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# The Soda-ash Market in Europe: Collusive and Competitive Equilibria with and without Foreign Entry

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**Abstract**

In a recent decision of the Commission of the European Community (EC), the two main producers of soda-ash in Europe, ICI and Solvay, were accused of having engaged in a concerted practice from the early 1970s until the time of the Commission's decision. This article argues that the degree of information provided by the Commission leaves room to alternatively interpret the firms' behavior as competitive. Indeed, it is shown that the Commission did not have all information necessary to determine whether the firms collude or compete in the soda-ash market. In applying the indistinguishability theorem, I stress the difficulty to draw correct inferences on firm behavior when some relevant information is lacking. I found that the degree of information provided by the Commission in its final report is not sufficient to determine whether the two firms played a collusive or a competitive game.

*I would like to thank L. Phlips and R. Harstad for helpful comments on an earlier draft. Needless to say all remaining errors are my own.

# 1 Introduction

In a recent decision of the Commission of the European Community (EC) [1], the two main producers of soda-ash in Europe, ICI and Solvay, were accused of having engaged in a concerted practice from the early 1970s until the time of the Commission's decision. This alleged infringement of Art. 85 of the EEC Treaty was based on an implicit agreement to avoid competition in each other's home markets. The Commission argued that the absence of trade between ICI's home markets (UK and Ireland) and Solvay's home markets (continental Europe) gave proof of the existence of tacit collusion which had led to monopoly prices in the above mentioned markets.

In this article I argue that the degree of information provided by the Commission leaves room to alternatively interpret the firms' behavior as competitive. Indeed, I will show below that it is not possible to distinguish between tacit collusion and competition properly with the available information.

# 2 The Market for Soda-ash and the Commission's Decision

Soda-ash, an alkaline chemical commodity, is mainly used as a raw material in the glass manufacturing industry. To a much lesser extent it serves for the production of detergents and in metallurgy. While natural soda-ash is extracted from mines in the US, Africa, Australia and Asia, Europe's entire output is produced by a synthetic chemical process invented by Solvay in 1865.

There are six suppliers of soda-ash in the EC among which Solvay is the largest single producer with 60 percent market share in western Europe. Solvay has plants in Austria, Belgium, France, Germany, Italy, Spain and Portugal. ICI is the second largest producer in the EC and

[1] OJ of the EC, No L 152, 91/297/EEC, 19.12.1990.

serves the UK and Ireland (serving about 90 percent of this market) from its two plants in the UK [2]. On the continent, Solvay faces competition from two German, one Dutch and one French producer. It must be emphasized that these suppliers mainly serve their respective domestic markets. Solvay is thus the only virtually European producer that can be regarded as a multinational company. Despite this fact, the company never tried to gain access to the British market. Similarly, ICI does not sell soda-ash in continental Europe. Other competitors from third countries (mainly from the US) play only a minor role in Europe's soda-ash market.

Transportation costs constitute a considerable fraction of a firm's cost function when supplying soda-ash to a customer. Therefore, prices for soda-ash significantly increase with the distance from the delivering plant to the final customer. Overseas shipping incorporates additional costs, not only because of its expensive rates for freight and insurance, but also because the commodity has to be stored in the foreign harbor. The ability of a firm to serve the commodity continuously on a daily or weekly basis is extremely important in the glass manufacturing industry. Since most customers have established continuous process plants for which they hold stocks of soda-ash for a few days only.

Further, it should be mentioned that the overall demand for soda-ash in Europe (and in the world market) went through a phase of stagnation in the early 80's, but experienced a strong increase in sales towards the end of the decade. Since then production has been run at full capacity, due also to it being difficult, if not impossible to get permission for the construction of a new plant in the EC [3]. In addition, there have been longstanding commercial links between ICI and Solvay. After several cartel ageements dating back to the last century, the two firms settled a new agreement right after the second world war. The essence of this so-called "Page 1000" agreement consisted of a market sharing cartel for soda-ash. Continental Europe was assigned to Solvay while ICI agreed to restrict its activity to the British Commonwealth. After having obtained

[2] ICI closed one of its original three plants in 1984.

[3] Due to the increasingly restrictive EC environmental laws.

legal advice that the agreement was against Art. 85 of the Treaty of Rome, ICI and Solvay formally terminated Page 1000 on Dec. 31th 1972 in order to prevent an action by the Commission.

The Commission used the fact that neither ICI nor Solvay invaded each other's market after the agreement was cancelled, as proof that market separation, and hence collusion, still continued. The only difference being that ICI and Solvay now engaged in a concerted practice, the Commission's terminology for what is known in economics as tacit collusion. The Commission argued that the absence of market penetration can only be explained by a tacit agreement to maintain the formerly explicit cartel agreement. Competition would have provoked mutual entry, prices in both markets being monopolistic and thus, leaving positive profit opportunities for a foreign entrant.

To justify its reasoning, the Commission pointed to the price gap between the two markets which had existed over a long period of time. Before 1980, the price for soda-ash used to be lower in the UK than on the continent. During the last decade however, UK prices rose by about 15-20 percent above those of continental Europe. This price movement served as an indication that it would have been profitable for the firm in the lower price market to enter the higher price market. Furthermore, ICI purchased large tonnages of soda-ash from Solvay between 1985 and 1988 in order to meet its long-term contracts with its British customers. Hence, ICI's obvious difficulty in serving its home market should have given an additional incentive for Solvay to enter the UK market directly rather than selling soda-ash to a potential competitor. The Commission therefore accused Solvay of deliberately not having invaded the lucrative British market in the 1980's.

# 3 The Theoretical Framework: Collusion detection and Foreign Entry

In economic theory, the soda-ash market constitutes an example of potential foreign entry. The question now is whether the fact that neither

firm entered the other's home market unambiguously reflects collusive behavior or whether mutual staying out may also arise in a competitive equilibrium. The latter requires each incumbent to set the price such that the potential entrant cannot make profits through entering the foreign market. If mutual staying out can be the result of either a competitive or a collusive strategy, the Commission cannot infer the underlying firm behavior from the observed market structure alone. This case is formally developed in the so-called indistinguishability theorem by Harstad and Phlips (1993). They show that an informational disadvantage on the behalf of the governmental authorities concerning the necessary parameters to calculate competitive and collusive prices may make it impossible to distinguish between competition and collusion.

