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The European gas market as a bargaining game

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3.1 THE EUROPEAN GAS MARKET

Natural gas is usually transported through pipelines from the gas fields to the users. Due to this structure of the transmission system, which involves large transportation costs, there is no world market for natural gas. Instead we find a set of segmented or geographically separated markets. In Western Europe, it is useful to distinguish between continental Europe and the UK: continental buyers are able to buy gas from several sources, whereas the UK must rely on Norway as the only source in addition to its domestic production (disregarding the possibility of LNG imports).

There are four major countries exporting natural gas to continental Europe: the Netherlands, Algeria, the USSR and Norway, and each country is linked to the Continent by a transmission system. Among the buyers, four countries, namely West Germany, France, Italy and the UK, had 73% of the European consumption of natural gas in 1987. Moreover, in each of the selling and buying countries sales and purchases are dominated by one large company, such as British Gas in the UK and Ruhrgas in West Germany. These companies are in several cases under strong regulation by the government. As the European gas market is dominated by only a few agents on each side of the market, we could characterize this special market structure as 'bilateral oligopoly'.

It is well known that even for bilateral monopoly situations, traditional market theory does not predict a unique outcome for price and quantity. Within a bilateral monopoly framework, price and quantity are usually determined through negotiations between the parties involved. Future prices for natural gas are therefore extremely difficult to predict.

The main focus of the present chapter is an analysis of bargaining when there is more than one seller and/or one buyer of natural gas. In section 3.2 we discuss some aspects which are important for the outcome of negotiations between a seller and a buyer of natural gas. Section 3.3 gives a theoretical analysis of a simple case of one buyer and two sellers. The core of the game is derived and discussed.

In section 3.4 the simple model of section 3.3 is extended to a numerical model of a four-player bargaining game. The four players are the USSR and Norway as gas sellers and continental Europe and the UK as gas buyers. The volumes and prices of gas for the year 2010 belonging to the core are given in section 3.5, both for a reference case and for several alternatives.

3.2 BARGAINING BETWEEN TWO PARTIES

The simplest bargaining situation between two parties is one in which the traded quantity is fixed (provided an agreement is reached). In this case the negotiated price must lie somewhere between the reservation prices of the two parties. The seller's reservation price is the lowest price which is compatible with the seller being at least as well off with an agreement as without. Similarly, the buyer's reservation price is the highest price which is compatible with the buyer being at least as well off with or without an agreement.

It is, however, not reasonable to assume that the gas quantity is fixed before negotiations start. The gas quantity is usually determined simultaneously with the gas price through the negotiations. In order to understand the relationship between the price and quantity of natural gas, one must examine the character of the buyer in more detail.

In negotiations of gas trade, the buyer is a distribution company (or a consortium of several distribution companies) for natural gas. This distribution company buys gas from the gas seller and resells it to the ultimate users (households, industry, etc.). Provided that the ultimate users are not rationed, there is a unique relationship between the price these users are willing to pay and the gas quantity they use (given other energy prices, income, etc.). In spite of this unique relationship, there need not be a corresponding unique relationship between the price and quantity in a negotiated agreement between a gas seller and the gas distribution company buying gas. There are two reasons for this. In the first place, the gas distribution company usually buys gas from several sources, so that a relationship between average price and total quantity does not imply a particular relationship between price and quantity in each gas deal. In the second place, even though the quantity of gas sold by the distribution company determines the price paid by the ultimate users, and therefore this company's total revenue, this does not determine the price paid by the gas

distribution company for the gas it buys and resells. The lower the gas price paid by a gas distribution company, the higher will the profits of this company be (for a given gas quantity). Whatever quantity a seller and a distribution company agree upon, the distribution company will therefore try get as low as possible a price in the negotiations.

To see how gas prices and quantities may be determined in negotiations, consider the simple case in which quantities from all other gas sellers are given. Moreover, to simplify we ignore distribution costs and price discrimination between different gas users. With these simplifications we get a unique relationship between the quantity of gas delivered by the gas seller under consideration and the ultimate gas users. This relationship is downward sloping, as in Fig. 3.1, since it represents the demand curve of the ultimate gas users.

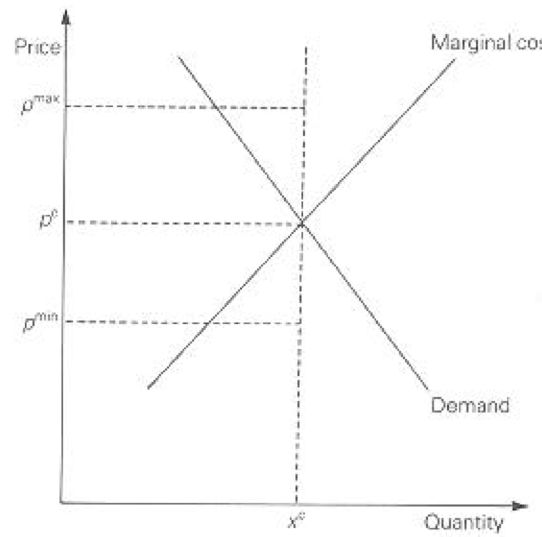

Fig. 3.1

The upward-sloping curve in Fig. 3.1 represents the marginal cost of extracting and transporting natural gas.[1] The intersection between the two curves represents the competitive equilibrium, giving a gas quantity x^c and price p^c.

When there is complete information, it is usually assumed in bargaining theory that the two parties reach an agreement which is Pareto-optimal for them. In the present context, this implies that the gas quantity is chosen so that the total gains to the two parties are maximized, provided the price can be negotiated independently of which quantity is agreed upon. The quantity

[1] Implicitly, this figure assumes that any economies of scale in the transmission sector are dominated by diseconomies of scale in the extraction sector.

which maximizes the total gains to the parties depends on the objective of the gas distribution company. Assume first that the distribution company is a public utility which represents the interest of all citizens of the country. Ignoring income distribution issues (i.e. assuming that lump-sum taxation is possible), a reasonable objective of the distribution company is to maximize the sum of the company's profit and the consumer surplus. The gas seller wants his profit (i.e. revenue minus costs) to be as large as possible. In this case the total gain to the two parties is equal to the area under the demand curve minus total extraction and transportation costs. It is well known that the competitive quantity x^c maximizes this total gain.

Given the quantity x^c, the buyer wants the price to be as low as possible, while the seller wants the price to be as high as possible. The outcome of the negotiation will be somewhere between the two reservation prices p^{min} and p^{max}. Here p^{min} is defined by

$$p^{min}x^c - c(x^c) = 0$$

where $c(x)$ is the total cost function; p^{max} is defined by

$$u(x^c) - p^{max}x^c = 0$$

where

$$u(x^c) = \int_0^{x^c} (p(x)dx)$$

where $p(x)$ is the inverse of the demand curve.

Notice that the ultimate consumers pay p^c for the quantity x^c no matter what the negotiated price between the seller and the distribution company is. In particular, if the negotiated price is above p^c, the distribution company makes a financial loss. The reason why it nevertheless may accept such an outcome is that the consumer surplus will exceed the company's financial loss as long as the negotiated price is below p^{max}.

Consider next the case in which the distribution company is a profit-maximizing firm. In this case the total gains to the two parties is simply the difference between total revenue from selling to the ultimate users minus the total extraction and transportation costs of the gas volume. The gas quantity which maximizes these total gains is the monopoly quantity x^M in Fig. 3.2. The gas consumers pay p^M for this gas quantity. Since the distribution company in this case will not accept a deal giving a financial loss, p^M is also the reservation price of the distribution company.[2] The reservation price for the seller is in this case $^*p^{min}$ (defined by $^*p^{min}x^M - c(x^M) = 0$). The negotiated price will therefore be somewhere in the range between $^*p^{min}$ and p^M.

From the discussion above it is clear that both the gas quantity and the interval of possible negotiation outcomes for the gas price depend on the

[2]With positive distribution costs, the reservation price is of course below p^M.

nature of the company which buys gas from the producer. In practice, natural gas distribution companies are generally either public utilities or regulated private firms. However, this does not imply that the case illustrated in Fig. 3.2 is irrelevant. Even publicly owned or regulated companies may be strongly influenced by self-interest in addition to their role of representing the citizens of the country.

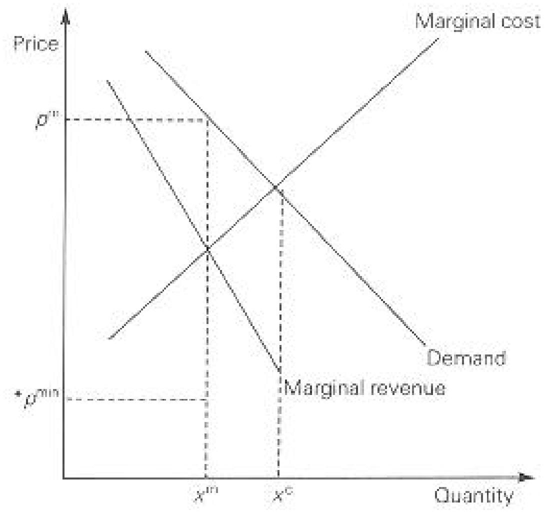

Fig. 3.2

So far, nothing has been said about where in the possible range [p^{min}, p^{max}] or [$^*p^{min}$, p^M] the negotiated price will be. This question has been treated, for example, by Hoel and Vislie (1987) and Vislie (1987), who also explicitly consider the dynamics of the bargaining problem due to the exhaustible nature of natural gas. In the present chapter, we shall instead concentrate on extending the bargaining situation to one in which there are more than two parties involved.

