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# On the Workings of a Cartel: Evidence from the Norwegian Cement Industry

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# On the Workings of a Cartel: Evidence from the Norwegian Cement Industry*

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**Abstract**

Using the institutional set-up of the Norwegian cement industry, in particular its sharing rule, we are able to identify the workings of a cartel in some detail. Given data on prices, production, and exports, we are able to identify marginal costs as well as the effectiveness of the cartel. We compare our marginal cost estimates, which are derived from an equilibrium condition, to detailed cost accounting data, and find that our estimate of marginal cost is very much in line with the data. We then show that the cement cartel has been ineffective in the sense that the sharing rule induces "overproduction" and exporting below marginal costs. In this sense it is consumers, not firms, that benefit from the sharing rule. We find that the ineffectiveness of the cartel is becoming so large that domestic welfare of a merger to monopoly would in fact be positive at around 1968, which is exactly when the merger *actually* took place! However, we also show that competition would have resulted in even higher welfare gains over the entire sample.

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# 1 Introduction

There are relatively few empirical studies on the workings of a cartel. The primary reasons for this is that cartels are often illegal and therefore data are difficult to obtain. Even though antitrust agencies sometimes achieve detailed information on cartels, strict confidentiality rules often keep data from academic research. A notable exception is the seminal work by Porter (1983), which investigates price wars in a railroad cartel operating in U.S. in the late 19th century.[1] More recently Genesove and Mullin (1998) use data from 1892 to 1914 of the American sugar industry, where the American Sugar Refining Company controlled (through acquisition) 95% of the US sugar market by 1895. Finally, the so-called Lysine cartel, an industry producing feed additive used to ensure the proper growth of livestock, has provided more information on the workings of cartels international settings (see Griffin, 2001).[2]

Most empirical studies on cartels focus on markets where a known cartel exists and investigate the ability of the cartel to keep a collusive agreement in place, that is, on the cartel's efforts to prevent individual members from cheating on the agreement[3]. By contrast, there are few empirical studies that focus explicitly on the problem of the effectiveness of a particular cartel agreement, such as the choice of a sharing rule, which determines how the monopoly rents are divided up amongst the members.

This paper studies the effectiveness of a cartel. By effectiveness, we mean the ability of a legal cartel to achieve profit maximization in light of a particular sharing rule. Given the legality of the Norwegian Cement Cartel, we have a large amount of primary data allowing us to do a complete welfare analysis. Using the unique institutional set-up of the Norwegian cement industry, in particular its sharing rule, we are able to identify the workings of a cartel in some detail. Taking these institutional factors into account, we focus on the two fundamental problems that a cartel faces: deciding on domestic quantity as well as on the distribution of rents[4]. Given data on domestic and world

[1] See also Green and Porter (1984) and Rotemberg and Saloner (1986).

[2] The cartel was in place for the period 1992 to 1995 and was fined on the order of $100 million plus personal fees and prison sentences for some of the employees. To expose the cartel the FBI used covert cameras to tape cartel meetings, providing us with detailed information on the workings of the Lysine cartel.

[3] See for example Levenstein (1997) for a historical study of the stability of cartels looking at the pre World War I Bromine industry. Genesove an Mullins (2001) discuss how rules and frequent meetings prevented unnecessary retaliations among the sugar cartel members and how they maintained a collusive price level. See also McCutcheon (1997) for a discussion on the importance of information sharing in cartels. Suslow (1988) provides a comprehensive list of different cartels that were active in the inter-war period.

[4] Osborne (1976) in a seminal contribution refers to these two problems as "the sharing problem" and the "locate the contract surface" problem. He also mentions "detection" and "deterrence" as two

market prices, production, and exports, we use a simple model to identify marginal costs, which in turn allows us to study the effectiveness of the cartel and its impact on consumers and welfare.

The Norwegian cement industry was cartelized in 1923. Our empirical analysis is based on available data for the cartel period of 1955-1968. In 1968, the three firms that had formed the cartel merged to monopoly. In addition to the cartel period (1955-1968), we also have data for the subsequent monopoly period from 1968-1982.

Coordination of the cartel's activities was achieved through the common sales office *A/S Portland cementkontor* and various other cross industry information sharing and coordination institutions as *Norwegian Cementforening.* In principle the cartel has to decide on the total amount of cement that is sold domestically and on a *sharing rule,* which determines how the rent is split up amongst the cartel members. In this paper - motivated by the Norwegian case - we study a particular sharing rule that appears to be rather reasonable from the cartel's point of view: the cartel decides to reward domestic market shares based on the members' share of total capacity. An important aspect of the cartel's sharing rule was that total capacity was not restricted. Whenever total domestic production exceeded the domestic sales set by the common sales office, the excess output was exported at current world market price.

Following this institutional set-up of the Norwegian cement industry, we consider the decisions of the members of the cartel in a simple two-stage analysis. First, each cartel member decides on how much capacity to install, taking the sharing rule into account. That is, each member's domestic quota is based on the member's share of *total* Norwegian production. Second, the cartel collectively decides (through the common sales office) on how much of total production to allocate to the domestic market.

As we will see below, this sharing rule will create an incentive to "overproduce" and export (even when marginal costs are above the world market price), since each member of the cartel increases their share of the domestic rent. This overproduction reduces the cartel's effectiveness in the sense of lowering profits to the cartel. Moreover, we will show that the effectiveness crucially depends on the world market price. Since the world market price represents the opportunity costs of not exporting, the common sales office maximizes the cartel's profits by equating marginal domestic revenue with the world market price[5]. As a result, a lower world market price implies that the cartel allocates more production to the domestic market, which reduces the cartel's domestic rents (to the benefit of domestic consumers).

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further internal cartel problems. The last two are unlikely to play a role in the Norwegian cement industry. See also Eswaran (1996) for a study on cartel unity in the face of business cycle effects.

[5] We assume that the world cement price is *exogenous,* which is reasonable for a country like Norway.

Methodologically, the main contribution is the way in which we identify marginal costs, which is the basis for our complete welfare analysis. This paper uses a structural approach to study this industry. As usual, the structural approach does not rely on direct cost data, but rather infers marginal costs from an equilibrium condition. To add credibility to the structural estimates of marginal costs, we then compare our estimates to separate accounting data on costs. Using rather detailed cost accounting data (such as cost data on wages, electricity and material inputs) we are able to compare our estimate of marginal cost with an accounting cost index. The results are very encouraging, in the sense that accounting evidence is strongly supporting our structural estimate.

By contrast the paper by Steen and Sørgard (1999), which also investigates the Norwegian cement industry, is a reduced form analysis. They do not use an explicit equilibrium model to identify marginal costs. As a result of the equilibrium approach, we are able to provide also a complete welfare analysis and study the workings of a cartel in some detail.

There are a number of related papers that have studied the set-up that is present in the Norwegian cement industry. Davidson and Deneckere (1990) - look at a game where firms tacitly collude on price, but compete in capacity. Building on work by Benoit and Krishna (1987) they show that equilibria exist where firms will carry excess capacity in order to support collusive outcomes (see also Osborne and Pitchik (1987)). They do not explain as to why firms can not collude in capacity, but rather cite a number of examples of where firms are in such a situation of "semi-collusion" (or as it is also called "mixed games", see Brander and Harris (1984)). They also state that "it is well-known that even in cases of *overt* collusion (such as the German Cement cartel in the 1920s and 1930s, or the Texas oil industry in the 1930s) firms find it exceedingly difficult to collude in capacities - emphasis added" (see Davidson and Deneckere p.523). Scherer (1980, pp. 370-71) writes that "In Germany during the 1920s and 1930s, shares were allocated on the basis of production capacity. Cartel members therefore raced to increase their sales quotas by building more capacity".

