WILL AN INCUMBENT GENERATOR BUY IMPORT TRANSMISSION CAPACITY?

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Abstract

A region with a high cost incumbent monopolistic generator is connected with a competitive low cost region through a low capacity transmission line. Access to the transmission line is auctioned. The paper shows that welfare decreases when the monopolist obtains the transmission capacity and that the monopolist has a higher valuation for transmission capacity than arbitrageurs. This does not mean that the monopolist will buy the transmission capacity. It depends on the degree of arbitrage between the regions who will buy capacity. If arbitrage is perfect, the monopolist buys no transmission capacity. If arbitrage is imperfect, the monopolist obtains some of the capacity.

1 INTRODUCTION

The paper gives some simple intuition for what happens when an incumbent monopolist is allowed to buy import capacity. The results in this paper are not new (see for instance Joskow and Tirole, 2000), but are presented in a simpler way.

We consider the standard two node network with a monopoly at the importing region, and a competitive market in the exporting region. Access to the transmission line is auctioned. We study whether arbitrageurs or the monopolist will buy the transmission capacity. We also look at the welfare effects.

The model has been inspired by the situation at the French-Belgian border. France has cheap nuclear power. Given the small transmission capacity between France and Belgium the interconnecting transmission lines are almost always congested. Belgian consumers are concerned that the Belgian incumbent generator would buy all transmission capacity to keep out its competitors. We show under which conditions this will be the case.¹

This paper uses a two stage game. In stage one the arbitrageurs and the monopolist buy transmission capacity. In stage two the monopolist sets the prices. It is shown that the monopolist has a higher valuation for transmission capacity than the arbitrageurs. Owning transmission capacity gives the monopolist not only the possibility to import cheap electricity, but also increases his market power in its home market.

It depends on the structure of the model, who will buy the transmission rights in stage one. We will look at two settings: (1) all transmission capacity is allocated in one block, and (2) transmission capacity is allocated continuously, and arbitrage is perfect.

¹ Note that the paper makes abstraction of market power in the French electricity market.
2 SET UP OF THE MODEL

Consider two regions $i \in \{1,2\}$. See Figure 1. Region 1 has consumers with a demand for electricity $h(p)$, and a monopolistic generator with a constant marginal production cost $c_H$. Region 2 has a competitive electricity market with a constant marginal production cost $c_L$. Production costs are higher in region 1 than in region 2 ($\Delta c = c_H - c_L > 0$). As region 2 is competitive, its price for electricity is $c_L$. A transmission line with limited capacity $k$ connects both regions.

![Diagram of transmission network with regions 1 and 2, high and low cost producers, and transmission capacity k.](image)

**Figure 1** The model considers two regions, region 1 has a high cost monopolist, and region 2 has a low cost perfectly competitive market. Consumers in region 1 have a demand function $h(p)$.

The model has two stages:
In the first stage, the monopolist buys $x_i$ transmission rights, and the arbitrageurs buy $x_A$ rights. It is assumed that transmission capacity $k$ is small, so that the transmission constraint is always binding $k = x_A + x_i$.

In the second stage, the monopolist sets the price for electricity given the amount of transmission rights that were sold ($x_i$ and $x_A = k - x_i$). The second stage profit function of the monopolist is:

$$\pi(p,x_i) = h(p)(p-c_H) - x_A(p-c_H) + x_i \Delta c$$

It has three terms. The first term is the monopolist's profit when there would be no transport at all. He produces all electricity locally at a cost $c_H$, and sells $h(p)$ units of electricity at a price $p$.

The second term is the sales lost to arbitrageurs who import $x_A$. The third term, $x_i$, is the cost reduction for the monopolist who can buy electricity at a lower price. As it has been assumed that $x_A = k - x_i$, the objective function of the monopolist can be written as a function of $p$, and $x_i$ only.

The following two sections look at two different market micro structures for transmission capacity.
3 ALL CAPACITY IS SOLD AT ONCE

In this section we assume that all transmission capacity is sold in one package: i.e. either the arbitrageurs or the monopolist end up with all the transmission rights. We solve the model first for the second stage.

3.1 Second stage

We compare the two possible allocations: (1) Arbitrageurs have all the transmission rights \((x_{G} = 0, \text{ and } x_{A} = k, )\), and (2) The monopolist has the transmission rights. \((x_{G} = k, \text{ and } x_{A} = 0 )\).

If arbitrageurs own the rights (See Figure 2), then the monopolist has a residual demand function \(h(p) - k\) and obtains a profit:

\[
\pi(p, 0) = (p - c_{H})(h(p) - k)
\]  

(2)

Figure 2 Arbitrageurs own the transmission capacity. The optimal price for the monopolist is \(p(0)\). The area \(B\) is the monopoly profit, area \(A\) the consumers’ surplus, and area \(W\) the value of the transmission rights for arbitrageurs.