3.3 THE CORE OF A SIMPLE THREE-PLAYER BARGAINING GAME

Negotiations about natural gas deliveries are usually carried out on a bilateral basis. The existence of several other potential gas buyers and sellers is nevertheless important for the bargaining outcome. In the preceding section we argued that the bargaining outcome would lie between the reservation prices of the buyer and the seller. A similar requirement applies when there is more than two parties: also in this case each seller (buyer) only accepts a gas deal if this gives him a price which is not lower (higher) than his reservation price. Moreover, it is reasonable to require that each subgroup of players (with two or more members) should be at least as well off from a set of gas deals as this subgroup could be without having any gas trade with the rest of the participants in the gas market. A set of deals which satisfies these requirements belongs to the core of the multi-player bargaining game.

To illustrate the concept of the core, we shall consider a simple three-player game. We have two sellers, players 1 and 2, and one buyer, player 3. Each seller wishes to sell one unit of gas, and their reservation prices are c_1 and c_2, with $0 < c_1 \leqslant c_2$. The buyer wishes to buy one unit of gas and has a reservation price b, where $b > c_2$ is assumed.

In the absence of seller no. 2 (1), we would have a situation similar to the situation discussed in section 3.2. One unit of gas would be sold from seller no. 1 (2) to the buyer, and the negotiated price would be in the range $[c_1,b]$ ($[c_2,b]$).

With two (potential) sellers, the situation is more complex. Denote the pay-off (or benefit) to the three players of a set of deals by π_1, π_2 and π_3. Gas deals in the core must satisfy

$$\pi_1 + \pi_2 + \pi_3 = b - c_1 \quad (3.1)$$

$$\pi_i \geqslant 0 \qquad i = 1, 2, 3 \quad (3.2)$$

$$\pi_1 + \pi_2 \geqslant 0$$

$$\pi_1 + \pi_3 \geqslant b - c_1 \quad (3.3)$$

$$\pi_2 + \pi_3 \geqslant b - c_2$$

Equation 3.1 is a requirement that the solution is Pareto-optimal for the three players. In other words, the players will not settle with a set of deals when an alternative set of deals can improve the situation for all players. This requirement implies that the buyer gets one unit of gas, and that this unit of gas is delivered by the seller with the lowest reservation price. (If the sellers have equal reservation prices the gas may be delivered by either of the two sellers.)

The inequalities 3.2 are requirements of individual rationality, i.e. that none of the three players can improve their situation by staying out of the natural gas market.

The inequalities 3.3 are requirements of group rationality, and are in a sense a generalization of Equation 3.2. Since the two sellers cannot achieve anything without the buyer, we have the trivial requirement $\pi_1 + \pi_2 \geqslant 0$ (which also follows from Equation 3.2). Seller no. 1 and the buyer can achieve $b - c_1$ without the participation of seller no. 2. These two players therefore only accept deals which satisfy $\pi_1 + \pi_3 \geqslant b - c_1$. The same argument explains the last inequality in Equation 3.3.

Straightforward manipulation of Equation 3.1–3.3 gives

$$\pi_2 = 0$$

$$0 \leqslant \pi_1 \leqslant c_2 - c_1 \quad (3.4)$$

$$b - c_2 \leqslant \pi_3 \leqslant b - c_1$$

Consider first the case in which the two sellers have equal reservation prices, i.e. $c_1 = c_2 = c$. From Equation 3.4 this gives $\pi_1 = \pi_2 = 0$ and $\pi_3 = b - c$. In this case the gas is sold at a price equal to the common reservation price of the sellers. The whole gain from the trade therefore goes to the buyer. In this case the buyer can thus 'set the sellers up against each other', and thereby capture the whole gain himself.

If $c_1 < c_2$, we still get $\pi_2 = 0$, which is consistent with the fact that seller no. 1 now supplies the gas to the buyer. In this case seller no. 1 might get some of the gains from the trade, but this pay-off cannot exceed $c_2 - c_1$. Denoting the gas price by p, we see that $\pi_1 = p - c_1 \leqslant c_2 - c_1$ implies $p \leqslant c_2$. The buyer's pay-off cannot exceed $b - c_1$, i.e. $p \geqslant c_1$ (from $\pi_3 \equiv b - p \leqslant b - c_1$). We thus see that the negotiated gas price must lie in the range $[c_1,c_2]$.

In this example, it is only seller no. 1 and the buyer who are involved in any gas trade (for $c_1 < c_2$). The existence of player no. 2 as a potential seller is, however, important for the possible outcomes of the negotiations between seller no. 1 and the buyer. In the absence of player no. 2 the negotiated price lies in the range $[c_1,b]$. Hence, the existence of player no. 2 as a potential seller narrows down the possible bargaining outcomes to $[c_1, c_2]$, which means a better bargaining position for the buyer.

We shall conclude this section with a brief discussion of which of the prices in the core are likely candidates for the outcome of the bargaining process. In the absence of seller no. 2 all prices in the range $[c_1,b]$ are in the core. For this extremely simple case most bargaining theories would suggest that the bargaining outcome is the price in the middle of these two reservation prices, i.e. that the negotiated gas price is $(c_1 + b)/2$. The well-known (symmetric) Nash bargaining solution is an example of a bargaining theory predicting this outcome. The Nash bargaining solution for this simple case has the reservation prices c_1 and b as the 'disagreement point', leading to the bargaining solution $(c_1 + b)/2$.

Assume now that $c_1 < c_2$ and that seller no. 2 offers his gas at the price c_2, i.e. at a price equal to his reservation price. In such a situation we might expect that the relevant reservation price for the buyer in his negotiations with seller no. 1 is c_2, since the buyer can always obtain his gas at the price c_2. This line of reasoning suggests that b should be substituted by c_2 in the expression for the equilibrium price, i.e. instead of $(c_1 + b)/2$ the bargaining outcome for the price should be $(c_1 + c_2)/2$. Notice that this candidate for a bargaining outcome belongs to the core, which contains all prices in the range $[c_1, c_2]$.

The use above of the outside option c_2 as the disagreement point in the Nash bargaining solution is quite common in the bargaining literature. However, recent theory of bargaining formulated as a non-cooperative extensive form game has shown that this way of using outside options is not necessarily correct (cf. e.g. Binmore, Rubinstein and Wolinsky, 1986; Binmore, 1987). For our example this theory suggests that the introduction of seller no. 2 changes the bargaining outcome for the price from $(c_1 + b)/2$ to $\min[c_2, (c_1 + b)/2]$ (and not to $(c_1 + c_2)/2$). In other words, the so-called 'outside option principle' will work here; an offer of c_2 from seller no. 2 only influences the negotiated gas price if this offer is better for the buyer than the bargaining outcome in the absence of the outside option (in which case the negotiated gas price will be equal to the outside option). Notice that

$$c_1 < \min[c_2, (c_1 + b)/2] \leq c_2$$

i.e. the proposed bargaining solution belongs to the core.

In the example above it was assumed that seller no. 2 gave a binding offer equal to c_2. In practice a buyer is often uncertain about what alternative offer he can get if he breaks the negotiations with the original seller. Even if there exists one or several alternative sellers, they will seldom give binding price offers before serious negotiations with the buyer take place. Possible outcomes of the bargaining process when these types of complications are allowed for have been analysed by, for example, Hoel (1986), Sutton (1986) and Vislie (1988). These analyses reveal that the outcome of a bargaining game is quite sensitive to details of the rules of the game. This confirms that in practice it is difficult to predict the likely outcome of negotiations.

3.4 THE CORE OF THE EUROPEAN GAS MARKET

We have made numerical calculations of the core of a somewhat extended version of the bargaining game in section 3.3. In this section we give a rough description of the model (see Hoel, Holtsmark and Vislie (1987) for further documentation). A more detailed discussion of assumptions, parameter values, etc. is given in the Appendix.

3.4.1 A four-player game

The model includes two sellers and two buyers. The sellers are the USSR and Norway, while the buyers are continental Europe and the UK. In 1987 these two buyers imported a total of 130 bcm natural gas (including imports from the Netherlands). The imports were divided between the USSR

(30%), Norway (23%), Algeria (18%), the Netherlands (27%) and others (2%). In the model, imports from Algeria and the Netherlands are given exogenously. Moreover, continental Europe is treated as one buyer. In 1987, the total imports of 118 bcm natural gas to continental Europe were divided between West Germany (38%), France (23%), Italy (20%) and others (19%).

At present, there is no pipeline across the Channel. This means that gas sales from the USSR to the UK are excluded. The relevant gas flows are therefore from the USSR to continental Europe and from Norway to continental Europe and the UK.