Given its empirical relevance, this paper provides some evidence on the workings of the incentive to "overinvest" in capacity. Our empirical findings are as follows. The cement cartel has been ineffective in the sense that the sharing rule induces "overproduction" and exporting (below marginal costs). We further show that the ineffectiveness of the sharing rule was increasing over time, that is consumers benefited more (relative to monopoly), while producers were losing both domestically as well as in the export market. In this sense it was consumers, not firms, that benefited from the sharing rule. Finally, we find that the ineffectiveness of the cartel was becoming so large that domestic welfare of a merger to monopoly was in fact positive at around 1968, which is exactly

when the merger *actually* took place! Insofar our results suggest that the merger to monopoly took place exactly when a benevolent domestic dictator - ignoring adjustment costs - would have merged.

We conclude, however, by stating that there was another alternative to an outright merger, namely competition (a la Cournot). While the merger yields positive welfare gains after 1968, we show that competition would have resulted in considerably higher welfare gains over the entire sample. In this sense, the merger which took place in 1968 was only second best.

The paper is organized as follows. We begin by presenting the Norwegian cement industry and the cement cartel. We then discuss sharing rules more generally. Section 4 presents the model and some useful comparative statics. The empirical implementation and results are presented in Section 5. Concluding remarks are in Section 6.

# 2 The Norwegian Cement Industry

The Norwegian cement cartel has several features and institutional arrangements that allow us to learn more about the workings of cartels. There are relatively few empirical contributions on Cartels, which is not due to lack of interest, but rather lack of data. Given the legality of the Norwegian Cement Cartel, we have a large amount of primary data allowing us to do a complete analysis of the effects of the Norwegian cartel[6]

The first Norwegian cement plant, A/S Christiania Portland Cementfabrikk (CPC) was established in 1892.[7] At the end of World War I, three new plants were established in Norway: A/S Dalen Portland-Cementfabrikk (DPC) in 1916, CE-NO Portland Cement A/S in 1917 and a firm in Northern Norway, Nordland Portland Cementfabrikk A/S

[6]In addition to annual reports from Christiania Portland Cementfabrikk and NORCEM, we have a detailed industry history written by Gartmann (1990) and business knowledge from sources as Lorange (1973).

[7]The technology in this industry was *gradually* improving over the sample period in Norway. A cement kiln is built as a tubelike oven, and the kiln's production capacity is primarily determined by the length of the "tube". In the beginning a kiln would be in the order of 20-30 meters long, whereas the newest kilns installed after 1965 was several hundred meters long. In 1920 an efficient rotary kiln produced 50 000 tonnes annually. After the second world war the corresponding amount was 150 000 tonnes, whereas in 1966 and 1967 the largest kilns at Dalen and Slemmestad produced 500 000 tonnes each. The technology also changed from "wet process" to "dry process" over this period, where the newer "dry process" was more efficient and required less energy. The enormous new kilns that are in use today have a capacity of more than 1 million tonnes per kiln, but none of these where installed in our sample period. Gradually expansion of kiln size together with the fact that older kilns only gradually where phased out as they got non profitable made therefore the technology improvement relatively smooth in Norway.

(NPC) in 1918. The capacity expansion, combined with the recession in Norway from 1920, led in the early 20s to a domestic capacity amounting to almost twice the domestic demand [see Gartmann (1990; 114)]. The mismatch between capacity and demand triggered a price war and later the establishment of *A/S Norsk Portland Cementkontor* in 1923, a joint sales office for the three firms in Southern Norway (CPC, DPC and CE-NO). Five years later, NPC became a member of the common sales office as well. CE-NO was acquired by DPC in 1927 (see Gartmann, 1990), which increased DPCs market share to the level of CPC.

The Norwegian cement industry has been cartelized through the *common sales office* since 1923. The reasons for the creation of the sales office was clearly to remove competition: "*both companies (in the south) had to sacrifice something on the alter of collaboration. The sales office primary task was to organize the sale in a better way, to prevent cross-transportation and unprofitable competition. A/S Norsk Portland Cementkontor took care of the sale for both factories* [CPC and DPC]. *Later* [1928] *also the Northern firm's sales* [NPC]*were included trough a common sales agent in Trondheim.*" (Gartmann, 1990 p. 46). This implied that from 1928 all cement was sold trough one agency, and no cement was sold directly from the factories. In particular, the common sales office determined the total domestic sale and sets domestic quotas according to each firm's total capacity (domestic production plus exports)[8].

After establishing the common sales office, more institutional ties were developed. In 1927, "*Norsk Cementforening (NC)*" was founded. NC was an institution (funded by the industry) that coordinated standards, lobbied government committees, and took part in the education of engineers and cement workers. Gartmann (1990 p.47) claims that "*the sales office and NC, were forerunners to the full merger in 1968. Norcem came to a finished table arrangement with coordinated sales and information already established over a long period*". In the beginning only the two big producers in the south joined NC, but later also the northern firm entered [9].

[8] As long as prices are higher than short run marginal cost (which is the case, see below) it is optimal to use all the installed capacity such that capacity equals production. Storage is not an option either, due to limited storage capacity for cement. In the annual report from NORCEM in 1968 we could read (p.9): *"Because the capacity for storing finished cement is so small, production has to conform quite closely to sales."* The sharing rule can thus also be considered a production sharing rule.

[9] The cement producers started several other institutions as they moved into downstream activities. For instance, the production of cement products as tubes and panels had their own body, called "*The Cement producers price co-ordination body*" that was founded in 1928, whose task was to "*collaborate on prices and rebates to prevent non serious producers to enter the market* " (Gartmann, 1990, p. 62). In the same fashion NC controlled that the local concrete mixers, which were small firms often organized in local oligoplolies produced according to quality standards. In 1964 these firms founded a collaboration body: " *The local concrete-mixers institute*". The institute however had its secretariat

As we mentioned above, the common sales office and the sharing rule will create an incentive to export. Let us look at exports. The three firms' exports fell gradually during the 30s, from more than 50% of total domestic production to approximately 10% of domestic production at the beginning of World War II. In the mid 50s exports grew rapidly, and in the late 60s over 40% of the domestic production was exported. In 1968 the three firms merged and established the firm Norcem, and during the 70s Norcem closed down the excess capacity.

Norwegian exports predominantly went to non-European markets, such as South- and North-America, as well as Africa. The reason why little cement was exported to other European countries has been explained through a retaliation game. Essentially, competition is a multi-market game where credible threats to enter each others markets prevent firms form entering other countries (see for example Röller and Friederiszick (2003)). Aiginger and Pfaffermayr (1997) undertake a study of the competition in the cement and paper industries. On page 252 they state that: "*the cement industry is faced with limited geographical competition*". Later they say that: "*we are confident that the EU is the relevant geographic market for the paper industry, for cement this is clearly not the case*" (p.263). As a result, Norwegian exports went to non-European markets in order to prevent possible retaliation from neighboring European countries.