In order to illustrate the indistinguishability problem in the soda-ash market, I set up a linear demand model with $\alpha_k$ being the intercept of the demand curve with the vertical price axis. For simplicity, we assume the slope of the demand curve to be $-1$. Firms are supposed to play price strategies, an assumption that is based upon some characteristics of the soda-ash market. Usually, suppliers set up list prices and rebate schemes for one year in advance. Having long-term contracts with their customers, producers guarantee that prices remain fixed for the duration of the contract of delivery. Consequently, producers adjust quantities according to demand throughout the year. Since the production process is rather simple (soda-ash is obtained through a fall-out process of some basic chemicals), it is fairly easy to increase or to decrease production in the short term.

Under these conditions it is straightforward that the joint profit maximizing price per period is

$$p_{ik}^{M} = \frac{\alpha_k + c_{il}}{2} \qquad i = 1, 2 \tag{1}$$

in home market $k$ where firm $i$ is low cost. Since collusion protects firms from foreign entry whenever the discount factor $\delta$ is close enough to 1 in an infinitely repeated game, collusion yields a market structure of $k$ monopolies with a national supplier in each of them.

Under the competitive equilibrium, prices for the duopoly in market $k$ have to be at marginal cost. Theoretically, there exist two equilibrium prices because marginal costs differ across firms in each market, so that either a price of $p_{ik}^N = c_{il}$ or $p_{ik}^N = c_{ih}$ may prevail [4]. But as soon as $p_{ik}^N < c_{ih}$, the foreign firm will have to exit market $k$. Therefore, the domestic low cost firm, firm $i$, will set $p_{ik}^N \approx c_{jh}$, where $j$ indicates the foreign (high cost) firm This involves slightly undercutting the foreign firm's marginal cost in order to prevent the rival from gaining any market share and hence capturing the entire market $k$ in each time period of the game. Put differently, at a price of $p_{ik}^N \leq c_{jh}$, there would be no profit opportunity and hence no incentive for the foreign firm to enter market $k$. Therefore, the competitive equilibrium requires incumbent $i$ to set a price of

$$p_{ik}^N = c_{jh} \tag{2}$$

in market $k$. Pricing at the rival's marginal cost level constitutes a limit pricing strategy to deter entry. This strategy forms a subgame perfect Nash equilibrium and reflects competitive behavior.

Transferring this result to our indistinguishability problem, we can state the following.

1) A monopoly price as in equation (1) indicates *unacceptable* behavior from the point of view of the authorities.

2) A Nash limit price as in equation (2) indicates *acceptable* behavior.

These inferences can only be drawn if the authorities know the true values $\alpha_k, c_{il}$ and $c_{jh}$.

If the authorities have no or no correct information on at least one of the true values $\alpha_k$, $c_l$ or $c_h$ [5], the indistinguishability theorem can be illustrated by the following example. Suppose the authorities know that price strategies are played and that price formation is as in (1) or (2).

[4] Due to the law of one price there has to be a unique Nash price for both firms in market $k$.

[5] We drop the indices $i$ and $j$ for this illustration, assuming thereby that cost differences are symmetric between firms. Hence, $c_{il} = c_{jl} = c_l$ and $c_{ih} = c_{jh} = c_h$.

Let $\hat{\alpha_k}$, $\hat{c_l}$ and $\hat{c_h}$ denote estimates of the true values of the parameters and consider the following relationships. If

$$\hat{\alpha_k} = 2c_h - c_l \tag{3}$$

or

$$\hat{c_l} = 2c_h - \alpha_k \tag{4}$$

then acceptable behavior is not distinguishable from unacceptable behavior since $p_k^M = p_k^N$ when either (3) or (4) is substituted into (1).

Similarly, if

$$\hat{c_h} = \frac{\alpha_k + c_l}{2} \tag{5}$$

it is straightforward to see that acceptable behavior appears the same as unacceptable behavior. In other words, the authorities observe a price behavior which does not allow them to distinguish whether firms are engaged in a competitive or collusive game.

# 4 Some Numerical Examples

The purpose of this section is to highlight the theoretical results with some numerical examples based on the information we possess on the soda-ash case. We consider the Commission's task of determining whether ICI and Solvay engaged in an action prohibited by Art. 85 of the EEC Treaty. We assume that the Commission has all the information outlined in section 2 (empirical knowledge) and in section 3 (theoretical knowledge). The special characteristics of both the product and the market require the following assumptions:

First, let firm 1 be ICI with home market $a$ representing the UK and Ireland. Solvay is labelled firm 2, with home market $b$ corresponding to continental Europe. ICI's home market is definitely smaller than Solvay's home market. This is due to the fact that the glass industry, which represents the prime demand for soda-ash, is an important industrial sector in all major EC member countries while Ireland has only a few glass manufacturers. We have to be careful in defining the appropriate

intercept, $\alpha_k$, required to calculate monopoly prices in each market. For ICI's home market, we can take the intercept $\alpha_k$ to represent its entire home market. The reason is that we consider ICI as being a monopolist in Ireland and in the UK, serving both countries from its two British plants.

Matters are quite different for Solvay. We know that Solvay is confronted with several other EC competitors of respectable size. We know further that Solvay usually satisfies demand within national borders. Hence, French customers are supplied through French plants, German customers through German plants and so on. This phenomenon is related to transportation costs, as we will see later. Apart from this, the fact that delivery is within national borders provides important information about how to choose the intercept for the determination of the collusive outcome.