In our model, we may assume that this trade structure remains valid in the future. However, we can alternatively assume that a pipeline across the Channel will be built in the future. In this case gas exports from the USSR to the UK are possible. Since such gas must pass through continental Europe, exports from the USSR to the UK need the consent of continental Europe. It therefore seems most reasonable to assume that the total gains possible for the USSR and the UK without cooperation of the other two players are zero even if a pipeline across the Channel is built. In the model it is also possible to assume alternatively that transport of gas from the USSR to the UK is always possible, provided the transport costs are paid. As long as transport costs are not too high, the gains to the USSR and the UK without cooperation with other players is positive under this assumption.

3.4.2 Cost structure

The cost structure in the model is extremely simple. Extraction costs are of the 'inverse L' type, i.e. unit extraction costs are constant up to an exogenous capacity limit. Extraction costs for gas from the USSR are assumed to be somewhat lower than for gas from Norway (cf. Table 3.1).[3]

Unit transport costs depend only on where the gas is transported to and from. Transportation from the USSR to the gas-using countries costs considerably more than transportation from Norway. As is clear from Table 3.1, the sum of extraction and transportation costs are therefore slightly higher for the USSR than for Norway.

In addition to transport costs, there are country-specific distribution costs. Like other costs, these distribution costs are assumed to be proportional to the gas quantity.

3.4.3 Import diversification

From Table 3.1 we can see that gas from the USSR has higher total unit

[3]Costs are measured in 1987 Nkr per m^3. At the exchange rate of September 1989 (Nkr 7.25 per \$US), Nkr 1 per m^3 is equal to \$US4.30 per million BTU.

Table 3.1 Unit costs of production, transport and distribution of natural gas (1987 Nkr per m³)

From:	*USSR*		*Norway*	
To:	*Continental Europe*	*UK*	*Continental Europe*	*UK*
Unit production costs	0.12	0.12	0.20	0.20
Unit transport costs	0.35	0.45	0.22	0.15
Unit distribution costs	0.55	0.66	0.55	0.66
Total unit costs	1.02	1.23	0.97	1.01

costs than gas from Norway. This is true both for gas deliveries to continental Europe and the UK (provided a pipeline across the Channel is built). Without any capacity restriction on Norwegian gas, we thus get a situation similar to the one described in section 3.2: the gas seller with the highest unit costs (USSR) will not sell any gas in the solutions belonging to the core. However, this situation does not occur in our model, since we assume that there is a binding capacity limit to Norwegian gas production (60 bcm in the reference case).

Even in the absence of any production capacity constraints, it is unreasonable to assume that an importing country buys all its gas from the seller with the lowest cost. It is more reasonable to assume that the importing countries wish to diversify their gas imports somewhat.[4] The diversification argument is included in our model in a somewhat crude way by setting an exogenous limit on imports from the USSR as a share of total gas consumption in the buying countries. In our reference case we have set this limit equal to 30% both for continental Europe and the UK. This corresponds to the limit recommended by the IEA to their member countries. This import limit implies that it would be possible for Norway to sell gas even if Norway had higher costs than the USSR, and even if there was no capacity limit on production in the USSR (see Vislie, 1989 for further discussion of this market share requirement).

[4]For a further discussion of such diversification issues, see Hoel and Strøm (1987) and Manne, Roland and Stephen (1986).

3.5 RESULTS

We have used the model to see what the core of the bargaining game implies for gas quantities and prices in 2010. In our reference case we have assumed that the gas-importing companies are pure profit-maximizing firms. We have also assumed that a pipeline across the Channel will be built, but that transport of gas from the USSR to the UK needs the consent of continental Europe.

Table 3.2 gives the gas quantities in the core in 2010 for the reference case. These quantities are, of course, strongly influenced by exogenous variables and parameters, such as GNP growth, demand elasticities, the Norwegian production capacity, and the maximal share of USSR imports in total gas consumption.

Table 3.3 gives minimum and maximum prices for the sellers and buyers (excluding the constant unit costs of transport and distribution). The most striking feature of Table 3.3 is the wide range of possible prices for the players which are consistent with solutions in the core.

Table 3.2 Gas quantities in the core in 2010 (bcm)

	UK	*Continental Europe*	*Continental Europe+UK*
Imported from Norway	17	43	60
Imported from the USSR	20	53	73
Imported from Norway and the USSR	37	96	133
Imported from Algeria and the Netherlands	0	55	55
Total gas consumption	67	176	243

Table 3.3 Price ranges in the core in 2010 (1987 Nkr per m³)

	Minimum	*Maximum*
Gas from Norway	0.32	1.05
Gas from the USSR	0.12	0.58
Gas to the UK	0.20	0.86
Gas to CE	0.21	0.83

Table 3.4 indicates which divisions of the total surplus (106 bn 1987 Nkr) are possible for solutions in the core. Norway and continental Europe are guaranteed part of the total surplus, while the USSR or the UK may end up getting none of the total surplus from the gas trade. In fact, both the

USSR and the UK may end up receiving zero pay-off. The reason for this is that in the reference scenario, it is assumed that transportation of gas from the USSR to the UK is only possible with the consent of continental Europe. The total gain possible for the USSR and the UK without cooperation from the other players is therefore zero.

Table 3.4 Distribution of total surplus in the core of 2010 (bn 1987 Nkr)

	Minimum		*Maximum*
Pay-off for Norway	7		51
Pay-off for the USSR	0		34
Pay-off for continental Europe	16		74
Pay-off for the UK	0		25
Total pay-off		106	

The maximal surplus Norway can get is 1987 Nkr51 bn. With 2% yearly real GNP growth in Norway from 1987 to 2010, this corresponds to the surplus from gas exports being maximally 6% of Norway's GNP in 2010.

Finally, Table 3.5 shows how some of the relevant variables depend on which assumptions we use. Norwegian exports are in all of the cases considered to be determined by the Norwegian capacity limit. However, exports from the USSR and price range for Norway are quite strongly affected by which assumptions are made.

In the reference case it is assumed that a pipeline across the Channel will be built. Without a pipeline (scenario B), the USSR cannot export to the UK. This import loss to the UK is partly compensated by increased imports from Norway. This in turn reduces Norwegian exports to continental Europe (due to the Norwegian capacity constraint). Since the constraint on imports from the USSR is as a percentage of total imports, the reduction in imports from Norway implies reduced imports from the USSR to continental Europe. Total Soviet exports are thus considerably lower without a pipeline across the Channel than with.

Norway's bargaining position is stronger without a pipeline across the Channel, moving the price range for Norway upwards. However, the difference between the two cases is modest, at least for price and pay-off intervals for Norway.

With a lower international GNP growth, the demand for gas in 2010 will be lower. In scenario C we see that this implies lower gas exports from the USSR, and a slight reallocation of Norwegian exports from continental Europe to the UK. The price range for Norway is also somewhat lower the

Table 3.5 Exports (bcm) and prices (1987 Nkr per m^3) under alternative assumptions

	Exports from Norway		*Exports from the USSR*		*Price for Norwegian gas*	
	To Continental Europe	*To UK*	*To Continental Europe*	*To UK*	*Min*	*Max*
A. Reference case	43	17	53	20	0.32	1.05
B. No pipeline across Channel	33	27	48	0	0.38	1.20
C. 1.5% demand growth (reference case = 2%)	37	23	50	11	0.28	0.89
D. 25% reduction in transport costs from the USSR	43	17	53	20	0.28	1.09
E. Max. share of imports from the USSR 40% (ref.case = 30%)	27	33	71	6	0.27	0.75

lower the demand growth is. However, for this alternative the consequences for Norway are also relatively modest.

In the reference case, it is assumed that Norwegian gas has a lower unit cost of production plus transportation than gas from the USSR. Cost estimates for the USSR are, however, very uncertain. In scenario D we therefore consider a 25% reduction of transportation costs from the USSR. This makes the total unit costs of gas from the USSR to continental Europe lower than for Norwegian gas. Without any restriction on imports of gas from the USSR, this could have a dramatic impact on Norwegian gas exports. However, the restriction that gas from the USSR should not exceed 30% implies that the cost of gas from the USSR is of far less significance for Norway. As is clear from Table 3.5, exports from Norway as well as the USSR are unaffected by this reduction in Soviet costs. From Table 3.5 we also see the somewhat surprising result that reduced costs for gas from the USSR does not unambiguously move the price range for Norwegian gas downwards: the maximal price Norway can get is higher the lower the costs of USSR gas are. In other words, the aggregate gain of reduced costs might not be divided only between the USSR and the gas buyers. Some of the aggregate gain might go to Norway, through buyers paying more for Norwegian gas although their average price for gas imports is reduced.

The importance of the restriction on imports from the USSR is illustrated by scenario E, where it is assumed that maximal share of imports from the USSR is 40% instead of 30%. It is clear from Table 3.5 that this only gives a modest increase in total Soviet exports. However, much more of the exports now go to continental Europe, while a larger share of Norway's gas now is sold to the UK. The reason for this reallocation of exports is that continental Europe in a sense is more constrained by the import limit on Soviet gas than the UK. Although a 30% limit is binding for both continental Europe and the UK, a 40% limit is only binding for continental Europe (in this case only 8% of the UK's imports come from the USSR). If there was no limit on gas imports from the USSR, continental Europe would import 48% of its gas from the USSR, while the UK would only import from Norway.

It is clear from Table 3.5 that the increase in the limit of imports from the USSR gives quite a significant downward movement of the range for Norwegian prices.

