimal

[17] Note that we rule out the possibility that the reshuffling of production following an acquisition is so substantial that the price difference disappers, or that the reshuffling is restricted by the production constraint. If we had allowed for such possibilities, our main result would not change. However, the reduction in the price difference could have been more limited than what we show, or, in the limiting case, not even changed at all.

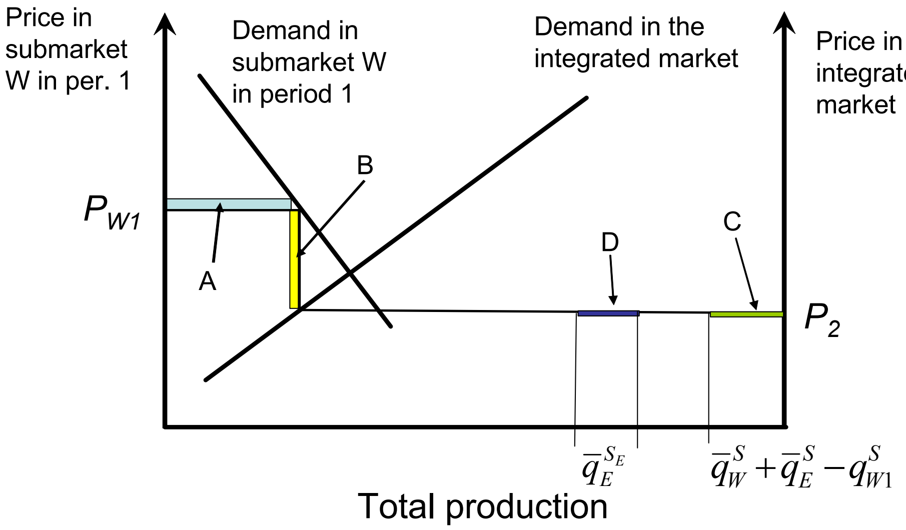

Figure 3: Change in profits from reshuffling of sales

way. However, after the acqusition it can easily be seen that such an allocation is no longer optimal. Since A < B + C + D, it is now optimal for the dominant firm to shift sales from the integrated market to the market in region W in period 1. This results in a reduction in the price difference between those two markets.

From the equilibrium conditions we can derive the change in profits following an acquisition. Let π_0^S denote producer S's profit before the acquisition and let $\pi_0^{S_E}$ denote producer S_E's profit before the acquisition. Furthermore, let π_1^S denote the profit for producer S after acquiring producer S_E. It can be shown that:

$$\pi_1^S - \pi_0^S - \pi_0^{S_E} = \frac{\left(\bar{q}_E^{S_E}\right)^2}{8(1+2b)(1+b)} > 0.$$

We see that the acquisition is always profitable. The reason is that the outsiders cannot respond to the acquisition, since they produce the same quantity after the acquisition as they did before the acquisition and none of them is able to shift production between markets. After the acquisition producer S can therefore reallocate its sales without triggering any aggressive response from its rivals. It avoids the traditional outsiders' response problem that was first pointed out in Salant *et al.* (1983), and which could make an acquisition unprofitable.

We can summarize our results as follows:

Proposition 2 *Let us assume that* $p_{W1} - p_2 > 0$ *initially and that only* S *produces in both regions. Then* S *acquiring* S_E *will reduce the price difference by* $\frac{\overline{q}_E^{S_E}}{2(1+2b)}$ *and the acquisition will always be profitable.*

Note that the change in the price difference only depends on two parameter values: the relative market size (region W versus region E) and the size of the acquired producer ($\overline{q}_E^{S_E}$). Both effects are quite intuitive. The larger the size of the acquired firm, the larger the price change following the acquisition; the larger the size of the integrated market, the smaller the price change following the acquisition.