To illustrate this point, let us take a closer look at price formation in continental Europe. It is straightforward to see that Solvay would maximize global profits over all national submarkets in market $b$ if it were a monopolist. However, there are other suppliers in some countries [6]. The product being homogeneous, firms have to agree to set a single price (including transportation cost) in each of the national (sub-)markets. In other words, $p_b^M$ will differ in each national submarket according to the number of competitors in that market. Hence, the intercept relevant to Solvay's entire home market, will be defined as $\alpha_b = \sum_{m=1}^{n} B_m/n$, where $B_m$ is the market size in submarket $m$ and $n$ is the number of submarkets on the continent[7].

Second, analogous to our definition of the relevant intercept for the computation of $p_k^M$ we have to split up the cost function. While

[6] Notably in France, Germany and the Netherlands.

[7] We are aware of the fact that this will lead to only an approximation of collusive prices. However, we have to take into account that the Commission argues with a continental price as against a 'British' price for soda-ash. In order to illustrate the theory behind the observed price behavior and to respond to the Commission decision, we have to stylize our representation of the soda-ash industry. Nevertheless, our approximation does not prevent us from drawing reasonable inferences concerning theoretical and empirical price formation.

production technology seems to be relatively mature and standardized, care has to be exercised with respect to the transportation cost as a component of variable costs. In order to take into account the additional costs incurred when soda-ash is shipped overseas, we specify total costs for firm $i$ as follows:

$$c_{ih} = c_{il} + t_{ik} \qquad k = a, b \qquad i = 1, 2 \tag{6}$$

where $c_{il}$ includes the production as well as transportation costs of serving customers in the home market. Although the cost of transportation clearly increases with distance to the customer, we can think of $c_{il}$ as a production cost plus an average cost parameter. Again, we have to approximate $c_{il}$ by averaging over each submarket. As before, this procedure is necessary for the computation of both Nash and collusive prices since $c_{il}$ influences limit prices in both markets, $a$ and $b$. Average transportation costs may vary between countries depending on the distance between the location of plants and the location of customers in the national markets. The second term in (6), $t_{ik}$, stands for the costs of shipping overseas and delivering soda-ash to the foreign market. This is zero if sales occur only in the home market. Consequently, each firm is low cost $c_{il}$ in its home market but high cost $c_{ih}$ in the foreign market.

The purpose of averaging costs and intercepts is to get a reasonable proxy for the price levels of soda-ash in markets $a$ and $b$. One argument the Commission used as proof of a concerted practice was that prices on the continent were higher than in the UK in the 1970s while the reverse was true throughout the 1980s. But prices also vary between other European countries, making it difficult to determine whether prices in market $a$ tended to be higher or lower on average than in market $b$. Although market $a$ is relatively homogeneous on both the demand and the supply side [8], market $b$ is characterized by differences in the number of customers, the extent of locational distance between suppliers and customers and in the number of competitors in each country. Therefore, we cannot avoid at least some averaging.

[8] Even transportation costs within market $a$ are not likely to vary too much as most customers for soda-ash are located in the South-West of England.

With these preliminaries in mind, we can proceed to some numerical examples reflecting price behavior in the soda-ash industry. First we will model prices consistent with the soda-ash market in the 1970s when prices in market $a$ were lower than in market $b$.

List prices for soda-ash varied from \$200 – \$240 per metric ton (MT) in the EC at the end of the 80s. However, these list prices are not equivalent to those prices effectively paid by the customers. First, a 5 per cent rebate on list prices seems to be common in the industry. Second, all suppliers try to bind customers through bulk discount schemes [9]. If we take into account all rebates and discounts, we arrive at effective prices which lie around 10 – 15 per cent below list prices. We therefore assume prices to be equal to $p_a = 180$ and $p_b = 200$ in our example [10]. Since both firms produce soda-ash with the same production technology, we suppose that the cost of production to is the same for each firm, yielding an F.O.B. price of \$95 per MT. Home market delivery costs, an important fraction of the firms' cost, account for some 25 per cent of production costs on average. We specify these cost as \$25 per MT. ICI serves its home market, the UK and Ireland, from its two plants located in the UK. Although Solvay has a much larger home market in terms of geographical area, it also owns more plants than ICI. With six production facilities in six different EC countries, Solvay serves customers over similar distance to ICI. This is reflected by the fact that delivery on the continent is carried out mainly within national borders. Thus, we assume that average transportation costs within the home market is the same for both ICI and Solvay. Adding production and local transportation costs together, we get $c_{1l} = c_{2l} = c_l = 120$.

The cost supplement $t_{ik}$, incurred when serving the foreign market, can be split up into overseas shipping and on-land delivering components. The costs of shipping the product overseas is comprised of freight and insurance to the foreign harbor as well as warehouse and handling

[9] E.g. through price reductions per MT if more than a certain quantity per annum is ordered.

[10] Unless otherwise mentioned, we refer to prices and costs in \$ US per MT of soda-ash.

costs. Overseas shipping and warehouse costs are assumed to account for roughly 15 percent of FOB prices or \$15 per MT. On-land delivery costs in the foreign market are the costs of transportation from the warehouse to the foreign market customer. Average transportation costs on the continent are relatively high for ICI because customers are widely spread throughout Europe. Hence, we add an average of \$25 per MT to ICI's cost function when serving continental Europe, assuming that ICI faces the same on-land transportation costs as Solvay in market $b$. On the other hand, Solvay's delivery within the UK is less costly since most potential customers are located close the southern shore. For the purpose of our example, we take these costs to be \$15 per MT. From these figures we can compute total transportation costs for the foreign market. Serving continental Europe from its British plants would cost $t_{1a} = 40$ for ICI, whereas Solvay would have transportation costs of $t_{2b} = 30$ when delivering soda-ash to the UK [11].

Plugging our numerical values into (6) yields Nash prices of

$$p_a^N = c_{bh} = c_l + t_{2b} = 120 + 30 = 150 \tag{7}$$

$$p_b^N = c_{ah} = c_l + t_{1a} = 120 + 40 = 160. \tag{8}$$

Derivation of the limit prices requires calculating Nash prices in the home market from the rival's cost function provided the rival firm sells soda-ash in the foreign market. Theoretically, it suffices that $c_{bh} < c_{ah}$ for prices to be lower in market $a$ than in market $b$. If the overseas cost supplement, $t_{ik}$, was the same for ICI and Solvay, then differences in Nash prices would necessarily stem from differences in domestic transportation costs.