3.6 CONCLUSIONS

Since natural gas is traded on a bilateral basis, via a pipeline system connecting a seller with a transmission or distribution company, we have several geographically separated markets for gas in Europe. In each market segment, trade is governed by a long-term contract, determined in negotiations between a seller and a buyer. Each contract usually stipulates the volume of gas to be delivered each year and a delivery price, which is normally linked to other energy prices. In the present chapter we confined ourselves to an atemporal analysis of some important aspects of gas contracts.

We first considered a pure bilateral monopoly, where we emphasized the nature of the buying company. The volume of trade and the range of possible negotiation outcomes for the gas price were seen to depend strongly on whether the buying company was a public utility or a profit-maximizing firm. Whereas the volume of trade was uniquely determined within each context, we were only able to derive a range for the gas price, determined as the set of prices between the agents' reservation prices.

We next considered a simple three-player bargaining game, with one buyer and two sellers. In the absence of the high-cost seller, the core of the game was identical to the price range in the pure bilateral monopoly situation. The impact of the second (high-cost) seller on the core and the (symmetric) Nash bargaining solution was that the core of the game became smaller, in the sense that the maximal price in the core now became equal to the reservation price of the second (high-cost) seller. The presence of another seller thus favours the buyer even though the buyer still purchases all gas from the low-cost seller. The appropriate Nash bargaining solution gives an equilibrium price which is equal to the Nash solution in the case with only one seller, provided this price does not exceed the upper limit of the core. If it does, the equilibrium price is equal to this upper limit, i.e. equal to the reservation price of the high-cost seller.

Finally, we presented a numerical model in which the European gas market was modelled as a game between two sellers (the USSR and Norway) and two buyers (continental Europe and the UK). The focus of attention was on production and price ranges for Norwegian gas compatible with the core of the game for the year 2010. Given the proposed assumptions about cost structure and demand, we derived a reference scenario for production in each selling country, its distribution among the buyers and a price range for Norwegian gas.

One of the most striking features of the model is the wide range of possible prices for the players which is consistent with solutions in the core. We also studied how the core depends on which assumptions we use. Norwegian exports are assumed to be determined by the Norwegian capacity limit in all of the cases we considered. However, the distribution of these exports between the UK and continental Europe depends significantly on which assumptions are used. Price and pay-off ranges are also affected by which assumptions are made. We found that the propects for Norway are worse (i) with a pipeline across the Channel than without, (ii) the lower is the demand growth, and (iii) the higher share of Soviet gas in total consumption the importing countries accept. Of these factors, the last one seems to be the most important for the price of Norwegian gas. This factor is also important for the distribution of Norwegian exports: relaxing the constraint on the share of Soviet imports gives a significant increase in the volume of gas Norway sells to the UK. We also found the somewhat surprising result that reduced costs for gas from the USSR does not unambiguously move the price range for Norwegian gas downwards: the maximal price Norway can get is higher the lower the costs of USSR gas are. In other words, the aggregate gain of reduced costs might not be divided only between the USSR and the gas buyers. Some of the aggregate gain might go to Norway, through buyers paying more for Norwegian gas although their average price for gas imports is reduced.

APPENDIX

Demand assumptions

The demand for natural gas in continental Europe and the UK is given by linear demand functions. The two parameters of each demand function in year 2010 are derived as follows: first, we find the point on the demand curve in 2010 for the 1987 real price of natural gas. This follows from the assumed GNP growth and the income elasticity of natural gas, as well as the assumed real oil price growth and the cross-elasticity of gas consumption with respect to the real oil price. In the base case GNP growth is assumed to average 2.5% throughout the period 1987–2010, both for the UK and continental Europe. The income elasticity of gas is assumed to be 0.8 in the UK and 0.7 in continental Europe. The real oil price is assumed to grow by 25% from 1987 to 2010, and the cross-elasticity is assumed to be 0.4 in both the UK and continental Europe. Once the points on the two demand curves corresponding to an unchanged gas price have been found, the two parameters of each demand function follow from the assumed direct price elasticities at these points on the demand curves. These elasticities are assumed to be −0.8 both for continental Europe and the UK.

Supply assumptions

The cost assumptions for Norway and the USSR have already been given in the text. In addition to imports from Norway and the USSR, the importing countries may have indigenous production as well as other imports. We assume that continental Europe (excluding the Netherlands) and the UK produce 25 and 30 bcm natural gas, respectively, in 2010. Moreover, it is assumed that the Netherlands and Algeria export 25 and 30 bcm to CE in 2010, respectively. The UK is assumed to import no gas from the Netherlands or Algeria, even if a pipeline across the Channel is built.

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4

Bargaining, vertical control, and (de)regulation in the European gas market

JON VISLIE

4.1 INTRODUCTION

In the market for natural gas in Europe, negotiations play an important role in the determination of terms of trade between various agents. Due to the small number of countries involved in the trade of nautral gas on the European continent, this market could be characterized as a 'bilateral oligopoly'. As trade between a buyer and a seller can be implemented only if the parties make investments in relationship-specific infrastructure (pipelines and terminals), the agents, once these investments have been undertaken, are locked into a bilateral monopoly position. Since the parties cannot rely on the market once the investments are undertaken, a trade agreement is usually governed by a long-term contract, established between a selling country (or a national enterprise) and a buyer, which is normally a transmission company, reselling gas to local distribution companies in various regions. Long-term contracts will not only regulate trade between upstream suppliers and transmission companies; such contracts are also prevalent in regulating trade between transmission companies and downstream firms, such as local distribution companies. Hence, there is no ordinary spot market for natural gas, but a set of segmented or geographically separated markets, where terms of trade are determined in a complex interrelated bargaining game comprising upstream as well as downstream agents. Within such a market structure, a transmission company has a rather strong market power, as a player 'in between' the upstream suppliers and the downstream buyers; for further details, see Bjerkholt, Gjelsvik and Olsen (1989).

The present paper will analyse some aspects of the European natural gas market. We focus on the aspects of bargaining or negotiations that take place between agents in a set of vertically related markets. To simplify the picture, we will consider two selling countries – Norway and the USSR – one large transmission company, which in a rough manner can be thought of as a company similar to Ruhrgas, and one local distribution company, buying natural gas from the transmission company and reselling gas to ultimate consumers, which we can think of as households. The transmission company can buy gas from either Norway, the USSR or both. The price charged by the USSR is assumed fixed, whereas the price paid for Norwegian gas is determined in negotiations. The total volume of natural gas to be purchased by the transmission company and the price will, on the other hand, be determined in negotiations with the local distribution company. With this market structure as a benchmark, we proceed to analyse aspects of vertical control and (de)regulation, in order to draw some tentative conclusions as to the impact on prices of deregulating the European gas market as proposed by the EC Commission.

According to Bjerkholt, Gjelsvik and Olsen (1989), the unit cost production and transportation of natural gas from the USSR is higher than that from Norway as of 1987. However, in the present chapter, we will assume that at least for some range of production, gas from the USSR is less expensive than gas from Norway. If the transmission company under these circumstances were allowed to buy all gas from the less expensive buyer, Norway would have been driven out of the market. However, as discussed by Hoel and Strøm (1987), the transmission company may, in order to minimize the risk of an embargo, diversify its purchases; so in that case, Norway will be able to compete, even though her gas production is more expensive. Diversification will also be the result if the recommendation given by the IEA, saying that the market share of USSR gas should not exceed 30%, is in fact obeyed. If that is the case, the transmission company would also purchase gas from Norway. In the present chapter, such recommendations are considered more closely, in order to see how the total volume of gas consumption and the prices paid between the various agents are affected by, say, an upper limit on the market share of natural gas from the USSR.

In order to cope with this rather multifaceted problem we simplify on other fronts as much as possible: we neglect that natural gas is an exhaustible resource, we analyse the whole problem within a static framework, we assume that investments in infrastructure have already been undertaken and, finally, we suppose that all bargaining outcomes satisfy the Nash bargaining solution.

4.2 THE MODEL

Let us first consider the two selling countries: the USSR is selling a volume z of natural gas to the transmission company. The (constant) unit cost of extraction and transportation is denoted c_S, and, by assumption, the price charged by the USSR per unit of z, p_S is fixed, e.g. proportional to c_S. Hence, the pay-off or net gain to the USSR from selling z units of gas to the transmission company at a net price $p_S - c_S$, is given by

$$W_S = (p_S - c_S)z \tag{4.1}$$

The other seller, Norway, produces x units of natural gas with a (constant) unit cost of extraction and transportation c_N. The unit price paid by the transmission company is p_N, and the pay-off or net gain to Norway from selling x units at a price p_N is then

$$W_N = (p_N - c_N)x \tag{4.2}$$

On the other side of the market, we have the local distribution company, which by assumption represents the ultimate consumers in that region or country. The gross benefit in some monetary unit of having $x + z$ units of natural gas, will be given by a strictly increasing and strictly concave benefit function $U(x + z)$. (Note that the price paid by the consumers will, by assumption, be $U'(x + z) = q$. In Hoel and Vislie (1987) a model of natural gas trade for a pure bilateral monopoly situation is analysed, where the buyer is assumed to behave as a monopolist when selling gas to the ultimate consumers. This situation can be captured within the present framework by redefining the pay-off function to the local distribution company; instead of $U(x + z)$, the revenue of the monopolist would have been $U'(x + z)(x + z)$.)