Let us now look at imports. A further implication of the European stale-mate was that there were little imports (at least from other European countries) into Norway. In addition, there were also few imports from other parts of the world. The reason for this was that the domestic market was protected both by high tolls and by relatively high transport costs. For instance, in 1959 the toll was 8 NOK per ton. This was approximately 9% of the factory price. CPC considered this a significant toll barrier. (CPC annual report 1959 p. 4). It is therefore no surprise that imports were low.[10] In addition, there was a relative high transport cost to Norway, primarily due to the trade pattern at this time period. Norwegian boats had excess capacity for bulk transport leaving Norway, depressing transport prices out of Norway (some minimum ballast is in fact needed for oversea journeys). By contrast, for coming back to Norway there was

in the same offices as NC, suggesting that NC played a rather influential role in co-ordination of the cement industry during the cartel period.

[10] To the extent that we saw imports it was small and typically seasonal – in some periods more cement then what was produced was needed. "*To cover the max-consumption during the fall season there was an import of 32 000 tonnes of cement ... and as usual in addition to this some minor quantities of special cement that is not produced in Norway was imported*" (CPC-annual report 1959 p.3) In 1959 total production was 1103 000 tonnes, suggesting an import less then 3%. The export in this year was 80 000 tonnes, so Norway was a net exporter also in 1959. Note that the overproduction in 1959 was small compared to what we saw develop during the 60s.

plenty of cargo from ports in the US, Latin America[11] and Africa. As a result, transport costs to Norway were considerably more expensive (Gartmann, 1990).

In sum, there has been little import of cement into Norway and most of the exports have been to non-European countries. Given that Norway is a very small producer on the (non-European) world market, we will assume below that the (non-European) world market price for cement is exogenous to the cartel decision problem.

This paper will focus on the large capacity built up after 1955. We will argue that this is due to "overproduction" stemming from the common sales office and the sharing rule. As we have mentioned above, the common sales office existed since 1923. However, prior to the 1950's, firms had to ask the government for permission to undertake capacity investments. The reason for this was that imports of technology to undertake capacity expansions were rationed, due to shortages after World War II. As rationing was ended, the regulation of capacity was also ended by the mid 1950's. We would therefore expect the "overproduction" to emerge only in the mid 1950's.

Let us take a first look at the data. Figure 1 shows domestic production and domestic consumption of cement for the period 1955 to 1968. From 1955 to 1968 production increased by 150%, whereas the Norwegian consumption only increased by 50%. By 1968 this lead to an export of some 828 000 tonnes, almost as much as Norway's total production in 1955. There is thus rather striking evidence that overproduction took place.

[Figure 1 approximately here]

As we have mentioned above, this paper will focus on the sharing rule and its incentives to explain the above phenomenon. What about alternative explanations? In principle, there may be two other reasons for the observed capacity increase (see also Steen and Sørgard (1999)): the Norwegian producers built up such high capacity levels due to unrealistically high anticipation of increased future consumption, or to deter entry. Let us take these alternative explanations in turn.

Regarding the unanticipated consumption slowdown, the CPC undertook a very comprehensive and detailed ten year forecast of Norwegian cement consumption in 1957 (annual CPC-report 1958 pp.14-28), including a number of different economic and demographic trends (such as fertility, household size, average number of rooms per house, building and construction trends, GNP, population growth). Comparing the 1957 forecast with actual realized consumption, one finds that the forecast was rather accurate

[11] For instance, Norway imported large quantites of Bauxit from Latin America for the Norwegian aluminium industry.

with a margin of error below 5% (except for 1959). The forecast for 1967 (made in 1957) predicted a Norwegian consumption of 1.35 million tonnes, while the actual consumption in 1967 was 1.358 million tonnes! It appears that the industry's ability to predict future domestic consumption was exceedingly good, making an argument for a dramatic capacity built-up based on optimistic consumption expectations implausible. If entry deterrence was the motive for over production, we should have expected other European countries to have a similar capacity expansion at that time, as they would have had the same strategic incentives to deter entry. As can be seen in Figure 2 the built-up in other European countries was much later.

[Figure 2 approximately here]

We therefore conclude that the incentives created by the cartel's sharing rule is the most plausible explanation for the large capacity investments in Norway.

Given the incentives created by the sharing rule in the mid 1950's, one may wonder why the firms did not merge earlier than 1968. A reasonable explanation are the existence of other institutional agreements that have been agreed on a long-term basis. In particular, the firms entered into two long-term agreements in 1957 and 1962. In these contracts the firms were tied together even stronger . "*When the industrial firms start a market collaboration is it natural that this lead to increased contact and exchange of views also within other fields of the firms activities. In the cement industry this lead to an extension of the collaboration, both with regards to particularities and more general issues. Common purchases, standards of cement types, common packaging was agreed upon. This was particular formalized in the agreement of 1957, and even more so with the revision of the agreement in 1962.*" (Gartmann, 1990 p. 115). CPC themselves described the agreement in their annual report (1962 p. 7) as "*An agreement that has as main object to govern a good collaboration between the cement factories to obtain a rational solution of the industry's production and distribution tasks*". Interestingly enough the 1962 agreement was denoted "the 7 year agreement" lasted until December 31, 1968. Hence, the merger in 1968 came at a time where either a new market agreement had to be negotiated, or an alternative industry structure. As losses from exporting where mounting up (as we will show below) and other agreements were running out in 1968, a merger to monopoly was ultimately implemented.

Another factor allowing a merger to monopoly in 1968 was that antitrust concerns vis-à-vis the merger were unlikely to be significant in Norway at that time, as an effective merger control did not exist and consumers did not play much of a role in competition

concerns[12]. The general view at the time was that all mergers were good. As a result, there was no visible opposition against the NORCEM merger in 1968[13].

# 3 Sharing rules in practice

The Norwegian cartel was subject to a very formal agreement where the market sharing rule was implemented with rigor. This can be illustrated by the fact that CPC and DPC implemented side payments to adjust for sales that were in excess of the firms' domestic market share. The background for this was that DPC had better export facilities (such as port loading technology). This need for these market divisions and organization of the exports was bluntly stated by the industry: "*CPC's deliveries to its ordinary, domestic market increased from 464.000 tonnes in 1963 to 484.000 tonnes in 1964. In addition, it delivered 54.000 tonnes to DPC's customers, which implied that DPC's export increased with an identical amount. For this indirect export, CPC compensated DPC according to the ordinary export prices.*" (p. 13). There are several similar statements in other annual reports.[14]

There are other examples of similar sharing rules that have been used by other cartels. We have already mentioned the German cement cartel of the 1920s and 1930s. Another example is the domestic cartels in Japan, which allocated quotas according to relative capacity, led to excess capacity in many Japanese industries during the 50s and 60s [see

[12]In fact, Norway had no real merger control in 1968. The first formal law dealing with competition policy in Norway was the "trustlaw" approved in 1926. In 1932 Norway passed an extension to the "trustlaw" that allowed authorities to cartelize industries by law. In addition, the 1932 extension outlawed excessively low prices in order to "prevent excessively low profitability in the industry". Consumer interests were practically irrelevant and this cartel-friendly practice continued up to world war I (Nordvik, 1995). In 1953 Norway issued a new law on competition – the so-called price law. The law stated very general objectives on competition issues, but once again the authorities practice was quite cartel friendly. Due to lack of resources the authorities who were responsible at the time (the "Prisdirektoratet") did not really focus on the analysis of markets (Halvorsen and Undrum, 1995). Interestingly enough the authorities themselves concluded as late as in 1982 that the "price law from 1960 did not warrant cartel control". However during the 80's the political views changed and merger control was introduced in Norway by 1988.