He sets a price \(p(0) = \arg \max_{p} \pi(p, 0)\). In
Figure 2 the monopolist obtains a profit $B=\pi(p(0),0)$.
If the **monopolist owns the rights**, he obtains a profit

$$\pi(p,k) = (p-c_h)h(p) + \Delta c k$$

(3)

He maximizes against the full demand function and receives a profit $k \Delta c$ from importing cheap electricity. See Figure 3. He sets the price $p(k) = \arg \max_p \pi(p,k)$. In Figure 3 the profit of the monopolist is the area $B'$.

### 3.2 First Stage

In stage 1, the players bid for the transmission rights. Without specifying the actual mechanism we assume that the player with the highest valuation receives the transmission rights. The value of owning the transmission right for the monopolist is

$$V = \pi(p(k),k) - \pi(p(0),0)$$

(4)

In the figures this is area $B'-B$. The value for arbitrageurs of a unit of transmission rights is equal to the price difference between the regions: $p(0)-c_L$. Their total valuation for $k$ transmission rights is

$$W = (p(0)-c_L)k$$

(5)

See region $W$ in Figure 2. The monopolist has a higher valuation than the arbitrageurs $V > W$.

The proof is simple and uses a revealed preference argument for the monopolist: It is obvious that $B+W < B'$, as otherwise $p(k)$ would not be the optimal price for the monopolist. Rearranging the terms gives $W < B'-B$, which is equation (6).

The figures show also that welfare is higher if arbitrageurs obtain all transmission capacity. Forbidding the monopolist to buy transmission capacity is thus optimal in this situation.

### 4 CONTINUOUS ALLOCATION WITH PERFECT ARBITRAGE

In this section we assume that transmission capacity is allocated continuously and that arbitrage is perfect. Again the second stage is solved first.

#### 4.1 Second Stage

The monopolist obtained $x_g$ transmission rights in the first period. The monopolist maximizes profit and sets a price

$$p(x_g) = \arg \max_p \pi(p,x_g)$$

(7)

If the monopolist owns more transmission rights, his market power increases and he will set a higher electricity price.

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2 If arbitrageurs and consumers can coordinate, they would organize themselves and take into account the infra-marginal rents. They will outbid the monopolist. See Willems (2003)

3 This result is less general than the previous one ($V > W$). Welfare is higher if the consumers obtain all transmission capacity with a concave demand function.
The actions of the monopolist in the first period depend only on the normalized profit function $V(x_i)$ of the monopolist.

\[ V(x_i) = \pi(p(x_i), x_i) - \pi(p(0), 0) \]  

(9)

The function $V(x_i)$ is the generalization of the value of all transmission rights in the previous section. There we looked at two corner points of the allocation: $x_i = 0$ and $x_i = k$: If the monopolist owns all the transmission capacity, his normalized profit is equal to $V(k) = 0$. If he has no transmission capacity he gets zero profit $V(0) = 0$.

The inverse demand function of the monopolist for transmission is his marginal willingness to pay. It can be calculated using the envelope theorem:

\[ \frac{dV(x_i)}{dx_i} = \frac{\partial \pi(p, x_i)}{\partial x_i} = p(x_i) - c_L \]  

(10)

His marginal valuation is equal to the regional price difference. The inverse demand function for transmission is thus an increasing (!) function in the transmission capacity. See Figure 4.

\[ V(x_i) = p(x_i) - c_L \]

Figure 4  Demand function of the monopolist for transmission capacity.

For an arbitrageur, the value of one unit of transmission capacity is equal to the regional price difference. $(p(x_i) - c_L)$. The full line in Figure 5, presents the valuation of one unit of transmission capacity, when other arbitrageurs have $x_i$ transmission rights. Note that his valuation is equal to the marginal valuation of the monopolist.

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4 This follows from $p'(k^*) = -\frac{\pi_p}{\pi_m}$, which is positive if the demand is concave and $p > c_L$. The latter is always the case for small transmission capacities, such that there remains local production.
If all arbitrageurs together own $x_d$ transmission rights, their total value is equal to: $W(x_d) = (p(x_d) - c_L)x_d$. If the arbitrageurs own no transmission capacity, their value is equal to $W(0) = 0$. If the arbitrageurs own all the transmission capacity, their value is $W(k) = W$. These two points were the corners solutions in the previous section. The inverse demand function of the arbitrageurs acting together for transmission rights is equal to

$$\frac{\partial W(x_d)}{\partial x_d} = p(x_d) - c_L - p'(x_d)x_d$$

(11)

The demand for transmission is decreasing in the price (See the dotted line in Figure 5).