In providing the ultimate consumers with natural gas, the local distribution company will usually have incurred transportation costs. However, in the present context we will neglect such costs. The price paid by the distribution company to the transmission company per unit of gas is denoted by π, which is determined in negotiations. Let us for ease of exposition assume that the local distribution company buys the entire volume of gas delivered by the two supplying countries and serves one country with natural gas. In that case, the net gain or pay-off to the consumers in this country of having $x + z$ units of natural gas at a total marginal cost equal to π, will be

$$W_B = U(x + z) - \pi(x + z) \tag{4.3}$$

The transmission company purchases natural gas from both sellers, where deliveries from the USSR are determined from the given market share requirement, whereas deliveries from Norway follow when total demand is determined. The transfer price p_N is then determined in negotiations between Norway and the transmission company, whose gross revenue from selling $x + z$ units of gas to the buyer is $\pi(x + z)$. Hence, the transmission company's pay-off or net gain will be

$$W_T = \pi(x + z) - p_N x - p_S z \qquad (4.4)$$

In order to simplify even more, we will introduce the following assumptions, for the case where contracts are determined through negotiations:

A1: The price charged by the USSR, p_S, is given.
A2: The unit cost of extraction and transportation in Norway exceeds the given price charged by the USSR, i.e. $c_N > p_S > c_S$.

Assumption A1 is introduced in order to minimize the complexity of the model. We could have allowed for negotiations between the USSR and the transmission company in the determination of p_S, but then the model would have become very complex. In order to get around the multi-player bargaining problem, we take p_S as a parameter. Assumption A2 says that the price charged by the USSR is below Norway's unit cost. This assumption can be justified on political grounds in the USSR; for instance, a high shadow price of foreign exchange might motivate the authorities in the USSR to stipulate a low value for p_S. Assumption A2 then means that if no restriction was placed upon the market share of gas from the USSR, and if there are no uncertainties of any kind, the volume of gas sold by Norway would have been zero. In order to rule out this solution, we introduce an upper limit on z as a share of $x + z$:

A3: $z \leq \alpha(x + z)$ where $\alpha \in (0, 1)$, saying that the market share for gas from the USSR should not exceed α; for instance, as proposed by the IEA, $\alpha = 0, 3$.

From the restriction in assumption A3, we can instead write $z \leq \beta x$ where the parameter $\beta \equiv \alpha/(1 - \alpha)$. As will be evident from the subsequent analysis, assumption A3 is crucial. When we go on to discuss a change in market structure, and analysing the outcome when the market segments are regulated in accordance with the proposition made by the EC Commission, we can derive explicit expressions for the loss in consumers' surplus from adhering to the policy proposed by the IEA.

In the model presented above, we have assumed away all costs of transportation. As there are likely to be decreasing unit costs of transportation due to large fixed infrastructure in the transmission sector (natural monopoly) and that the unit cost of transportation usually differs depending on where the gas comes from, we lose some interesting and important aspects of the gas market by sticking to these assumptions. However, we end up with a rather simple model where we focus mainly on price determination in the various segments of the market. A simplified picture of

the structure of the European market for natural gas is presented in Fig. 4.1.

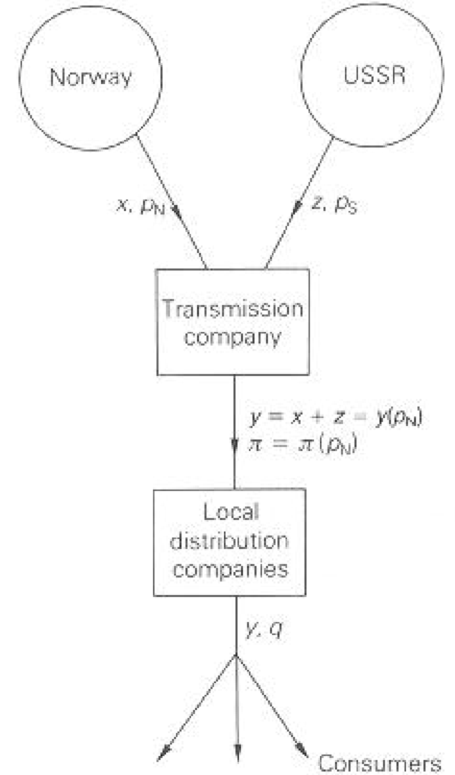

Fig. 4.1

4.3 CONTRACTS AND SUCCESSIVE BILATERAL MONOPOLIES

In this section we derive the agreements that will be established between the agents in the situation where we have successive bilateral monopolies. At each stage where negotiations take place, we assume that the resulting outcome satisfies the axioms behind the Nash bargaining solution. This means that the bargaining outcome has to be Pareto-optimal, individual rational, symmetric, invariant to linear transformations of the utility scales and independent of irrelevant alternatives; see e.g. Friedman (1986, Chapter 5).

Suppose we have the following sequence between the various negotiation stages: first, the transmission company and the local distribution company negotiate about volume of trade and price. As the outcome of these negotiations will depend upon the price paid for Norwegian gas, the local distribution company and the transmission company will agree upon a set of **contract rules**, rather than a strict contract, i.e. they will agree upon rules specifying how much gas to buy and a price π, both as functions of the price paid for Norwegian gas. Second, the transmission company and Norway negotiate about a price of Norwegian gas, given the contract rules from the first stage, and the α-requirement introduced in assumption A3 above. As the outcome of the first stage depends upon the price determined in the second stage, the strict terms of the contract between the local distribution company and the transmission company are determined once the second negotiating round is ended.

4.3.1 The bargaining outcome between the transmission company and the local distribution company

We will now consider the contract established between the transmission company and the local distribution company. They negotiate about a contract rule, expressed $\{\pi(p_N), y(p_N)\}$ where y is total gas purchase of the local distribution company, i.e. $y \equiv x + z$, and π is the price. At the point in time they negotiate, the price paid by the transmission company for natural gas delivered from Norway is not yet fixed and is considered as a parameter at this stage; so what they agree upon is a rule rather than a strict contract, where the rule is contingent upon the price paid by the transmission company for gas delivered from Norway.

According to the Nash bargaining theory, the bargaining outcome will be found as the pair $\{\pi(p_N), y(p_N)\}$ which maximizes the Nash product, i.e. the product of the parties' pay-offs, as their disagreement points, by assumption, are set equal to zero. Hence the contract will satisfy: maximize $[W_T W_B]$ with respect to y and π, under the restriction that neither of them will make a loss. In establishing these contract rules, we can solve the problem in two steps:

1. Choose a volume of trade $y(p_N)$ such that the sum of net gains is maximized.
2. Choose $\pi(p_N)$ such that total gain is distributed equally between them.

The volume of trade must satisfy the axiom of Pareto-optimality; whereas the price π according to the symmetry axiom must divide total gain equally between them. Consider the first problem:

$$\underset{y}{\text{Maximize}}\ W_B + W_T = U(y) - p_N x - p_S z \qquad \text{s.t. } z \leqslant \beta x \quad x \geqslant 0 \quad z \geqslant 0 \text{ where } y \equiv x + z \tag{4.5}$$

Suppose that $U'(0)$ is so high that the value of y that solves the problem in

Equation 4.5 is positive, even for very high values of p_N. It then follows that both y and x will be positive, and it is easy to show that $\beta x = z > 0$ as well. The optimal value of y, contingent upon p_N, must then satisfy the following condition:

$$U'(y) = (1 - \alpha)p_N + \alpha p_S \equiv q(p_N) \tag{4.6}$$

where q is the price the consumers, served by the local distribution company, are willing to pay at the margin for a total gas consumption equal to y.

From Equation 4.6 we can derive the relationship between total gas demand and consumer price, which will depend upon the price paid for Norwegian gas, p_N, as given by $y = e(q(p_N))$, of which a share $(1 - \alpha)$ is delivered from Norway. As the ultimate consumers' marginal benefit is strictly decreasing in y, we have that the lower q is, the higher is y, and due to the market share requirement on gas delivered from the USSR, the higher will x also be.

The price $\pi(p_N)$ of natural gas paid by the local distribution company to the transmission company, is determined as

$$\pi(p_N) = \arg\max_{\pi} [W_T W_B] \quad \text{given } z = \beta x \quad \text{and} \quad y = e(q(p_N)) \tag{4.7}$$

Due to the symmetry axiom, $\pi(p_N)$ is determined so as to make the gains to the two companies equal, i.e. $W_T = W_B$, from which it follows that the price must satisfy the following rule:

$$\pi(p_N) = \tfrac{1}{2}\,[\bar{U}(y) + (1 - \alpha)p_N + \alpha p_S] = \tfrac{1}{2}[\bar{U}(y) + q] \tag{4.8}$$

where $\bar{U}(y)$ is the ultimate consumers' average benefit of having y units of natural gas. (We have used Equation 4.6 in order to express π as a function of the consumer price q.)

The price π, i.e. the unit price the local distribution company is paying to the transmission company, is stipulated so as to equalize the gains to the two companies. It is obvious that $\pi(p_N)$ will exceed the consumer price q, due to strict concavity of the benefit function U. The interpretation that π exceeds the consumer price q is as follows: in order to reach an agreement with the transmission company, the consumers in the buying country as a group must collectively transfer part of their consumer surplus to the transmission company, e.g. through taxation.