[13]We have searched through old newspapers from that time and found no indications that large customers were opposed to the merger in 1968.

[14]In the following three annual reports we can find similar statements: "*In addition CPC supplied 73 000 tonnes in 1965, against 54 000 in 1964, by way of indirect export to DPC's customers*" (1965 report, pp. 13-14), "*The deliveries in 1966 went up to 580 000 tonnes, inclusive an indirect export of 70 000 tonnes*" (1966 report, p.13), and finally: "*In 1967 it was exported 632 000 tonnes. Our company [CPC] has indirectely taken part in this export operation by delivering cement to DPC's domestic area*" (1967 report, p.15).

Matsui (1989)].

Another prominent case of a cartel that divided the market according to production capacity is the so-called Lysine cartel that operated in the period 1992-95. According to Griffin (2001) the cartel members typically met late in the year in order to determine how much each producer had sold in the preceding year. The members then proceeded by estimating the market growth for the upcoming year and allocated the growth among themselves. The international lysine cartel did not face the same incentive problem as the domestic Norwegian cartel, both because of its international nature and because they did not use a common distribution system. However, the lysine cartel still faced the common cartel problem of how to limit cheating.[15].

The most recent examples of production sharing rules are found in the agricultural co-operatives (Bergman, 1997). The US had 5800 farm marketing and supply cooperatives in 1986 (Sexton, 1986). According to Bergman there were 4536 primary cooperatives just in Germany in 1997. Similar arrangements are found in many other European countries. Typically cooperatives purchase whatever their members have been able to produce, and then decide how much to sell at home. The rest is sold (often at much lower prices) on world markets. Since the cooperatives usually cannot restrict their members production, the incentive structure is analogous to our set-up.[16]

There are, of course, other sharing rules, most notably geographic market segmentation. An example of this is the so-called marine construction and transportation cartel, where the conspirators reached an agreement to allocate customers and agree on pricing heavy-lift derrick barge and related marine construction services in the major oil and gas production regions of the world[17]. Two firms owned all (six) heavy-lifter derricks in the world. In 1997 the two firms (and one of the firm's subsidiaries) were accused of regional market sharing and price fixing.

Geographic sharing rules have other incentive problems than the one studied in this paper, such as when economic growth varies considerably across regions. Since cement production is observable, it can be measured and the market can easily be divided.

[15]The volume allocation agreement then became the basis for an annual "budget" for the cartel, a reporting and auditing function and a compensation scheme (Griffin, 2001).

[16]In several countries as (e.g., Denmark, Finland, Sweden, France, Germany and Netherlands) agricultural marketing cooperatives are explicitly exempt from prohibitions that regulate other firms (Bergman, 1997).

[17]Heavy-lift derrick barges are floating crane vessels with a capacity to lift heavy structures, such as the decks of offshore oil platforms, in a marine environment. The conspiracy originally targeted contracts in the North Sea, but grew to include projects in the Gulf of Mexico and the Far East. Information on this cartel can be found for instance in the Department of Justice's press release Monday December $22^{th}$ 1997, (see http://www.usdoj.gov/atr/public/press_releases/1997/1325.htm.

Using production as a sharing rule will ensure that regional differences in consumption patterns will effect the individual cartel members' profitability in a symmetric way.

# 4 The Model

In this section we specify a simple model to illustrate how the sharing can be used to identify the effectiveness of the cartel. We model cement as a homogenous good. The domestic cement industry is characterized by a demand curve, $P(Q^D)$, where $Q^D$ is the domestic quantity and $P$ is the domestic price. We assume that the world market for cement is perfectly competitive, with the world market price exogenously given by $R$. Finally, we assume that $P(0) > R$ and that there are no imports.

There are $N$ domestic firms, which operate a legal cartel. The cartel decides on the total amount of domestically sold cement, $Q^D$ and on a *sharing rule*. In our case, the Norwegian cartel decided on a sharing rule that appears to be rather reasonable from the cartel's point of view: the cartel decides to reward domestic market shares based on the members share of total Norwegian capacity (i.e. exports plus domestic sales). Most importantly, the cartel does not restrict individual capacity decisions[18]. We therefore let firms decide on how much capacity to build non-cooperatively.

In terms of timing, we analyze a simple two stage game. In stage one, cartel members make non-cooperative capacity decisions, anticipating the sharing rule. Denote the capacity by firm $i$ as $q_i$,where $i = 1, .., N$. The production sharing rule is then $s_i \equiv q_i / \sum q_i$, such that $s_i$ is the domestic market share of firm $i$. In stage two, the common sales office cooperatively allocates the domestic output $Q^D$. This implies that $s_i Q^D$ is firm $i's$ domestic sales, while the remaining output, $q_i - s_i Q^D$, is available for exporting.

The profit function of firm $i$ is composed of domestic profits and returns from exporting, and is given by,

$$\pi_i = P(Q^D) s_i Q^D - c q_i + R \cdot (q_i - s_i Q^D),$$

where $c$ is the marginal cost of capacity, which we assume to be identical across firms.

**The Domestic Allocation Decision (The Common Sales Office)** In stage two, the common sales office sets domestic quantity, by $\max_{Q^D} \sum \pi_i$. Note that firm's domestic sales are proportional to the capacity share - so that firms will agree on the choice of industry domestic sales. Assuming that exporting occurs (see below) $Q^D < \sum q_i$, we arrive at the following first-order condition for the domestic market allocation,

[18] Since firms always produce up to capacity, we assume that the marginal production costs of cement is low enough such that firms' are capacity constrained.

$$P'Q^D + P - R = 0 \tag{1}$$

In words, the cartel allocates domestic output by equating marginal revenue in the domestic market to the world market price. Note that the marginal cost of capacity ($c$) does not enter the first-order condition for the domestic market equilibrium. As a result we can not follow the standard approach and identify marginal costs from equation (1). We will return to this point below.

By contrast the world market price $R$ enters (1) as it is the opportunity cost of not exporting. As a result, the world market price plays the usual role of marginal costs. Implicitly differentiating (1) it is straightforward to show that $\partial Q^D/\partial R < 0$. Accordingly, the lower $R$, the lower the domestic price. In particular, when $R$ is below $c$, the cartels price is below the monopoly price defined by the usual monopoly condition $P'Q^M + P - c = 0$. In this case, the ineffectiveness of the cartel leads to lower domestic prices and profits[19], and two higher domestic consumer surplus.

The previous discussion illustrates that the cartel's effectiveness to keep prices at monopoly levels in domestic markets is reduced when $R$ is low. It is interesting to ask under what conditions the domestic price is equal to a price level that would have emerged under symmetric Cournot competition. Let $q^C$ denote the firms' symmetric Cournot output defined by,

$$P'q^c + P - c = 0. \tag{2}$$

Prices in a symmetric Cournot game are higher than in the cartel outcome if, $c - P'(Nq^C)q^C > R - P'(Q^D)Q^D$. Using linear demand this can be written as, $((N+1)/2)(a-R)^2 > (a-c)^2$, where $a$ is the demand intercept. We therefore find that the cartel is less effective than a non-cooperative domestic Cournot solution (in the sense of lower domestic equilibrium prices) when $R$ is low, $c$ is high, and when the market structure is less concentrated (high $N$). A cartel using a production-based sharing rule may thus result in even lower domestic prices than a non-cooperative Cournot market. We will test whether this was the case in Norway in the empirical section below.