Price formation under monopoly can be calculated from equation (1). Equations (7) and (8) indicate that our effective prices of \$180 and \$200 respectively cannot be the result of a competitive game. Hence, these prices must be the result of collusive behavior. This information allows us to draw inferences about $\alpha_k$ in equation (1). We obtain

$$p_a^M = \frac{\alpha_a + c_l}{2} = \frac{240 + 120}{2} = 180 \tag{9}$$

[11] Note that $t_{ik}$ is the transportation cost of firm $i$ with home market $k$ delivering in the foreign market.

$$p_b^M = \frac{\alpha_b + c_l}{2} = \frac{280 + 120}{2} = 200, \tag{10}$$

or $\alpha_a = 240$ and $\alpha_b = 280$. In this example, differences in collusive prices across markets are due to differences in the intercepts. Generally speaking, it has to be verified that

$$\alpha_a + c_{1l} < \alpha_b + c_{2l} \tag{11}$$

for $p_a^M < p_b^M$ to hold. In other words, price differences under collusive behavior have to result from differences in intercepts, differences in home market costs or from a combination of both. Differences in foreign market transportation costs leave monopoly prices unaffected.

This example demonstrates that $p_a < p_b$ may hold under collusive or competitive strategies. In addition, both strategies require firms to stay out of their rival's home market. This is the condition under which the indistinguishability theorem is valid. The Commission has observed price behavior that could be either acceptable or unacceptable. For concreteness, assume that the Commission observed prices $p_a = 150$ and $p_b = 160$. The price gap between markets $a$ and $b$, together with the observation that neither firm entered its rival's market, was the core evidence of the existence of tacit collusion. In our example however, exactly the same behavior is the result of the competitive game. Our conclusion is that the information at hand is not sufficient to solve the indistinguishability problem.

Solving this problem requires acurrate and clearcut information about the underlying parameters that determine $p_k$. Since the market reveals list prices only, the Commission would have to rely on the firms' data and on its own estimations. Needless to say, firms have an interest in making the Commission believe they are playing the competitive game. As was already mentioned, they may manipulate this data to make collusion appear as acceptable behavior. Using the procedure in section 3, we can find estimators for each parameter faking competitive behavior and vice versa. If

$$\hat{t_{2b}} = \frac{a_a + c_{1l}}{2} - c_{2l} \quad \text{and} \quad \hat{t_{1a}} = \frac{a_b + c_{2l}}{2} - c_{1l}, \tag{12}$$

i.e. an overestimation of transportation costs to the foreign market, then collusive behavior seems to be competitive. Plugging in our chosen parameter values, we get $\hat{t_{1a}} = 80$ and $\hat{t_{2b}} = 60$. In other words, foreign market delivery costs have to be overestimated by 100 per cent in order to make collusion look like competition. Similarly, an underestimation of intercepts such that

$$\hat{\alpha_a} = 2(c_{2l} + t_{2b}) - c_{1l} \quad \text{and} \quad \hat{\alpha_b} = 2(c_{1l} + t_{1a}) - c_{2l} \tag{13}$$

gives $\hat{\alpha_a} = 180$ and $\hat{\alpha_b} = 200$. Thus, underestimating the intercept by 25 per cent and 29 per cent respectively will make behavior appear collusive even though firms are playing the competitive game.

Estimates of $c_{il}$ are more complex to analyze. While $\alpha_k$ influences only collusive prices and overseas shipping costs influence only competitive prices, costs of production and supply to the home market effects price formation for both strategies. An underestimation of $c_{il}$ such that

$$\hat{c_{1l}} = 2(c_{2l} + t_{2b}) - \alpha_a \quad \text{and} \quad \hat{c_{2l}} = 2(c_{1l} + t_{1a}) - \alpha_b \tag{14}$$

makes competitive behavior look like collusion. Since $\hat{c_{1l}} = 60$ and $\hat{c_{2l}} = 40$ given (14), the extent of underestimation has to be 50 per cent and 66.6 per cent respectively. An overestimation such that

$$\hat{c_{1l}} = \frac{\alpha_b + c_{2l}}{2} - t_{1a} \quad \text{and} \quad \hat{c_{2l}} = \frac{\alpha_a + c_{1l}}{2} - t_{2b} \tag{15}$$

on the contrary will lead to $\hat{c_{1l}} = 160$ and $\hat{c_{2l}} = 150$. In this case, overestimating the true values of $c_{il}$ by one forth and one third causes collusion to be mistaken for competition when (15) is substituted into (6).

One might argue that the deviations from the true values in our example are so large that it seems unlikely the Commission would make such bad estimates. We have to take into account, however, that the estimation of each parameter involves considerable uncertainty. Take $\hat{t_{ik}}$ for example. Since transportation costs to the foreign market allow for economies of scale, $t_{ik}$ doubles or even triples when small quantities are shipped instead of large quantities. Accordingly, $\hat{t_{ik}}$ depends heavily on

the market share the foreign firm could capture from the incumbent. Since both firms did not enter their foreign market, there is no available data on the entrant's (potential) market share. Thus, we could argue that the estimation of $t_{ik}$ is subject to the highest degree of uncertainty among all parameters. This justifies why an overestimation of 100 per cent may be quite plausible. In fact, $\hat{\alpha_k}$ and $\hat{c_{il}}$ show much less variation than $\hat{t_{ik}}$. Nevertheless, it is doubtful whether the Commission possesses reliable figures on any of these. The intercept depends on gross demand in each market and was inferred from effective market prices in our example. But as has been already pointed out, list prices do not coincide with market prices. Consequently, there is some uncertainty about the intercept as well. As for $c_{il}$, uncertainty arises from two sources. First, although production technology is the same for ICI and Solvay, the cost of production may still vary because of differences in the cost of inputs (energy, labor etc). Second, average delivery costs in the home market may be different for each firm. In addition, information on $c_{il}$ is firm specific and hence any available data has to be viewed with some caution. These two sources of uncertainty may lead to $c_{il}$ being either over- or underestimated considerably.