It is also obvious from the expression in Equation 4.8 that π is an increasing function of p_N; the higher the price the transmission company is paying for Norwegian gas, the higher is q, and the higher q is, the smaller is y, and the higher is the average benefit to the ultimate consumers. Since $\pi(p_N)$ is differentiable, we have $\pi'(p_N) > 0$, when $\alpha \in (0, 1)$.

Above we have derived the contract rules, $\pi = \pi(p_N)$ and $y = e(q)$ with $q = q(p_N)$, not the strict terms of the contract, for the trading relationship between the local distribution company and the transmission company, as both y and π are functions of the transfer price p_N (not yet agreed upon). In order to derive strict terms of the contract established between the local distribution company and the transmission company, we have to determine the price p_N, to which we now turn.

4.3.2 The bargaining outcome for the transfer price p_N

The transmission company and the Norwegian seller will negotiate only about the price p_N. Since total demand of the ultimate consumers is determined once p_N is fixed, Norway and the transmission company can only agree upon a price, not the volume of gas trade that will take place between the two, as x is not independent of p_N. At the point in time when the transmission company and the Norwegian seller are to agree upon some price, both agents have, by assumption, perfect knowledge about the ultimate consumers' demand function; hence, for any price p_N, both agents know total demand and the relationship between the two prices, as given by $\pi = \pi(p_N)$. Inserting the demand function for Norwegian gas and the relationship between the two prices into the pay-off functions, we can express these as

$$W_N = (p_N - c_N)(1 - \alpha)e(q(p_N)) \qquad (4.2')$$

$$W_T = [\pi(p_N) - (1 - \alpha)p_N - \alpha p_S]e(q(p)) = [\pi - q]\, e(q) \qquad (4.4)'$$

where we have $q = q(p_N) = (1 - \alpha)p_N + \alpha p_S$. When negotiating about the transfer price p_N, the seller knows that the higher this price is set, the higher will q and hence π be, and the lower will be the demand for natural gas. The buyer, on the other hand, is aware of the fact that the lower p_N is set, the higher will demand be, but the lower will the transfer price π also be. Both agents are therefore aware of the fact that a too favourable price, as seen from each other's perspective, will involve some opposing impact either on the volume of trade or on the price transmission company will get when reselling gas to the local distribution company. When negotiating about the price p_N, these elements are taken into account.

The price p_N is at this stage determined in such a way that the Nash product is being maximized:

$$p_N^* = \arg\max_{p_N} W_T W_N \qquad (4.9)$$

In order to derive some explicit conclusions, I will from now on assume that the ultimate consumers' benefit function is given by the following constant elasticity function, with μ as the demand elasticity and A a positive constant:

$$U(y) = \frac{Ay^{(1+1/\mu)}}{1 + 1/\mu} \quad \text{where } \mu < -1 \qquad (4.10)$$

With this benefit function, we have that the average benefit in the expression for $\pi(p_N)$ in Equation 4.8 will be equal to

$$\mu U'/(1 + \mu) = \mu q/(1 + \mu)$$

Using this in Equation 4.8, we get

$$\pi(p_N) = (1 + 2\mu)q/(2 + 2\mu)$$

When solving the problem in 4.9, which is done in the Appendix, we get the following price for Norwegian gas:

$$p_N^* = \frac{1 + 2\mu}{2 + 2\mu} c_N + \frac{\alpha}{1 - \alpha} \frac{(-1)}{2 + 2\mu} p_S = \theta_1 c_N + \theta_2 p_S \qquad (4.11)$$

where we have introduced the notation $\theta_1 = 1 + m$, $\theta_2 = \beta m$ where $m = (-1)/(2 + 2\mu)$. θ_1 gives the impact on the Norwegian price of an increase in Norway's cost of production, and depends only upon the elasticity of demand; the smaller $-\mu$ is, the higher is θ_1. The coefficient θ_2 gives the relationship between the Norwegian price and the price charged by the USSR, and depends upon the market share requirement and the elasticity of demand; θ_2 is higher, the higher α (and β) is and the smaller $-\mu$ is. As $\theta_1 = 1 + m$, we have $\theta_1 > 1 > \theta_2 > 0$ for finite values of μ and for $\alpha \in (0, 1)$. Norway's unit cost of production has a stronger influence on her own price than the price charged by the USSR. (We will return to Equation 4.11 in section 4.3.4.)

Inserting the expression for p_N from Equation 4.11 into Equation 4.6, we derive an explicit solution for the consumer price, q^*, as a function of the exogeneous parameters

$$q^* = (1 - \alpha)p_N^* + \alpha p_S = \theta_1[(1 - \alpha)c_N + \alpha p_S] = \theta_1\Gamma \qquad (4.12)$$

where Γ is defined as the term within the brackets in Equation 4.12. According to what has been said above, the price π^* follows directly as

$$\pi^* = \theta_1 q^* = \theta_1^2\Gamma \qquad (4.13)$$

With the benefit function in Equation 4.10, we have a very simple form of the demand function $y = e(q) = [q/A]^{\mu}$ from which we can determine the exact volume of gas purchased from the local distribution company. With the market structure characterized by successive bilateral monopolies, combined with the α-requirement on the market share of gas from the USSR, we get that total volume of gas purchase $y^* = [\theta_1\Gamma/A]^{\mu}$, of which a share $(1 - \alpha)$ is delivered by the Norwegian seller.

4.3.3 The distribution of gains

We turn now to the question of how the gains from trade are distributed among the various agents, whose pay-offs are given in Equations 4.1–4.4.

On using the explicit formulae for the various prices derived in preceding sections, we find

$$W_T^* = W_B^* = mA^{-\mu}[\theta_1\Gamma]^{1+\mu} = \theta_1 W_N^* \qquad (4.14)$$

We have according to previous results that the pay-offs to the transmission and the local distribution companies are equal and it can easily be demonstrated that this (common) pay-off will exceed Norway's pay-off. The pay-off to the transmission company (and the local distribution company, which is a measure of consumer surplus) will be θ_1 times the pay-off accruing to Norway. The reason why the Norwegian seller will obtain a smaller pay-off than the buyer (the transmission company) within the present framework, is that the two agents only negotiate about price, whereas quantity follows from the ultimate consumers' demand function. As total gain to distribute between the two will now be smaller than what would have been possible is they had negotiated separately about quantity and price, the seller will 'lose' some market power to the transmission company which captures a greater share of the gain as compared to the seller; see Golombek and Vislie (1985) for further details.

4.3.4 Comparative statics

Let us consider some comparative static results for the model consisting of successive bilateral monopolies with an upper limit on the market share for gas from the USSR.

From the expression for Norway's price in Equation 4.11, we observe that p_N^* is positively related both to the market share requirement α and to the price charged by the USSR, p_S. On the other hand we note, when using assumption A2, that the consumer price q^* in Equation 4.12, and the intermediate price π^* in Equation 4.13, will be decreasing in α and increasing in p_S.

In order to understand the forces behind these relationships, let us first consider the impact of a higher maximal market share on gas delivered from the USSR. (A higher value of α may be the consequence of a change in attitude as, for example, the IEA believes that due to *perestroika*, Europe should no longer fear an embargo from the USSR.) From Equation 4.11 we note that a higher value of α, for a given p_S, yields a higher price for Norway. One explanation for this result is the following: a higher value of α will, according to Equation 4.12 and assumption A2, give a lower consumer price (Γ will be smaller) and a greater total demand. Consumption of gas delivered from the USSR will increase relatively more than total consumption, implying that total delivery from Norway will be reduced. As a result, total aggregate gain will increase. As shown in Equation 4.14, Norway's gain will be a fraction of the gain accruing to the transmission company, which is increasing in α. Since x is being reduced due to a higher

value of α, Norway can obtain a higher pay-off only by being paid a higher price.

As total aggregate gain will be higher when the market share requirement is being relaxed, it seems difficult, from an efficiency point of view, to justify why the IEA should recommend its member countries to restrict their consumption of gas from the USSR. However, there are in fact other circumstances that might justify some limitation in gas purchases from the USSR, like capacity constraints and risk factors. If, for instance, α were allowed to become equal to 1, all countries, except Norway, would gain. But a modest increase in α will be to the benefit to all countries, Norway included.

Consider next the impact on the price structure of a change in the price charged in the USSR. (For instance, we can imagine the USSR becoming more 'aggressive' in the sense that p_S is being reduced, in order to sell more gas 'today' or to create some positive reputation for the future.)

Let us analyse the impact on the price structure of p_S being reduced. Less expensive gas from the USSR, with a given maximal market share α, will cause Norway's price p_N^* to fall, and the consumer price q^* will go down along with a reduction in the intermediate price π^*. As q^* is being reduced, gas consumption, consumer surplus and total aggregate gain will increase. Due to the assumption of elastic demand, Norway will sell a larger volume of gas as α is kept constant. According to how aggregate gain is divided, Norway will obtain a higher pay-off, by selling a larger volume at a somewhat lower price. Whereas the consumer price q^* and the intermediate price π^* are both unambiguously reduced as p_S becomes lower, the impact on p_N^* will in general be ambiguous, as the relationship between p_S and p_N^* is very sensitive to the formulation of the demand structure. (For instance, with a linear demand function, and inelastic demand, a lower value of p_S will cause Norway's price to go up. With inelastic demand, the only way for Norway to capture her share of a higher aggregate gain, due to a lower p_S, is by being paid a higher price.)