As we have seen, the sharing rule induces positive domestic welfare effects. However, these gains have to be traded-off against losses in the export markets. The size of this inefficiency will depend on the total amount of capacity that is installed, which is a function of the incentives to gain a bigger share of domestic profits. We now turn to capacity decisions.

[19] To see the impact of $R$ on domestic profits, implicitly differentiate the domestic industry profit function $\Pi^D = PQ^D - F - cQ^D$, which yields $\partial\Pi/\partial R = \frac{\partial Q^D}{\partial R}(Q^D P' + P - c)$ which is positive. This implies that domestic producer surplus will fall with lower world market prices. The intuition for this result is that when $R$ falls below $c$, prices get closer to non-cooperative prices.

**Firm's Capacity Decisions** In stage one, firms decide on their individual capacity by solving $\max_{q_i} \{\pi_i\}$. The first-order condition is

$$(1 - s_i)\frac{Q^D}{Q}(P - R) + R - c = 0, \tag{3}$$

where the first term, $(1 - s_i)\frac{Q^D}{Q}(P - R)$, constitutes the incentive to export due to the sharing rule. Note that if the marginal cost of capacity $c$ is below $R$ for all capacity levels, then (3) can never be satisfied and capacity investments tend towards infinity. To concentrate on an interior solution we will assume that $c$ is above $R$ (see below). As a result the loss in the export market is $EL = (Q - Q^D)(c - R)$.

We have already seen that the impact of the world market price $R$ on domestic profits is negative. By contrast, the impact of $R$ on profits in the export market is ambiguous. Implicit differentiation yields $\partial EL/\partial R = \frac{\partial(Q-Q^D)}{\partial R}(c - R) - (Q - Q^D)$. The first term is positive, which is the loss from increased exports below costs[20]. The second term is negative, which decreases the loss due to the increase in export price $R$. We thus find that even though the impact of a higher $R$ on domestic profitability is positive, the effect on total profitability is ambiguous, while the impact on domestic consumer surplus is negative.

Overall, we find that a cartel using a capacity-based sharing rule leads to higher domestic consumer surplus, but the impact on profitability is ambiguous. This trade-off can also be represented graphically. We illustrate the cartel and monopoly equilibrium in Figure 3. The monopoly outcome is the usual solution where marginal revenue meets marginal cost, yielding a price $P^m$ and quantity $Q^m$. No export will take place in monopoly equilibrium, since the world price $R$ is below marginal cost of capacity. The cartel solution is the price-quantity combination ($P^{cart}$, $Q^{cart}$) where marginal revenue equals $R$. Exports are given by the difference between total domestic production, $Q$, and the domestic quantity sold $Q^{cart}$. The change in consumer surplus by moving from cartel to monopoly is therefore given by the sum of the areas A and C. The impact on producer surplus is given by A minus B plus the saved export loss, D. Finally, the change in welfare is D-B-C, which is ambiguous.

[Figure 3 approximately here]

[20] Implicit differentiation of (3), yields after some manipulation that $\frac{\partial(Q-Q^D)}{\partial R} > 0$. That is firms export more whenever $R$ increases.

Given that the effectiveness (in terms of cartel profitability) of the Norwegian cement cartel is in theory ambiguous, we now turn to the data in an attempt to evaluate the trade-off empirically.

# 5 Empirical Implementation

As is often the case in empirical studies of market behavior, one does not have reliable data for marginal costs. Marginal costs are then inferred through equilibrium behavior (usually through a first-order condition such as equation(2)), provided that an estimate of demand is available. For example, estimation of both the monopoly and the Cournot equilibrium (such as (2)) would need to proceed in this fashion.

The lack of data on marginal costs is no different in the case of the Norwegian cement industry. However, in our case we can use the institutional set-up of the sharing rule to identify marginal cost, even without estimating demand. To see this, consider the first-order condition for capacity choices by firms (3). Since there is excess capacity, capacity choices by individual cartel members do not affect the domestic allocations by the common sales office (see (1)). As a result, domestic demand conditions are irrelevant for the capacity choices and we can identify marginal costs without demand estimation from (3).

Our identification of marginal costs rests on the existence of the cartel's sharing rule, which produces an incentive to export. We will test this assumption below by checking whether exporting takes place in equilibrium.

## 5.1 Demand

While marginal costs are not needed for the estimation of the domestic market equilibrium (1)[21], we do need an estimate of demand. In this section we estimate demand using data from both the cartel period, as well as the monopoly period resulting from the domestic merger. We estimate the demand by instrumental variables using data from both periods, that is we assume that the structure of domestic demand has been stable over this time period. Given the homogeneity of cement we use the following Autoregressive Distributed Lag (ADL) formulation for demand,

$$P_t = \beta_0 + \beta_{QD} Q_t^D + \beta_{QD1} Q_{t-1}^D + \beta_Z Z_t + \beta_{Z1} Z_{t-1} + \gamma P_{t-1} + \varepsilon_t \tag{4}$$

[21] Recall, however, that both the monopoly and the Cournot equilibrium need an estimate of marginal costs of capacity, as well as demand. This is the usual model, i.e. a market without the sharing rule.

where $Z$ is an exogenous variable affecting domestic demand of cement. We use the Norwegian construction and building index (BC) as a $Z$ variable and various other cost shifters as instruments.[22] The data and summary statistics are presented in Table 1 (see Appendix A for detailed information on data sources and variable definitions). Specification (4) is an ADL(1,1) specification. The most common motivation for using this framework is the importance of accounting for short-run dynamics in the data. Short-run deviations may be caused by factors such as random shocks, sticky prices, contracts etc. By including lagged observations of the endogenous variables, the ADL framework also incorporates dynamic factors such as habit formation. The presence of habit formation in demand make static models inadequate (Pollak and Wales, 1992).

In addition to accounting for short run dynamics, the ADL model yields both a short- and long run demand elasticities. The short run demand elasticity is $E_{PP}^{SR} = \frac{1}{\beta_{QD}} \frac{Q^D}{P}$, while the long run elasticity is given by $E_{PP}^{LR} = \frac{1-\gamma}{\beta_{QD}+\beta_{QD1}} \frac{Q^D}{P}$ through the steady state solution (i.e. $P_t = P_{t-1}$ and $Q_t^D = Q_{t-1}^D$). The ADL model also provides an estimate of the speed of adjustment $(1-\gamma)$ which is normalized to lie between 0 and 1.