# 5 Solving the Indistinguishability Problem under Imperfect Information

Could the Commission have inferred the firms' actual behavior even though it did not have perfect information on all the parameters needed to calculate $p_k^M$ and $p_k^N$? The answer is yes - provided certain informational requirements are satisfied. Detection of collusion is possible in the following circumstances:

a) When it is known that $c_{1l} = c_{2l}$ and that $\alpha_a = \alpha_b$, then $p_a^M = p_b^M$ whatever the actual value of $c_{il}$ and $\alpha_k$. Then, any observed price differences between the two markets must be due to Nash pricing behavior.

b) When $c_{1l} = c_{2l}$ and $t_{1a} = t_{2b}$ and thus $p_a^N = p_b^N$. Consequently, price differences between markets $k = a, b$ must be caused by $\alpha_a \neq \alpha_b$ and are hence due to collusion.

c) When overseas transportation costs vary significantly between firms and markets. Nash prices then differ proportionally, as long as $c_{il}$ is about the same for each firm $i$. Similarly, differences in $\alpha_k$ are reflected in monopoly prices in each market. Again, it is important to know whether $c_{il}$ differs for $i = 1, 2$. If so, cost differences may dampen the effect of the gap in intercepts. In other words, one can detect the nature of the game that is played from the gap in parameters in each market. If the Commission knows that $c_{il}$ is almost equal for each firm $i$, significant price differences between market $a$ and $b$ can only be caused by differences in $\alpha_k$ or in $t_{ik}$. And, if the Commission knows further that the gap in one of these two parameters is small while the other one is large, it can draw inferences about the firms' behavior.

Our numerical example in the previous section reflected conditions in the market for soda-ash in the 1970s when prices in market $a$ were below prices in market $b$. According to the Commission, a crucial piece of evidence that a collusive price game is being played between ICI and Solvay is the reversal of this price gap in the 1980s. Given that prices in the UK were 15-20 per cent higher than on the continent during this decade, the Commission argues that Solvay should have had a strong incentive to enter the lucrative British market. The Commission claims that the only way to explain Solvay's absence in the British market is the existence of a tacit collusive agreement between the firms which allows ICI to raise its home market prices without provoking Solvay's entry. Our analysis provides several arguments to demonstrate the invalidity of the Commission's reasoning. The basic point is that any reversal in the price gap must have been due to a change in one or more of the parameters that influence price formation - regardless of whether firms play the collusive or the competitive game. In addition, the fact that UK prices tended to be significantly higher than continental prices throughout the 1980s may

have been the result of an increase in the price level in market $a$ or from a decrease in the price level in market $b$ or a combination of both.

The Commission's report gives no information on whether the reversal in the price gap comes from a rise in British prices or from a drop in continental prices. Since we already know that $\alpha_k$ and $c_{il}$ determine the collusive price, any price change under collusive behavior has to stem from a change in at least one of these two parameters. For $p_a^M$ to have risen, $\alpha_a$ must have increased or $c_{1l}$ must have decreased (or a combination of the two) until the sign of (11) is reversed. Alternatively, a decrease in $\alpha_b$, an increase in $c_{2l}$ or a combination thereof would have had the same effect. Under limit pricing on the other hand, an increase in $c_{2l}$ and/or an increase in $t_{2b}$ causes $p_a^N$ to rise. Equivalently, a drop in $p_b^N$, leading to $p_a^N > p_b^N$, also satisfies our condition. A decrease in $c_{1l}$ and/or a decrease in $t_{1a}$ make this alternative work.

Without knowing which of the above parameters actually changed and in which direction, no inference can be drawn about firm behavior. The fact that prices in one or both markets changed, as such, is not of any further help in solving the indistinguishability problem.

The Commission's report provides information on some particular characteristics of the soda-ash market in the 1980's. First, it is mentioned that the market stagnated at the beginning of the decade, but that sales soared at the end of the 1980's. Second, ICI closed one of its three plants in the UK in 1984, perhaps as a reaction to the sluggish demand in the British soda-ash market. Third, ICI bought large tonnages of soda-ash from Solvay in the mid- eighties to satisfy its domestic customers.

Several scenarios can be drawn on the basis of this information. Stagnation and sluggish demand potentially reduce the height of the intercept. If this phenomenon were the influence on the market, price changes would occur under collusion only. Limit prices would not be affectes since they do not depend on the value of the intercept. It can then be verified that $\Delta\alpha_a < \Delta\alpha_b$, i.e. that the decrease in demand was higher in market $b$ than in market $a$. This is the only way in which collusive prices could undergo a reversal such that $p_a^M > p_b^M$, all other parameters equal (see equations (9) and (10)). Unfortunately, the report

does not say anything about the development of $t_{ik}$ during the period of observation. We argued before that transportation costs are potentially higher for ICI when shipping soda-ash overseas. If we knew that a certain development in transportation costs alone was responsible for the reversal of the price gap, we would know unambiguously that firms must have played the competitive game.

An increase in $c_{1l}$ relative to $c_{2l}$ would be an alternative explanation of why the price gap reversed in the last decade. Recall that both Nash prices and monopoly prices rise with increasing $c_{il}$. ICI reacted to the stagnation of the market by closing one production facility and by increasing the capacity level of the other two plants. In addition, ICI had to buy soda-ash from Solvay to meet its home market contracts in the mid-eighties. This could be a hint of temporary efficiency and capacity problems for ICI. Thus, $c_{1l}$ might have increased relative to $c_{2l}$ during this period. Indeed, we find that average prices were again lower in the UK than on the continent by the end of the decade. The fact that $p_a > p_b$ during the 80s could thus have been due to temporary adjustments in capacity during this period.