However, despite the ambiguity concerning the way Norway's price is being affected by a change in p_S, the more interesting consequence is that all countries gain from facing a lower price of gas delivered by the USSR.

4.4 VERTICAL CONTROL AND (DE)REGULATION

We will now consider how the proposal for deregulating the European gas market set forth by the EC Commission can be implemented. The background for such a proposal is obvious from the preceding sections, where we have seen that the transmission company is in a rather strong position *vis-à-vis* both the upstream producers and the downstream agents. This strong market power is obviously detrimental to the ultimate consumers of natural gas, in the same way as the IEA requirement on the market share of USSR gas is.

In this section we will therefore consider deregulation of the European gas market, with the purpose of reducing the power both of the transmission company and the high-cost seller, which is sheltered behind the IEA recommendation. We will analyse the proposal of the EC Commission in two steps: first, we consider the impact on prices and volume of trade by changing the vertical control in the market via backward vertical integration. Within the present context, backward vertical control means, as opposed to forward vertical integration (analysed in Dixit, 1983), that the (local) distribution company has control over the transmission company. This vertical control manifests itself through the goal of the integrated company, by serving the interests of the end users. (There are, of course, a number of problems to be solved in order to realize such a change in ownership or control. We do not have enough space to discuss all problems, but take it for granted that it is possible to change the ownership structure in the desired direction; see also Grossman and Hart (1986) for further discussion.)

Second, some deregulation might also take place among the upstream suppliers. Within the present model, deregulation might be translated into increased competition among the upstream suppliers, by abandoning the maximal market share requirement on gas from the USSR. Competition is then introduced by letting the upstream suppliers behave as duopolists in a Nash–Cournot sense when selling gas to the vertically integrated company. Instead of negotiating with the Norwegian seller, while at the same time adhering to the IEA recommendation, the vertically integrated company 'presents' its demand function for gas to the sellers, who thereafter make their quantity decisions.

Note that we introduce four separate changes in the market structure: two changes take place when the downstream companies are vertically integrated and at the same time regulated so as to behave according to the ultimate consumers' objectives. The third change takes place when we relax the market share requirement on gas delivered from the USSR, and the last one when we also allow for increased competition among the upstream suppliers. We could have analysed each change separately in order to ascribe the various effects of each change alone. However, what we will do is to consider the impact on prices, consumption and pay-offs as the two downstream companies are vertically integrated and regulated, without relaxing the market share requirement. Thereafter, we simultaneously relax the market share requirement and allow for increased competition among the upstream suppliers. Lumping both changes together can be seen as an interpretation of the proposal for deregulating the gas market. Deregulation may require the introduction of the common carrier principle, which here is interpreted literally as each supplier having 'free access' to the transmission

network. Hence, opening up for 'free access' implies no discrimination among the sellers and increased competition in the upstream industry, and we may consider the changes simultaneously.

4.4.1 Backward vertical control with market share requirement

Let the pay-off to the vertically integrated company be denoted W_V. As this company, by assumption, is a representative for the end users, its pay-off will be equal to consumer surplus:

$$W_V = U(y) - p_N x - p_S z = U[(1 + \beta)x] - p_N x - \beta p_S x \qquad (4.15)$$

where we have, according to assumption A3, that $z = \beta x$ and $y = (1 + \beta)x$. (Norway's pay-off is still given in Equation 4.2.)

The Norwegian seller and the buyer will in the new situation negotiate about a transfer price p_N and the volume of gas to be purchased from Norway. (Once the volume of gas to be purchased from Norway is determined, gas deliveries from the USSR follow directly from the market share requirement.) The two-stage bargaining structure in the previous sections is now replaced by a one-stage bargaining situation, involving only the Norwegian seller and the vertically integrated company.

In this new bargaining situation, Norway and the vertically integrated company negotiate about a transfer price p_N and a volume of trade x, so as to maximize the Nash product $W_N W_V$ with respect to p_N and x. By adopting the procedure used in section 4.3.1, the terms of the contract are now easily derived. The volume of gas to be purchased from Norway, denoted x^0 (and hence total gas consumption, denoted y^0) is determined so as to maximize the net gain to the agents. For an interior solution, we must have

$$U'(y^0)(1 + \beta) - \beta p_S - c_N = 0 \qquad (4.16)$$

which can be written in a more familiar way as

$$U'(y^0) = (1 - \alpha)c_N + \alpha p_S \equiv q^0 \qquad (4.17)$$

saying that the consumers' marginal benefit should be equal to a weighted average of Norway's marginal cost of production and the given price charged by the USSR, with $(1 - \alpha)$ and α as weights. This condition determines the consumer price q^0, which in the present case will be identical to the term Γ defined in Equation 4.12. When comparing the consumer price in Equation 4.17 with the one in Equation 4.12, we observe that q^0 will fall below q^*, and total gas consumption will therefore increase as a result of backward vertical control. The price paid for Norwegian gas is stipulated so as to equalize the net gains to the companies. Let this price be denoted p_N^0. Straightforward calculation yields

$$p_N^0 = \tfrac{1}{2}[\bar{U}(y^0)(1 + \beta) + c_N - \beta p_S] = \theta_1 c_N + \theta_2 p_S = p_N^* \qquad (4.18)$$

where the last equality follows directly from using the benefit function in Equation 4.10.

What is surprising is that the price Norway gets is identical to the price paid to the Norwegian seller in the pre-integrated situation. As the consumer price is lower in the new situation, whereas Norway's price p_N is unchanged, Norway's pay-off, as well as consumer surplus, will increase. On using our results above, along with $y^0 = [\Gamma/A]^\mu$, the pay-offs are easily calculated:

$$W_N^0 = W_V^0 = mA^{-\mu}\Gamma^{1+\mu} > W_B^* > W_N^* \tag{4.19}$$

The end users and the Norwegian seller will gain from the proposed change (backward vertical control) in market structure.

It is obvious that vertical integration without any changes in prices would cause no efficiency gains, along with a pay-off accruing in the new distribution company simply as the sum of the former pay-offs of the two downstream companies. However, as the vertically integrated company is negotiating directly with the Norwegian seller about a price and gas deliveries, total gain will increase as more gas will be consumed at a lower marginal price than before. (Note also that the average price paid by the consumers, which in the pre-integrated situation was identical to π, will go down as the former distortion due to the transmission company's market power vanishes.) As consumer surplus increases, Norway's net gain has to increase even more for the condition of equal division of the gains from trade in Equation 4.19 to be satisfied. This is accomplished simply by a larger volume of trade from Norway, as total consumption is higher and the market share requirement is the same as before, without changing p_N. The higher volume of trade from Norway is therefore sufficient for Norway's pay-off to increase to the same level as that of the downsteam company.

4.4.2 Backward vertical control and deregulation in the upstream industry

Consider next the following change in market structure: the vertically integrated company, which is a representative for the end users, chooses to abandon the market share requirement, by letting the suppliers in the upstream industry compete. Suppose that competition is in quantities, so the natural equilibrium concept is the Nash–Cournot equilibrium. Let again the consumer price be denoted by q. Since the vertically integrated firm is a representative for the end users, the price the consumers pay at the margin for an arbitrary volume of gas purchase y, is determined from $q = U'(y)$, from which we have the derived demand facing the duopolists, namely $q = U'(y) = P$, where P is the price paid to the sellers, determined in the Nash–Cournot equilibrium. With the benefit function in Equation 4.10, the demand function is $y = [P/A]^\mu = E(P)$, or its inverse $P = P(y) = U'(y)$.

The sellers' pay-offs or profits in the present situation are given by

$$W_N = [P(x+z) - c_N]x \quad \text{and} \quad W_S = [P(x+z) - c_S]z \tag{4.20}$$

The following two conditions constitute together a duopoly equilibrium (or a non-cooperative Nash–Cournot equilibrium) in quantities:

$$P(x+z) + xP'(x+z) = c_N \quad \text{and} \quad P(x+z) + zP'(x+z) = c_S \tag{4.21}$$

stating that each seller's perceived marginal revenue is equal to marginal cost. Adding these yields the market price P^{NC}:

$$P^{NC} = \frac{\mu}{2\mu+1}[c_N + c_S] = \frac{\bar{c}}{1 + 1/2\mu} = q^{NC} \tag{4.22}$$

where $\bar{c} = (c_N + c_s)/2$ is the arithmetic average of the sellers' unit costs. As no transportation or transmission costs are included, the consumer price must be equal to the producer price.

In the preceding section we considered the impact of an isolated backward vertical control, without relaxing the market share requirement. We concluded that consumer price was reduced, the price the Norwegian seller obtained was unchanged, and both the Norwegian seller and the vertically integrated firm received a higher pay-off, compared with the non-integrated bargaining situation. Are these changes reinforced or counteracted when competition among the upstream suppliers is introduced?