[Tables 1 and 2 approximately here]

The results for demand estimation are presented in Table 2. The model shows no signs of autocorrelation; the Box-Pierce test statistics is low, indicating no first order or higher order autocorrelation (see Q1 and Q4 in Table 1). The adj. $R^2$ is 43%. The short run elasticity is estimated to be -0.46, implying an inelastic demand in the short run. The long run elasticity is estimated at -1.47. This is in line with intuition, as other materials like wood and metal can be substituted for cement in the long run. The adjustment speed is estimated at 0.46, which implies that 46% of a short run shock is absorbed each year. Both the relatively large difference between short run and long run elasticities, as well as the relatively low adjustment speed are reasonable for the cement industry. Most larger construction contracts will be longer than one year. Hence, within a year there is relatively little scope for adjustment, whereas between years this scope increases substantially; new contracts can be negotiated and other building materials chosen.

[22] A posibble concern with using BC as an exogenous variable is its potential endogeneity with cement quantity and prices. However, the gross output of the cement industry has less than 1% weight in the BC index, e.g., in 1960 the weight was 0.8%. The exogeneity of cost shifters is given by the fact that production is not directly determined by costs (see equation (1)).

## 5.2 Marginal Costs and Consistency

As discussed, given the institutional set-up and the sharing rule, we are able to identify marginal costs from (3) as

$$c = (1 - s) \frac{Q^D}{Q} (P - R) + R, \tag{5}$$

where $s$ is the symmetric market share $\frac{1}{N}$. As is the case in all empirical studies that use equilibrium concepts to identify marginal costs, we depend on the correct specification of (5).

In order to test our approach, we provide two consistency checks. The first one is based on $c > R$, which needs to be satisfies for our model to make sense. Figure 4 plots the predicted marginal capacity costs ($c$), the world market price ($R$), as well as the domestic price ($P$). As can be seen, marginal capacity costs are always above the world market price implying that the data are consistent with our maintained assumption.

[Figure 4 approximately here]

A further important consistency check of our structural approach is based on a comparison between the predicted marginal costs recovered via the equilibrium condition (5) and other information on cost accounting data. Figure 5 plots three input price series - electricity and fuel, wages, as well as materials - based on accounting data sources (see Appendix A for details) as well as our predicted marginal cost. As can be seen, except for a jump in the electricity and fuel costs in 1967 when also the predicted marginal cost has a small increase, the accounting cost data information and our (equilibrium) marginal cost are remarkably similar. The simple correlation between our inferred measure of marginal cost and the input factors are 0.93 (electricity and fuel), 0.89 (wage) and 0.82 (materials), respectively.

An alternative is to aggregate the three input factors into an average unit cost per ton of cement. The comparison of the aggregate unit cost index is given in Figure 6. Again, one can see that the (short run) average unit cost measure is highly correlated with our marginal cost measure derived from the first order condition (the correlation is 0.96).[23] It is worth noting that our measure of marginal cost is a long-run measure, i.e. it includes capacity, which is why the marginal cost line is above the average unit cost measure in Figure 6.

In sum, we find that information on accounting cost data is consistent with our equilibrium measure of marginal costs, lending considerable credibility to our approach.

[23] The common negative trend in both cost measures will bias the correlation upwards. Taking the first-order differences of these cost measures yields a correlation that is still quite high (0.59).

[Figures 5 and 6 approximately here]

## 5.3 Welfare Analysis

Using our demand and cost estimates we are able to perform a complete welfare analysis. In order to analyze the impact of the cartel we first compare the cartel situation to that of a monopoly. In doing so, we use the long run demand estimates given by $P_t = \beta_0^* + \beta_{QD}^* Q_t^D + \beta_Z^* Z_t$, where $\beta_{QD}^* = \frac{\beta_{QD}+\beta_{QD1}}{1-\gamma}$, $\beta_Z^* = \frac{\beta_Z+\beta_{Z1}}{1-\gamma}$ and $\beta_0^* = \frac{\beta_0}{1-\gamma}$ and compute the monopoly equilibrium. Figure 7 compares moving from the cartel to a monopoly equilibrium for each of the years 1955 to 1968.

As can be seen in Figure 7, the cartel is not effective at all. In particular, losses from exporting are very large. Apparently, the sharing rule creates a considerable incentive problem, leading to significant overproduction and exporting below marginal costs.[24] By contrast, the losses in the domestic market are substantially lower, indicating that the common sales office is rather effective in keeping domestic prices close to monopoly levels.

As a consequence of the sharing rule, domestic consumers are better off under the cartel relative to a monopoly. The cartel's ineffectiveness is to the benefit of consumers.

Figure 7 also shows that the effectiveness of the cartel is declining dramatically over time, as the incentive problem is becoming more and more of a problem for the cartel. Interestingly, the cartel was operating so inefficiently around 1967 that a merger to monopoly actually had a positive effect on welfare. The loss from exporting is so large that the gains to consumers are outweighed, resulting in positive domestic welfare from a merger to monopoly.

[Figure 7 approximately here]

Insofar our results suggest that the timing of the merger took place exactly at the right time, i.e. when a benevolent domestic dictator would have merged. Given the likely absence of benevolent dictators in Norway, one may wonder why the merger took place in exactly 1968, i.e. exactly when the net benefit of consumers and firms becomes positive. As already discussed in Section 2, a reasonable explanation are the existence of other institutional agreements that have been agreed on a long-term basis. As losses from exporting where mounting up and other agreements were running out in 1968, a

[24] These patterns are consistent with what we find in other agricultural cooperatives. Members of the cooperatives would be even better off if they reduced capacities and sold less at home and prevent costly export. However, the monopoly price at home compensate enough to make them better off than the alternative of competition.

merger to monopoly was ultimately implemented. Another factor allowing a merger to monopoly in 1968 was that antitrust concerns vis-à-vis the merger were unlikely to be significant in Norway at that time.

The previous findings suggest that the merger took place exactly at the optimal time for welfare. However, this conclusion is premature, as it ignores the possibility of competition. Table 3 presents the comparison with Cournot competition for the year 1968, as well as the accumulated rents over the sample period 1955-1968.

[Table 3 approximately here]

As can be seen in Table 3, domestic consumers would have benefited from Cournot competition, *i.e.* the cartel is not as ineffective that it drives domestic prices down to non-cooperative levels. On the other hand, competition would have lowered producer surplus.

In light of this, the wisdom of the merger to monopoly in 1968 has to be reassessed. The merger may have come at the right time, but only if the alternative is to do nothing (i.e. keep the cartel in place). If the alternative is to move to competition, neither cartel nor merger to monopoly have been to the benefit of Norwegian welfare. A well functioning competition policy authority would have broken up the cartel and not allowed the merger to monopoly (recall that at the time there was none, however).

In 1968 alone the welfare gain from breaking up the cartel in favor of competition is some 131 million NOK, while the merger to monopoly increases welfare by only 11 million NOK. In other words, the apparent welfare enhancing merger to monopoly, left 120 million NOK "on the table" by not allowing competition. In this sense the merger to monopoly was a distant second best solution. The picture is even more dramatic with regard to consumers. While domestic consumers lose from the merger (some 37 million NOK), our model suggests that they would benefit 237 million NOK from competition in 1968 alone.

In sum, we find that relative to keeping the cartel in place, the merger to monopoly in 1968 was exactly what a benevolent dictator would have done. However, the picture is rather different, if the alternative is competition. In this case, the Norwegian cement industry is subject to a considerable public policy failure.