Let us now extend the model by introducing more than one producer with production in both regions. We assume that there are now n symmetric producers in both regions. The following result can then be shown:

Proposition 3 *Let us assume that* $p_{W1} - p_2 > 0$ *initially and that there are* n *producers that produce in both regions. Then producer* S^i *acquiring* S_E *would reduce the price difference by* $\frac{\overline{q}_E^{S_E}}{(n+1)(1+2b)}$ *and the acquisition will be profitable if* $\overline{q}_E^{S_E} > \frac{(n-1+2nb)(1-v)+2b(1-v)+(2\overline{K}+\overline{q}_E^{F_E})(n-1)}{n^2-n+1}$.

Proof. See Appendix B. ■

We see that the result concerning the change in the price difference is identical to the one obtained in the situation referred to in Proposition 2, except that the existence of the other producers with capacity in both regions dampens the price effect following an acquisition. The reason is that the outside firms respond in a way that partly eliminates the initial price effect following an acquisition. They sell more in the sub-market where the acquired firm sells less, and they sell less in the sub-market where the acquired firm sells more. By doing so they reshuffle production in the opposite direction from that of producer S, and they are free riders on the strategic behaviour by producer S. Each of them sells more in the market where the price increases and less in the market where the price decreases.

In contrast to the case with only one producer with capacity in both regions, we see from Proposition 3 that an acquisition can now be unprofitable. The driving force is the outsiders' response to the acquisition. Although the response is mixed in the sense that there is an aggressive response in one sub-market and a soft response in another sub-market, the net effect is that the change in the price difference the acquiring firm is trying to achieve is partly eliminated by the outsiders' response. The outsiders' response hurts the acquiring firm, as is the case in a traditional merger model like Salant *et al.* (1983). In contrast to the traditional case, though, total production is fixed in our model. Our results therefore illustrate that even when total production is fixed for each outside firm they can make the acquisition unprofitable simply by reshuffling their total sales between different markets.

The larger the capacity the acquired firm controls, the more limited scope there will be for an disadvantageous response from outsiders. This explains why an acquisition is profitable when the acquired firm S_E is sufficiently large. If an acquisition is unprofitable according to our analysis, it may still be rational to implement it. For example, one motive for the acquisition might be exogenous cost savings.

4 Some concluding remarks

The competitive effects of higher concentration are less clear-cut in hydropower markets than in other markets. We show this by presenting an example where an acquisition with no cost synergies leads to higher welfare, which is not possible in a corresponding model with no reshuffling of production between different sub-markets.

Our study has important implications for the evaluation of the competitive effect of an acqusition or merger in a hydropower system. It suggests that it is important to evaluate any possible asymmetries between the merging parties. Are they located in different regions? Is one located in several regions, and another in only one region? Do they have the same flexibility with regard to storage of water, or could it be that one of them is able to store water from one year to another whereas the other does not have such an option? How are the price differences before the merger or acquisition? Is the producer that a large firm acquires primarely active in a low price market, which can be regarded as a dumping market? These and similar questions must be answered in order to determine whether a merger or acquisition is detrimental to welfare.

A Proof of Proposition 1

After the acquisition of producer F_W, producer S can follow three strategies (see Section 3.1). To simplify the exposition, we let production by producer S, denoted q_{it}^S, include production from producer F_W.

If three of the four sub-markets are integrated, then the aggregated inverse linear demand for this integrated market (market 2) becomes:

$$p_2 = V - \frac{1}{1+2b}(D_{W2} + D_{E1} + D_{E2}) \tag{14}$$

Producer S is the only one that can produce in both markets, and its production in market 2 is:

$$q_2^S = \overline{q}_W^S + \overline{q}_E^S - q_{W1}^S \tag{15}$$

The production in market 2 consists of the energy capacity available in region E and the difference between capacity in region W and production in the same region in period 1 (market $W1$). If producer S reduces production in market $W1$ enough to create congestion, we know that $p_{W1} > p_2$. We can then find the level of production from producer S in sub-market $W1$ corresponding to separate markets, where $W1$ is the high price market. In a similar manner we can find the production levels corresponding to the integrated market case when all four sub-markets are integrated and the case where sub-market 2 is the high price market, respectively:

$$\begin{bmatrix} p_{W1} > p_2 \quad \text{if} \quad q_{W1}^S < \frac{1}{2+2b}Q - (V-1)(\frac{1+2b}{2+2b}) - \overline{K} \\ p_{W1} = p_2 \quad \text{if} \quad -\overline{K} < q_{W1}^S - \frac{1}{2+2b}Q + (V-1)(\frac{1+2b}{2+2b}) < \overline{K} \\ p_{W1} < p_2 \quad \text{if} \quad q_{W1}^S > \frac{1}{2+2b}Q - (V-1)(\frac{1+2b}{2+2b}) + \overline{K} \end{bmatrix} \tag{16}$$

where $Q = \overline{q}_W^S + \overline{q}_E^S + \overline{q}_E^{S_E} + \overline{q}_E^{F_E}$. We can observe from (16) that the production range (q_{W1}^S) for which we have integrated markets increases with higher transmission capacity in place between the two sub-markets. Remember that before S's acquisition of F_W all sub-markets are by assumption integrated ($p_{W1} = p_2$), because F_W acted as a competitive fringe. We let p denote the price of the integrated market.

After the acquisition producer S faces different profit maximation problems depending on whether the markets are separated or not. The producer maximizes profit by choosing production in both sub-markets subject to the constraints on energy production in the two markets; $q^S_{W1} \leq \overline{q}^S_W$ and $q^S_2 \leq \overline{q}^S_W + \overline{q}^S_E$.[18]. When the two sub-markets are integrated producer S receives the price p for all the available energy. Thus the profit function (π^{SI}) becomes:

$$\pi^{SI} = p(\overline{q}^S_W + \overline{q}^S_E). \tag{17}$$

In a similar manner, we can define the profit functions corresponding to the case where production in market $W1$ is reduced sufficiently to create congestion and full import to $W1$ ($\pi^{SM} = p_{W1}(q^S_{W1}) + p_2(q^S_2)$) and full export from $W1$ ($\pi^{SL} = p_{W1}(q^S_{W1}) + p_2(q^S_2)$). Thus we have that:

$$\begin{bmatrix} \max_{q^{SWE}_{W1}} \pi^{SM} \text{ if } q^S_{W1} < \frac{1}{2+2b}Q - (V-1)(\frac{1+2b}{2+2b}) - \overline{K} \\ \pi^{SI} \text{ if } -\overline{K} < q^S_{W1} - \frac{1}{2+2b}Q + (V-1)(\frac{1+2b}{2+2b}) < \overline{K} \\ \max_{q^S_{W1}} \pi^{SL} \text{ if } q^S_{W1} > \frac{1}{2+2b}Q - (V-1)(\frac{1+2b}{2+2b}) + \overline{K} \end{bmatrix} \tag{18}$$

We note that in the case of integrated markets, producer S's profit is the same regardless of how production is allocated between the two sub-markets. The price p in the integrated market is determined by the total amount of energy available, Q. Thus, producer S's allocation of energy between regions and periods has no effect on the price as long as the sub-markets are integrated.

Proposition 1 can be illustrated by a numerical example (see figure 4). Let us assume that $V = 1$, $\overline{K} = (\frac{1}{32})$, $b = 0.5$ and $\sum_{ji} \overline{q}^j_i = 1$ with $\overline{q}^S_W = \frac{15}{32}$ and $\overline{q}^S_E = \frac{1}{32}$. It can then be shown that $\pi^{SI} = 0.333$ (profits if integrated markets) and $\pi^{SU} = 0.336$ (maximum profits if high price in region 1 in period W. The latter case corresponds to a production level $q^S_{W1} = 0.24$, which is low enogh to ensure that $p_{W1} - p_2 > 0$. In the choice between creating an import constraint on the transmission line in period 1 and letting

[18] In the situation $p_{W1} - p_2 > 0$, we have two possibilities. First, we may have a situation where one (both can not bind at the same time) of these two constraints are binding before the acquisition. If one of these constraints are binding we have a corner solution. Second, we may have a situation where all the energy is used and none of the two constraints is binding, implying that producer S in equilibrium sells in both markets. If we have a corner solution before the acquisiton takes place, this will constrain producer S from behaving differently after the acquisition. Furthermore, if one of the constraints only is binding on the solution after the acquisition this will limit producer S's behaviour. For the sake of simplicity we assume internal solutions both before and after the acquisition.