Figure 6 combines the information of figures Figure 4 and Figure 5. This is done by changing the direction of the X-axis in Figure 5, and using the fact that $x_d = k - x_L$.

Reading Figure 6 from left to right, the full line is the demand function of the monopolist. Reding Figure 6 from right to left, the dotted line is the demand function of all arbitrageurs acting together.

If the monopolist owns $x_L^*$ transmission rights, his normalized profit is $V(x_L^*)$. If arbitrageurs own $x_d^*$ transmission rights, their profit is $W(x_d^*)$.

The figures show clearly that the marginal valuation of transmission is lower for the arbitrageurs together than for the monopolist. This can be seen numerically by comparing equation (10) and (11).
Figure 6  Demand functions for transmission for the monopolist, and the arbitrageurs.

The figure also confirms the results of the previous section. Allocating all capacity to the monopolist gives him a profit $V$, (the area $acfg$ in Figure 6). Allocating all transmission capacity to the arbitrageurs, gives them a profit $W$ (The area $abfg$). The value for the arbitrageurs ($W$) is lower than the value for the monopolist ($V$).

4.2 First stage

If arbitrage is perfect, the price $\tau(x_i)$ that the monopolist pays for $x_i$ transmission capacity is equal the regional price difference for transmission capacity:

$$\tau = p(x_i) - c_i$$

The monopolist needs thus to pay his marginal valuation. As the marginal valuation of the monopolist is upward sloping, he will make a negative profit on transmission capacity: If the monopolist buys $x_i^*$ transmission rights he obtains the profit $V(x_i^*)$ in Figure 6, but he will have to pay $(p(x_i) - c_i)x_i$ (area $adeh$), which is more that the value of the rights. Therefore, the monopolist prefers not to buy transmission capacity.\footnote{Joskow & Tirole showed the analogy with the literature on takeovers (Grossman and Hart, 1980).}

4.3 When will there be perfect arbitrage?

Increasing the level of arbitrage between the regions is welfare improving as it reduces the market power of the monopolist.

Whether there is perfect arbitrage or not, depends on the precise market structure of the transmission markets.

Willems (2003) and Joskow and Tirole (2000) show for instance that arbitrage is perfect in a first price auction, but not in a pay as bid auction ($\tau(x_i) < p(x_i) - c_H$). In a pay as bid auction, the monopolist receives transmission capacity with a positive probability. The revenue for the network operator is higher then in the first price auction, and expected welfare is lower.

Even in a first price auction the monopolist might end up with some of the transmission rights:
If the monopolist could commit himself to set a low price for electricity if he does not obtain all the transmission rights, he can deter arbitrageurs of buying transmission rights.

In general, if the auctioneer of the transmission rights maximizes auction revenue he will like to allocate the transmission rights to the player with the highest valuation, i.e. the monopolist. A pro-profit auctioneer is thus not welfare optimal.

In practice, arbitrage can be improved by for instance allowing the resale of transmission rights, closing the transmission and energy markets at the same time, reducing the minimal size of transmission rights that can be sold etc... The ideal way to obtain perfect arbitrage is to replace the auctioning of transmission rights with Market Splitting. In such a system, arbitrage is perfect by design.\(^6\)

5 CONCLUSION

The paper considers a high cost monopolistic region that imports electricity from a low cost competitive region. Import capacity is limited by transmission constraints, and transmission capacity is auctioned to arbitrageurs and to the monopolist.

I show that the monopolist has a higher valuation for transmission capacity than the arbitrageurs, because the rights help him to set a higher price for electricity.

Therefore, if the transmission rights would be sold in a single package, the monopolist would buy them. Forbidding the monopolist to buy importing capacity, leads to lower electricity prices and is welfare improving.

Joskow and Tirole (2000), show that it is very difficult to generalize whether generators should be allowed to buy transmission rights when the network is meshed and when transmission rights are also used to hedge uncertainties.

The second part of the paper does no longer assume that transmission rights are sold in one package. Instead, it assumes a continuous allocation of transmission rights and perfect arbitrage i.e. the monopolist pays a transmission price \(\tau\) equal to the price difference between the regions. In this case, the monopolist does not buy transmission rights. This follows from the fact that his demand for transmission is increasing in its price, and that perfect arbitrage obliges him to pay his marginal valuation. So, despite the higher value of transmission rights for the monopolist, perfect arbitrage prevents the monopolist from buying transmission rights.

The last part of the paper discusses whether perfect arbitrage is likely in practice.

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\(^6\) Neuhoff (2003) showed that with multiple players Market Splitting has an additional positive effect because of a timing aspect. With market splitting the transmission markets and the energy markets clear at the same moment. With auctioning, the transmission market clears first, the energy market afterwards. The difference in timing has a strategic effect and makes Market splitting more competitive than auctioning, even with perfect arbitrage.
REFERENCES