# 6 Conclusion

Using a unique institutional set-up in the Norwegian cement industry, we are able to study the workings of a cartel in detail. We focus on the cartel's efficiency and in particular its sharing rule, which is commonly used in other cartels. Taking these institutional

factors into account, we focus on the two problems that the cartel faces: deciding on the domestic quantity as well as on the distribution of rents. Given data on domestic and world market prices, production, and exports, we are able to identify marginal costs, as well as the effectiveness of the cartel and its impact on consumers and welfare.

We show that the cement cartel has been inefficient by using a "production" sharing rule, which creates an incentive to overinvest in capacity and export (below marginal costs) in order to increase their share of a profitable domestic market. We have shown that this sharing rule benefits consumers (relative to outright monopoly pricing), while producers are losing both domestically as well as in the export market.

The domestic welfare implications of a merger to monopoly - which are in theory ambiguous - are empirically shown to become positive at exactly the time of the merger, i.e. in 1968. We thus find that relative to keeping the cartel in place, the merger to monopoly in 1968 was exactly what a benevolent dictator would have done. However, the picture is rather different, if the alternative of competition is included. In this case, the Norwegian cement industry is subject to a considerable public policy failure.

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# Appendix A: Data Description, Sources and Construction

The data is collected from four main sources; the Norwegian Industry Statistics (NIS), the Norwegian Trade Statistics (NTS), the Norwegian Historical Statistics (NHS), and the National Accounts Statistics (NAS), all published annually by the (Central Bureau of) Statistics Norway (SSB).

The Norwegian export figures are from NTS, containing the commodity numbers: 35.22, 25.23 and 2523.1000. Production and export are measured in tonnes and the export price (R) is the unit price measured as NOK per ton. The latter is calculated as the yearly export value divided by the yearly export quantity. The European export figures are from CEMBUREAU's production, trade and consumption statistics; «World Cement Market in Figures 1913-1981», World Statistical Review No.4, and yearly CEMBUREAU publications from 1982.

The cost observations are from NIS; ISIC code 3340 prior to 1970 and ISIC code 3692 from 1970 onwards. The instruments used in the demand equation are labor price which is labor expenses per man year, the material price which is calculated as material expenses per ton produced, and the electricity & fuel price which is also a per ton price. (Note that in Figure 5 is labor cost calculated as a per ton price to be directly comparable to derived marginal cost).

Yearly production is also found in NIS, but is checked against production figures provided by Norcem, and production figures from CEMBUREAU.

The export price, and the three cost measures are all deflated using the Norwegian Consumer Price Index (CPI), which is found in NAS and NHS.

The construction index we use as a measure of market size is a volume index of gross domestic product in the construction industry. It is derived from NOS National Accounts Statistics [National Accounts 1865 - 1960 (Table 45), Historical Statistics 1968 and 1984]. Data for the various time periods are spliced by the simple ratio method to form a consistent time series. The index is collected and constructed by Jan Tore Klovland, Norwegian School of Economics and Business Administration.

**Table 1** Summary Statistics for the main variables and the cost shifters for the period 1955 to 1982. (All values are deflated using the Norwegian CPI [1985=100] measured in NOK, costs are measured per ton, and wages are measured per man year. Quantity figures are measured in tonnes.)

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| *R* | 316.12 | 89.469 | 227.54 | 524.42 |
| *P* | 524.44 | 106.944 | 359.08 | 706.29 |
| *Z* | 1597.99 | 419.370 | 1108.39 | 2319.92 |
| $Q^D$ | 1393830 | 294242.4 | 799078 | 1795089 |
| *Production* | 1911776 | 651611.2 | 799878 | 2740169 |
| *Export* | 517946 | 402138.8 | 800 | 1217277 |
| *Price Materials* | 125.43 | 43.023 | 63.37 | 208.38 |
| *Price Electricity & Fuel* | 98.34 | 41.869 | 50.06 | 185.82 |
| *Wage* | 132952.8 | 45893.94 | 79390.5 | 211595.3 |

**Table 2:**
Two stage least squares estimates of demand

| | Coefficient | Standard Error |
|---|---|---|
| $Q^D_t$ | -8.13E-04** | (3.61E-04) |
| $CB_t$ | -0.212 | (0.315) |
| $P_{t-1}$ | 0.543** | (0.265) |
| $Q^D_{t-1}$ | 6.98E-04** | (3.11E-04) |
| $CB_{t-1}$ | 0.347 | (0.308) |
| *CONST* | 224.330 | (151.100) |
| | | |
| *Adj.-*$R^2$ | 0.432 | |
| *Q1* | 1.020 | |
| *Q4* | 4.400 | |
| | | |
| $E_{PP}^{SR}$ | -0.455** | |
| $E_{PP}^{LR}$ | -1.468 | |
| | | |
| *Adjustment speed* $(1-\gamma)$ | 0.457* | (0.265) |

***/Significant on a 2.5% level **/ Significant on a 5% level */ Significant on a 10% level

**Table 3**:
Impact on Producer Surplus, Consumer Surplus, and Welfare (1000 NOK).

| | *1968* | *Accumulated 1955 to 1968* |
|---|---|---|
| **Cartel to Cournot Competition** | | |
| Producer surplus | -106 797 | -668 521 |
| Consumer surplus | 237 350 | 1 467 765 |
| Net Welfare Effect | 130 553 | 799 244 |
| | | |
| **Cartel to Monopoly** | | |
| Producer surplus | 47 891 | 189 032 |
| Consumer surplus | -36 760 | -285 157 |
| Net Welfare Effect | 11 131 | -96 125 |