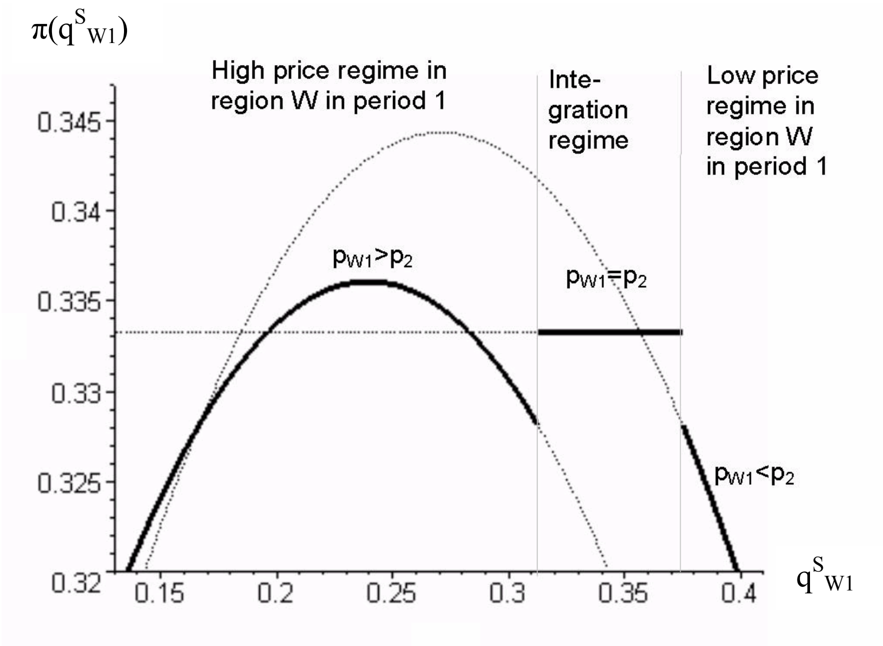

Figure 4: Profit functions for producer S under the three different price regimes ($p_{W1} > p_2$, $p_{W1} = p_2$ and $p_{W1} < p_2$). Attainable profit levels as a function of $q^S_{W1}$are represented by the solid line.

the markets be integrated, producer S would choose to induce congestion. If we look at the possible range of production corresponding to $p_{W1} - p_2 < 0$, there is no production level resulting in profits that are higher than in the integrated market case.[19] After the acquistion producer S would therefore find it profitable to reduce production in sub-market $W1$ which, in turn, would lead to congestion and higher prices in this market.

[19]The maximum profit from inducing congestion and lower prices in sub-market $W1$ is even higher, $\pi^{SL} = 0.344$. This corresponds to a production level $q^S_{W1} < \frac{1}{2+2b}Q - \overline{K}$ implying that $p_{W1} - p_2 > 0$. This is a contradiction, and therefore not attainable.

B Proof of Proposition 3

Let us assume that there are n other producers S^i (where $i = 1..n$) with energy capacity in both regions W and E. Each producer S^i has $\overline{q}_W^{S^i}$ available for production in region W and $\overline{q}_E^{S^i}$ for production in region E. Production in market 2 by producer S^i can be expressed as; $q_2^{S^i} = \overline{q}_W^{S^i} + \overline{q}_E^{S^i} - q_{W1}^{S^i}$. We assume that all producers S^i have the same energy capacity available in both regions; $\overline{q}_W^{S^i} = \overline{q}_W^{S}$ and $\overline{q}_E^{S^j} = \overline{q}_E^{S_{WE}}$.