All these arguments point to our inability to solve the indistinguishability problem from the observed reversal of the price gap during the last decade. The fact that ICI bought soda-ash from Solvay to supply the British market is not of great help in this context. At first glance it seems that if Solvay can make profits selling soda-ash to ICI, it could have made even higher profits in selling directly to British customers. Here, another characteristic of the soda-ash market comes into play. Long-term contracts and the sensibility of customers for assured delivery make it unattractive to switch to other suppliers for a limited period of time only. From the viewpoint of producers this means that stepping into a foreign market in which they are not yet represented (and hence in which they have no reputation for punctual and assured supply) is extremely difficult. It is therfore questionable whether Solvay would have been able to sell soda-ash to ICI's customers on any larger scale. ICI's business relations with its customers served as a vehicle by which Solvay could sell the product in the British market.

Furthermore, it seems that ICI's difficulty in meeting its contracts in its home market occurred during a limited time period only (from 1985 to 1988). Under these circumstances it may have been more profitable for Solvay to sell to ICI the quantity demanded instead of setting up its own transportation and delivery network. The latter would involve a risk that British customers would choose to purchase from the two competitors from Poland and the US when requiring additional supply, these two companies already being established in the British market [12].

A short remark on economies of scale in transportation costs should be made. The special long-term relationship between customers and suppliers is likely to leave a new entrant with only a small market share. Hence, a newcomer cannot benefit from economies of scale when shipping soda-ash overseas. It is quite reasonable therefore to assume that new entrants have significantly higher costs than incumbents in the soda-ash market.

There is another aspect worth stressing. One wonders why the Commission focussed exclusively on ICI and Solvay in its decision. Market separation and home market bias does not only exist between the British Isles and the continent, but also between the continental EC countries themselves. In order to assess the problem of foreign entry, it would be interesting to understand why for example a French producer of soda-ash does not sell in Italy. If the Commission states that ICI could make profits by entering the continental market, the same should be true for a continental supplier extending its current market to another country. Similarly, if Solvay is supposed to be able to enter the UK on a profitable basis, it is difficult to argue that other European producers can not do the same. One has to bear in mind that one basis for the Commission decision was the written agreement, "Page 1000", which existed between ICI and Solvay and which, according to Brussels, continued after its official termination. Nevertheless, the ICI-Solvay cartel in the 1950's and 1960's did not itself prevent other European producers from

[12]With reference to the theory of contestable markets as developed by Baumol W.J., Panzar J.C. and Willig R.D. (1982) we could say that "hit-and-run" strategies are not possible in this market.

entering the British market. But obviously, these firms did not choose to make use of the entering strategy either. One reason might be that, being bound by long-term contracts in their home markets, the smaller European producers did not possess enough capacity to serve an additional market. If this was not the case, their staying-out strategy must have been caused by limit prices in the British market or by a collusive agreement with ICI, either via a tacit agreement or via some explicit agreement of which the Commission is not aware.

The intra-continental behavior of firms may indeed turn out to be useful in solving the indistinguishability problem. So far, we have assumed that the other European producers of soda- ash behave in the same way as Solvay with respect to ICI. Either they collude in Continental Europe or they set limit prices to prevent ICI's entry. Since the profit functions of these producers differ from that of Solvay, we cannot a priori take their strategies to be equivalent to Solvay's. That is, these firms may have additional incentives to defect from a collusive price [13]. In a price game with homogeneous products, prices drop to marginal costs after the defector captured the entire market during the defecting period. This mechanism would lead to a Bertrand-Nash price of $p_b^B = c_{il}$ in all post-deviation periods. Each firm $i$ operating on the continent would then make zero profits, provided that marginal cost, $c_{il}$, are standardized throughout the industry. We do not know whether there has ever been such a price war on the continent.

But suppose for the moment that a price war has occurred at some point in the past. This implies that at least one of the continental soda-ash producers preferred to make a one shot gain rather than to collude with his competitors over an infinite time horizon. It is reasonable to assume $p_b^N > p_b^B$, i.e. that the limit price required to prevent ICI's entry into market $b$ lies above the Bertrand-Nash price. If so, collusion through a mutual staying- out strategy would not be a sustainable solution in the soda-ash market. First, as we have seen, once we depart from the collusive price, pricing will be at marginal cost and not at the limit

[13] Remember that firms make positive profits under both the collusive and the limit pricing strategy even though the product is homogeneous.

price level. Second, since Solvay does not have to fear ICI's entry when continental prices lie below the limit price, ICI cannot sustain monopoly prices in its own home market $a$. Indeed, as long as the price in market $a$ is such that $p_a > p_a^N = c_{2l} + t_{2b}$, it will always be profitable for Solvay to enter the British market.

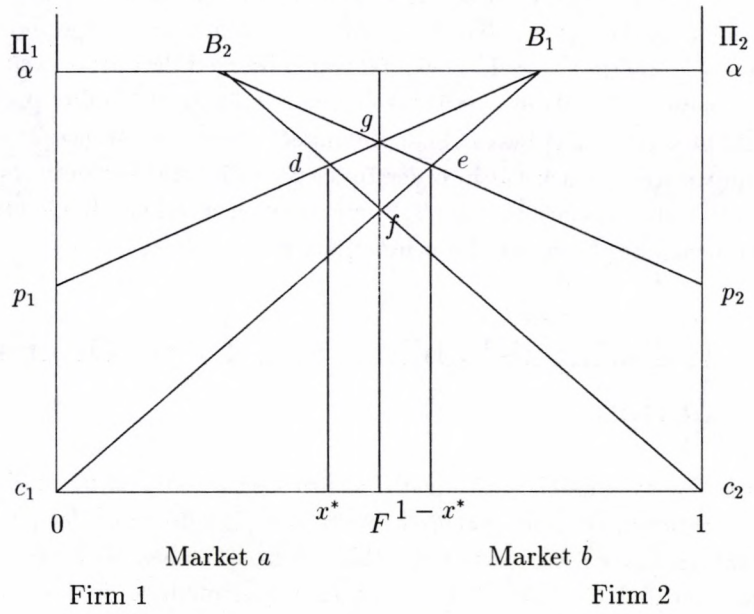
In other words, if Solvay cannot enforce the collusive equilibrium in its home market, this prevents the collusive game from being played in the foreign market as well. Thus, if it were observed that firms located in $b$ compete in their home markets, then our indistinguishability problem could be solved. The best ICI can do under these circumstances is to set a limit price in market $a$ in order to keep continental competitors out. The fact that neither ICI nor Solvay entered each other's home market would then be the result of a competitive game.