Let us first compare the producer prices p_N^0 and P^{NC}, where p_N^0, in Equation 4.18, is the price Norway obtains in the sheltered situation. This price is influenced more by Norway's own unit cost c_N, than what the equilibrium price P^{NC} is. We have that θ_1 in Equation 4.18 will be greater than $\mu/(2\mu + 1)$, for all finite values of μ less than -1. Hence, competition among the upstream suppliers reduces the impact of the unit cost of the high-cost country, causing the producer price to go down *ceteris paribus*. On the other hand, we get a stronger influence from the USSR when competition is introduced. In Equation 4.18, the administered price p_S enters with a weight θ_2, whereas in Equation 4.22, we have c_S multiplied by $\mu/(2\mu + 1)$. It can be shown that for all values of μ less than -1.7, and for all values of α less than 0.5, this coefficient will exceed θ_2. But as $p_S > c_S$, P^{NC} might go in either direction as compared to the price Norway obtains in the 'sheltered' situation.

What can be said about the impact on the consumer price? The gas price will be reduced, *ceteris paribus*, due to the fact that the high-cost seller (Norway) loses its dominant position. On relaxing the market share requirement, via competition, high-cost gas is replaced by low-cost gas from the USSR, which *ceteris paribus*, should make it possible among the suppliers to buy a larger share of total consumption from the low-cost seller. However, the competitive effect due to duopoly, without any market power on the buyer's side, will on the other hand have a positive impact on the gas price as P^{NC} exceeds p_S. Hence, the net effect on the gas price is ambiguous.

Above we have discussed how prices are affected when opening up for some competition among the upstream producers. The next question is in what way will consumer surplus and Norway's pay-off be affected by increased competition?

Straightforward calculation yields

$$W_V^{NC} = 2mA^{-\mu}\left[\frac{\bar{c}}{1 + 1/2\mu}\right]^{1+\mu} \tag{4.23}$$

$$W_N^{NC} = \frac{2m}{1 + 2m} s_N^2 A^{-\mu}\left[\frac{\bar{c}}{1 + 1/2\mu}\right]^{1+\mu} \tag{4.24}$$

where we have used a formula, from Dixit and Stern (1982), for Norway's market share, as given by

$$s_N = -\mu + \frac{c_N[\mu + \frac{1}{2}]}{\bar{c}} \tag{4.25}$$

(An expression for the USSR's pay-off can be found in the same way as we have found Norway's pay-off; the only change is that the USSR's market share s_S, similar to s_N, is substituted for s_N in Equation 4.24.)

We found earlier that due to backward vertical control alone, consumer surplus was higher than that in the bargaining situation discussed in section 4.3, as the change in ownership or vertical control led to a lower consumer price and a lower average price. As seen from Equation 4.19, Norway will also take a share of the previous pay-off of the transmission company. Increased competition among the upstream suppliers, along with the ownership structure outlined in section 4.4.1, implied that consumer price could go either way as compared to q^0. Hence, whereas backward vertical control alone will increase both consumer surplus and Norway's pay-off, as compared to our reference solution, the impact of allowing for some competition among the upstream suppliers on consumers' net welfare is ambiguous. When comparing the consumer surplus in Equation 4.19 with that in Equation 4.23, we note that for an unchanged consumer price, consumer surplus will double due to competition. However, as noted above, competition alone may cause the consumer price to go in either direction. Hence, there will be an offsetting effect on consumers' welfare if the consumer price should increase and an additional positive effect if it should decrease.

It is also obvious that the USSR will experience an increase in the pay-off W_S, as both price and quantity sold from the USSR increase. As mentioned above, Norway's pay-off increased as downstream firms integrated vertically. From Equation 4.24 we observe that even with the consumer price unchanged, competition will have a negative impact on Norway's pay-off. If competition should also lead to a higher consumer price, Norway would suffer an even greater loss.

4.5 CONCLUSIONS

We have considered the market for natural gas in Europe in a number of highly stylized models. We started out with a model emphasizing the role of bargaining in a set of vertically related markets, when there was assumed to be a restriction on the market share of gas delivered from the USSR, which was assumed to be the low-cost country. The various prices were derived under the assumption of a Nash bargaining solution. In the first situation, where Norway was sheltered by a market share requirement on gas from the USSR, we found that the transmission company had a strong market power. Negotiation between the local distribution company and the transmission company on the one hand, and negotiation between the Norwegian seller and the transmission company on the other, gave the transmission company a rather strong position both upstream and downstream. The bargaining outcome led to the equal pay-off to the downstream companies, but in excess of the pay-off to Norway. We then considered the impact of changing the vertical ownership structure (backward vertical control), while maintaining the market share requirement on gas from the USSR. The result of changing the vertical ownership structure was that the consumer price was reduced, whereas both Norway and the consumers gained from this change. Finally, we considered the impact of introducing some competition among the upstream suppliers. We derived the market solution (Nash–Cournot equilibrium) and found that the impact on the price structure was ambiguous. Even though the impact on consumers' surplus was ambiguous, it was obvious that the USSR will have a substantial gain from more competition, whereas Norway will lose.

APPENDIX

We will in this Appendix derive the price Norway obtains in the constrained bargaining situation, i.e. p_N^*, together with the consumer price q^* and the intermediate price π^*.

The price p_N^* was the solution of the following problem:

$$p_N^* = \arg\max_{p_N} [W_N W_T] \tag{A.1}$$

where the pay-offs to Norway and the transmission company, W_N and W_T, are given by

$$W_N = (p_N - c_N)x = (p_N - c_N)(1 - \alpha)e(q(p_N)) \tag{A.2}$$

$$W_T = \pi y - p_N x - p_S z = \pi(1 + \beta)x - p_N x - \beta x p_S$$

$$= [\pi(p_N)(1 + \beta) - p_N - \beta p_S](1 - \alpha)e(q(p_N)) \tag{A.3}$$

where we have used that $z = \beta x$ and $x = (1 - \alpha)e(q)$, where $e(q)$ is the ultimate consumers' demand function for natural gas.

Let $N(p_N) \equiv W_N W_T$. The transfer price p_N^* is then determined from setting $N'(p_N) = 0$. Differentiation with respect to p_N yields, when we use that $e'(q)$ and $q'(p_N)$ are the derivatives of $e(q)$ and $q(p_N)$ with respect to q and p_N respectively:

$$N'(p_N) = W_N[x(\pi'(p_N)(1 + \beta) - 1) + W_T(1 - \alpha)e'(q)q'/x] + W_T[x + W_N(1 - \alpha)e'(q)q'/x] = 0 \quad (A.4)$$

Now using that $q' = 1 - \alpha$ from Equation 4.6, the expression for $N'(p_N)$ can be written as follows:

$$[W_T - W_N]x + W_N x\pi'(1 + \beta) + 2W_T W_N(1 - \alpha)^2 e'/x = 0 \quad (A.5)$$

From the text we have the demand elasticity $\mu \equiv \mathrm{E}l y : q = qe'/y$, which is being used in order to eliminate $e'(q)$. In addition we have $\pi^* = \pi(p_N)$, defined in Equation 4.8. We can then use Equation 4.8 to find an explicit expression for $\pi'(p_N)$. Straightforward differentiation yields

$$\pi'(p_N) = (1 - \alpha)[1 + \mu(1 - \bar{U}/U')]/2 \quad (A.6)$$

Using that $U'(y) = q$ and the fact that with the benefit function in Equation 4.10 we have $\bar{U} = [\mu/(1 + \mu)]U'$, we can write Equation A.6 as

$$\pi'(p_N) = (1 - \alpha)(2\mu + 1)/(2\mu + 2) = (1 - \alpha)\theta_1 \quad (A.6)'$$

where we have used the definition of θ_1 in Equation 4.11. With the constant elasticity benefit function in Equation 4.10, we can find an explicit solution for the transfer price π^*:

$$\pi^* = \pi(p_N) = \theta_1 q(p_N) \quad (A.7)$$

as given in Equation 4.13. Inserting for $\pi'(p_N)$ into Equation A.5, and using that $(1 + \beta)(1 - \alpha) = 1$, and dividing through by W_N/x yields

$$[W_T - W_N]/W_N + \theta_1 + (1 - \alpha)^2 2W_T e'/x^2 = W_T/(W_N) - 1 + \theta_1 + 2(1 - \alpha)\mu W_T/qx = 0 \quad (A.8)$$

Using the definition W_T and W_N in Equation A.8, we find

$$(\pi - q)/[(p_N - c_N)(1 - \alpha)] + \theta_1 - 1 + 2(\pi - q)\mu/q = 0 \quad (A.9)$$

Inserting from Equation A.7 and some algebra yields

$$q + (1 + 2\mu)(1 - \alpha)(p_N - c_N) = 0 \quad (A.10)$$

Using the definition of q from Equation 4.6, we easily derive the desired result:

$$p_N^* = \theta_1 c_N + \theta_2 p_S \quad (A.11)$$

and the consumer price follows directly when inserting Equation A.11 into the definition 4.6. We then get

$$q^* = (1 - \alpha)[\theta_1 c_N + \theta_2 p_S] + \alpha p_S = (1 - \alpha)\theta_1 c_N + \alpha\theta_1 p_S = \theta_1[(1 - \alpha)c_N + \alpha p_S] = \theta_1 \Gamma \quad (A.12)$$

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