The transmission line between regions W and E is only constrained in period 1, and electricity flows from region E to W with market $W1$ being the high price market. We can now write our two new inverse linear demand functions:

$$p_{W1} = 1 - \sum_i q_{W1}^{S^i} - \overline{K} \tag{19}$$

$$p_2 = V - \frac{1}{1+2b}(n(\overline{q}_W^{S} + \overline{q}_E^{S}) - \sum_i q_{W1}^{S^i} + \overline{q}_E^{S_E} + \overline{q}_E^{F_E} - \overline{K}) \tag{20}$$

Producers S_E and F_E are only located with capacity in region E. The producer S^i, however, can choose how to distribute available capacity between the two markets. These suppliers simultaneously determine the level of production in market $W1$. The maximization problem of producer S^i can be expressed as:

$$\max_{q_{W1}^{S^i}} = p_{W1}(q_{W1}^{S^i}) + p_2(q_2^{S^i})$$

subject to the constraints that apply for production in one region; $q_{W1}^{S^i} \leq \overline{q}_W^{S^i}$ and $q_2^{S^i} \leq \overline{q}_W^{S^i} + \overline{q}_E^{S^i}$.[20] In order to find the equilibrium before the acquisition we solve the n producers first order conditions simultaneously to find the optimal values of production in market $W1$. Since the producers are symmetric, we have that $\sum_i q_{W1}^{S^i} = nq_{W1}^{S^i}$. We then use these values to calculate the pre-acquisition price difference:

$$\Delta p \equiv p_{W1} - p_2 = \frac{-(\overline{K} + V - 1)(1+2b) - \overline{K} + \overline{q}_E^{S_E} + \overline{q}_E^{F_E}}{(1+n)(1+2b)} \tag{21}$$

[20] With at least some production in both markets none of these constraints binds and we have an interior solution to the problem. As mentioned before, the second constraint is irrelevant here because with higher prices in market $W1$ the producer will always have some production in this market. Here we discuss the equilibrium price difference assuming an interior solution.

Let producer S^i gain control over producer S_E's energy capacity in region E. Because producer S^i now controls the production capacity of producer S_E, S^i can no longer be treated symmetrically with the other producers S^j (where $j = 1..n$, $j \neq i$) having capacity in both markets. We have to solve for optimal production by producer S^i and one of the other $(n-1)$ symmetric producers. Let us use the fact that $\sum_j q_{W1}^{Sj} = (n-1)q_{W1}^{Sj}$ and solve for the optimal values of production in market $W1$. By substitution we can then write the new price difference as follows:

$$\Delta\widehat{p} \equiv \widehat{p}_{W1} - \widehat{p}_2 = \frac{-(\overline{K} + V - 1)(1+2b) - \overline{K} + \overline{q}_E^{F_E}}{(1+n)(1+2b)} \tag{22}$$

We assume this price difference to be positive also after the acquisition. The change in price difference following the acquisition can be expressed by:

$$\Delta p - \Delta\widehat{p} = \frac{\overline{q}_E^{S_E}}{(1+n)(1+2b)} > 0 \tag{23}$$

This is the condition shown in proposition 3.[21]

Finally, let us check the profitability of an acquisition. Let $\pi_0^{S^i}$ denote producer S^i's profit before the acquisition and $\pi_0^{S_E}$ denote producer S_E's profit before the acquisition. Furthermore, let $\pi_1^{S^i}$ denote the profit for producer S^i after acquiring producer S_E. The acquisition is then profitable if $\pi_1^{S^i} > \pi_0^{S^i} + \pi_0^{S_E}$, which is true as long as:

$$\overline{q}_E^{S_E} > \frac{(n-1+2nb)(1-v) + 2b(1-v) + (2\overline{K} + \overline{q}_E^{F_E})(n-1)}{n^2 - n + 1}$$

We see that the acquisition is profitable as long as S_E's production is sufficiently large.

[21] Producer S^i's incentives to increase production in market $W1$ may be limited by constraints on production in region W. If producer S^i before the acquisition have used all the available capacity in region W, then the acquisition would not have any effect on the price difference. Similarly, the production constraint could constrain producer S^i from increasing production as much as wanted after the acquisition. In this case, the effect on the price difference would be lowered.

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