# 6 Indistinguishability and Price Discrimination

Until now we implicitly assumed that firms set a common net mill price for each customer and that each buyer pays in addtition 100 per cent of the transportation costs up to his location. It has been argued by Greenhut and Greenhut (1975) that firms can increase profits through discriminating between customers when transportation cost play a significant role in the final delivery price. The definition of spatial price discrimination requires firms to set net mill prices that vary according to the customer's location. With considerable transportation costs, firms will maximize profits by freight absorption, i.e. by charging the more distant customers less than the full cost of transportation. Compared with the previous strategy where each customer paid a uniform mill price and full delivering cost, this strategy enlarges the sales territory of a firm. By absorbing some transportation costs, a firm can serve those very distant customers whose reservation price lies above the mill price plus 100 per cent delivery cost. Furthermore, the supplier charges the closer customers relatively more by shifting transportation costs from the distant

customers to the closer customers. The counterpart of freight absorption is then a phantom freight by which closer customers subsidize the delivery of the more distant customers.

Figure 1




In this section we postulate a price discrimination strategy and examine whether the indistinguishability problem continues to exist when firms discriminate between customers. As Greenhut and Greenhut demonstrated, spatial price discrimination may well occur when two or more firms are located at two different production centers potentially serving the same geographical area [14]. Figure 1 illustrates this configuration, ICI

[14] Greenhut and Greenhut investigate price discrimination when firms are quantity setters. However, price discriminating behavior does not depend on assuming Cournot strategies. For a spatial analysis with Bertrand strategies, see Thisse and Vives (1988).

being located at $x = 0$ in market $a$ and Solvay being located at $x = 1$ in market $b$.

Customers are assumed to be distributed on a horizontal line of unit length. As before, we take demand to be linear with slope $b = 1$. Transportation costs increase proportionally with distance to the production center. Thus, firm 1 faces transportation costs of $tx$ and firm 2 faces transportation costs of $t(1 - x)$ as $x$ ranges from 0 to 1. Point F indicates the frontier between the two markets. $c_1$ and $c_2$ represent marginal costs of production which is supposed to be constant and the same for each firm. For the purpose of this analysis, we assume $c_1 = c_2 = 0$. Transportation costs rise along the line $c_1B_1$ [15]. The straight line $p_1B_1$ gives the prices at which firm 1 maximizes its profits under monopoly by charging $p_1^M = (\alpha + tx)/2$. Note that there is a different price for each location but that prices increase by less than the increase in transportation costs. This is reflected in $c_1B_1$ being steeper than $p_1B_1$.

If firm 1 were the only supplier for markets $a$ and $b$, it would deliver to customers located up to $B_1$. Thus, it would cover the entire market $a$ and the part of market $b$ that is closest to its production location. But the fact that a second firm located in market $b$ sells the same products reduces the sales territory for firm 1 to point $1 - x^*$. Between $x^*$ and $1 - x^*$ both producers offer the commodity. At $x^*$, $p_1^M = t(1 - x^*)$, i.e. firm 1's monopoly price is equal to the marginal cost of firm 2. At any location $x^* < x \leq 1$ , $p_1^M > t(1 - x)$. In the absence of tacit collusion, $p_1^M$ is not sustainable to the right of $x^*$, since firm 2 is able to undercut firm 1's monopoly price. The same argument is valid for $p_2^M$ at locations to the left of $1 - x^*$. Equilibrium prices in the area from $x^*$ to $1 - x^*$ follow Bertrand-Nash strategies. Prices are set equal to the marginal cost of the firm with the higher transportation cost at each point $x^* < x < 1 - x^*$. This corresponds to the V-shaped line $dfe$ in Figure 1.

Therefore, the competitive solution includes both an area of natural monopoly [16] situated at locations close to one of the production centers as

[15] Since the graph is symmetric for both firms, we discuss the situation from firm 1's viewpoint only.

[16] Natural in the sense that each rival would make a negative profit when serving

well as an area where prices are set at marginal cost situated at locations that are distant from the sellers' locations (and hence, close to the frontier $F$). Prices thus tend to decrease in the area where both competitors can sell. Now, if the incumbent, say firm 1 in market $a$, marginally undercuts $c_2$ along $df$, it would not be profitable for firm 2 to enter market $a$'s territory from $x^*$ to $F$. Similar reasoning holds for firm 2 in market $b$. Again, if we allow for limit pricing strategies, incumbents will undercut the cost of the potential entrantsin order to capture the entire home market up to $F$. Nevertheless, we observe competition in that prices around the frontier fall to the level of the potential entrant's marginal cost. Tacit collusion on the other hand allows each firm to set its monopoly price in its entire home market. Therefore, if we observe prices that increase continuously with distance from the production center up to the frontier $F$, we know that firms are playing the collusive game.

Consequently, our indistinguishability problem does not exist in this basic model. In order to consider our empirical case however, it is important to adjust the previous model to the specific cost situation in the soda-ash market. We know that whenever a firm wants to enter the foreign market, it has to pay a transport cost supplement for overseas delivery.

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the foreign market below $x^*$ and above $1 - x^*$ respectively.

Figure 2

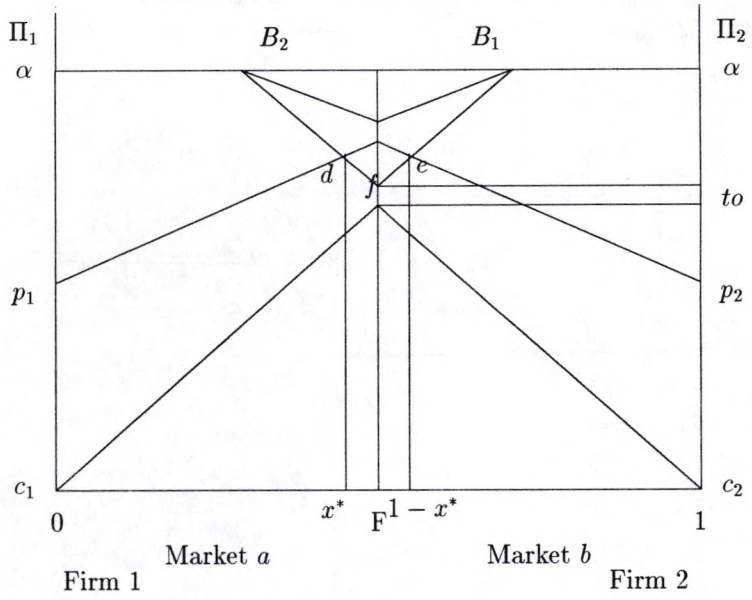


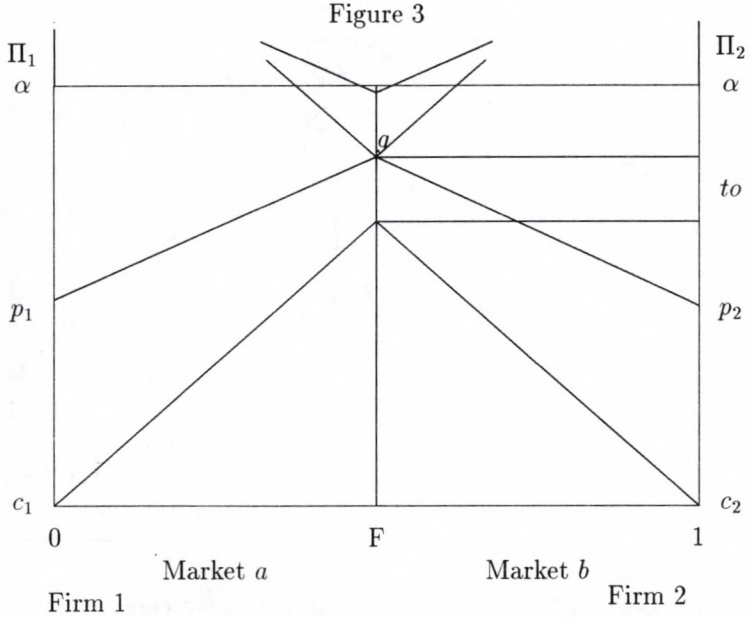

Figure 2 illustrates this case. Line $c_1B_1$ is not continuous but has a break at point $F$ [17]. The vertical difference $to$ between these two segments measures the size of the supplement. While the collusive solution does not change from that of the previous Figure, the competitive solution is characterized by an area of Bertrand-Nash prices that is smaller than before. That is, the area $x^* < x < 1 - x^*$ has shrunk. The overseas cost supplement allows firms to extend monopoly pricing to the more distant locations in their home markets, even though firms are playing the competitive game.

If we knew that the configuration in Figure 2 were the true one, we would not need to worry about indistinguishability. But we do not know whether the price and marginal cost lines do intersect at points $d$ and $e$, which would suggest that competition requires that prices fall between

[17] This implies that the price line is also discontinuous.

$x^*$ and $1 - x^*$. Figure 3 illustrates a scenario in which we can no longer distinguish between collusion and competition.

Figure 3




Indistinguishability arises here because the transportation cost supplement, $to$, is higher than in Figure 2. This means that the price and cost lines intersect exactly at $F$, the frontier between markets $a$ and $b$. It follows that staying-out is a competitive strategy in this Figure because none of the two firms can make a profit in their foreign market. In general, competitive behavior will be compatible with staying-out whenever price and cost lines either cross at point $F$ or do not cross at all. In the latter case, prices at the frontier are above marginal costs, allowing each firm to make a positive profit at the frontier of its home market. Entering the foreign market, however, would lead to a loss, since marginal costs then "jump" above the price line. The competitive equilibrium therefore

leaves us with a natural monopoly in each market. This final result gives us a situation in which there is a separation of markets, with monopoly prices being charged in each of them, regardless of whether firms play the collusive or the competitive game.

Hence, we have demonstrated the existence of indistinguishability in a model with price discrimination. Although the theoretical framework differs from that of the previous model, whether we can solve the indistinguishability problem or not again depends on the availability of information on the same parameters. It is straightforward to see from our Figures that the location and the shape of the marginal cost line determines the point of intersection between price and cost lines. Changes in $to$, in $c_1$ and/or $c_2$, the marginal cost of production, or in the slope of the cost line (e.g. due to economies of scale in transportation costs) will therefore alter the point of intersection with the price line. As in the limit pricing model, it is essential to have correct information about production and transportation cost. Without this knowledge, we cannot draw inferences on the behavior of price discriminating firms.

The model presented here is a stylized approximation of the soda-ash market in Europe when ICI and Solvay discriminate between customers. To keep matters as simple as possible, we illustrated our hypothesis in an entirely symmetric framework. Nevertheless, our basic argument, i.e. the presence of indistinguishability under imperfect information, does not depend on the symmetry of the model.

# 7 Concluding Remarks

In this article we have emphasized the difficulty of interpreting economic behavior out of an observed market situation. We pointed out that one has to be careful whenever one does not know all underlying economic parameters that influence the prices observed in the market. Our investigation of the allegation against ICI and Solvay served as an empirical example to highlight our general hypothesis. We did not say that the Commission's interpretation of the facts is wrong. Rather, we argued

that the Commission did not have all information at hand necessary to exclude an alternative interpretation of ICI's and Solvay's behavior. We examined under which conditions we can draw correct inferences on firms' behavior when some information is lacking. At any rate we found that the degree of information provided by the Commission in its final report is not sufficient to determine whether the two firms played a collusive or a competitive game. In dubio pro reo.

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