**Figure 1**
The development in Norwegian cement production and consumption in the period 1955 to 1968

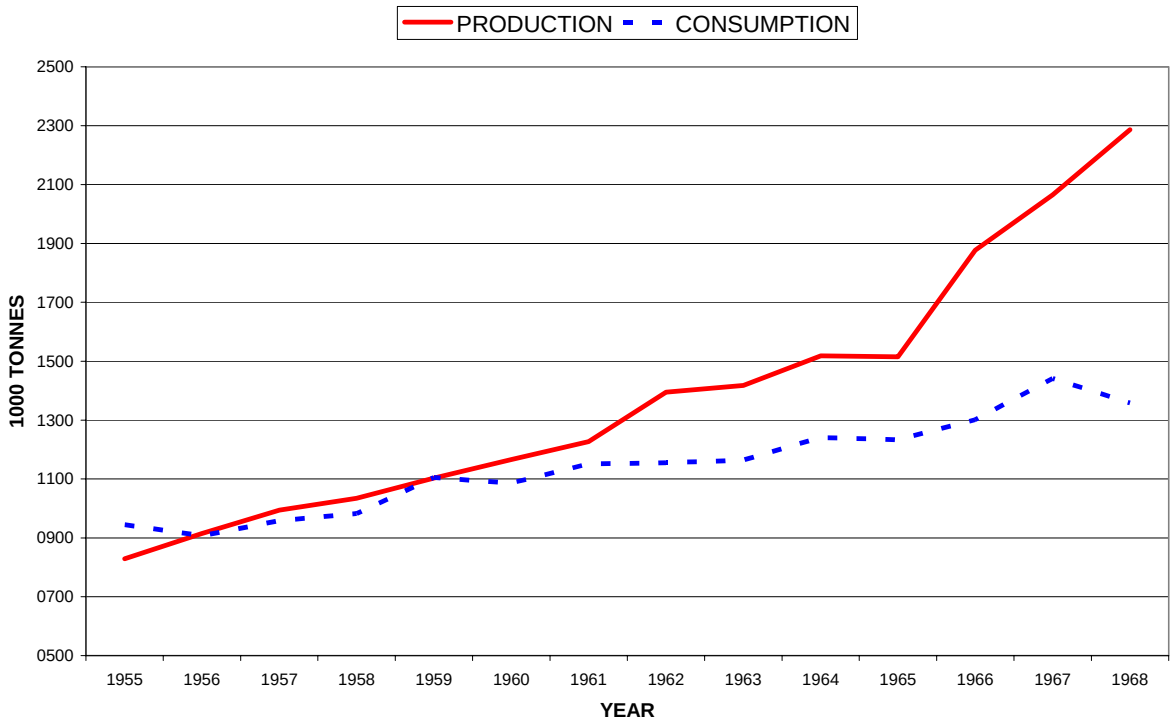

**Figure 2**
The expansion in European and Norwegian export

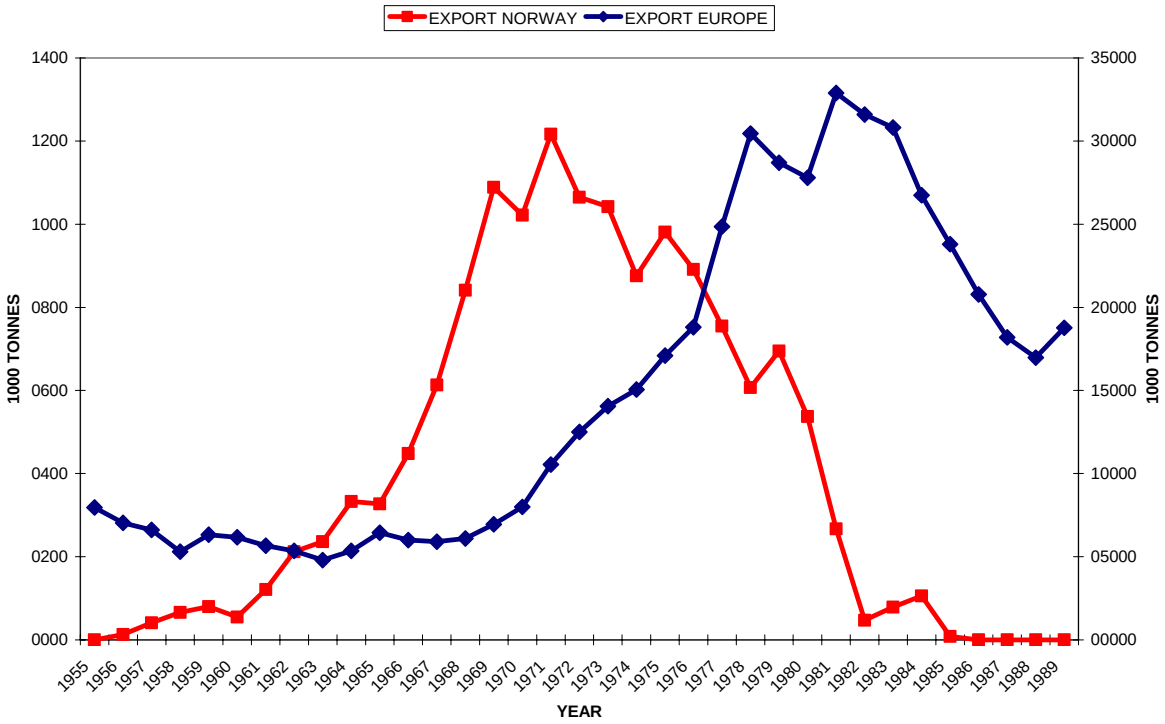

**Figure 3**
Welfare Analysis- Cartel and Monopoly

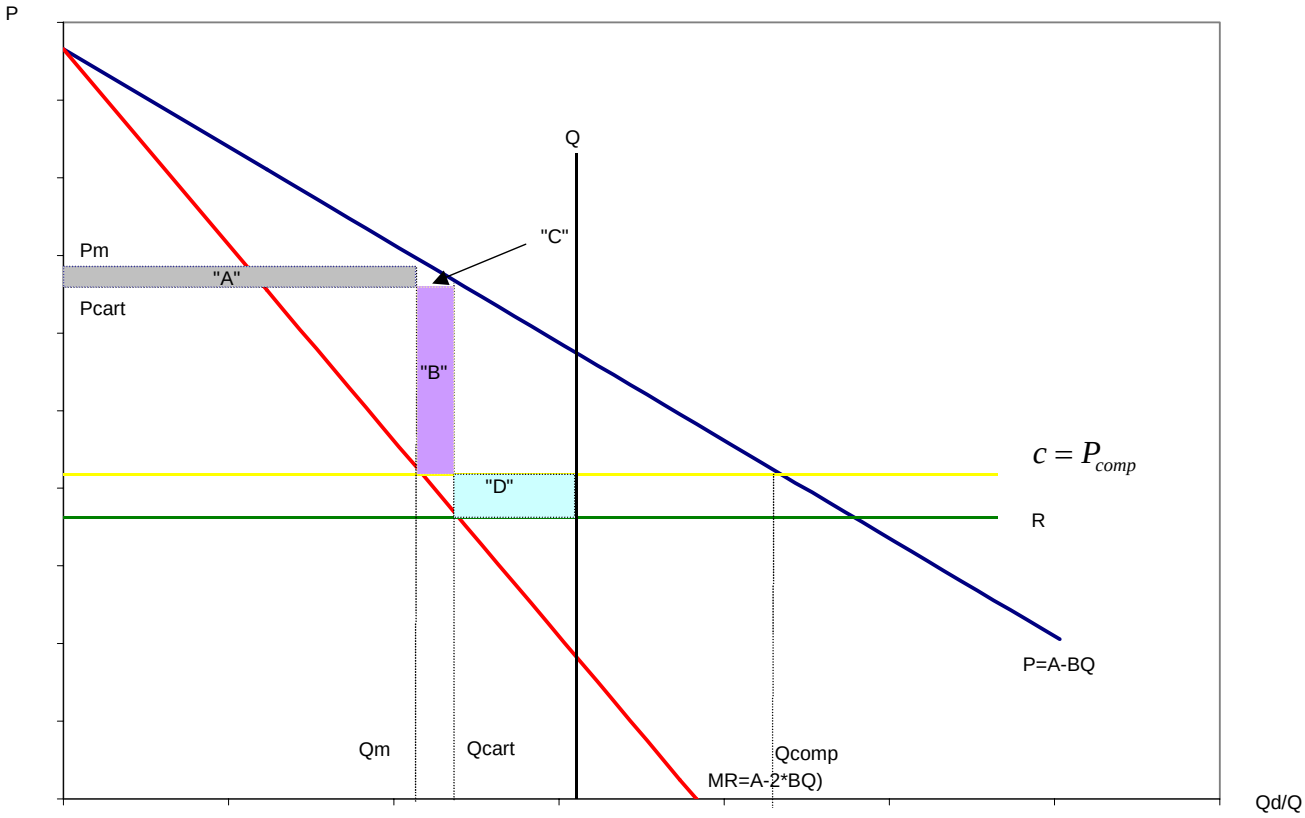

**Figure 4**

Consistency of predicted marginal Cost: Comparison of domestic price, export price and predicted marginal costs

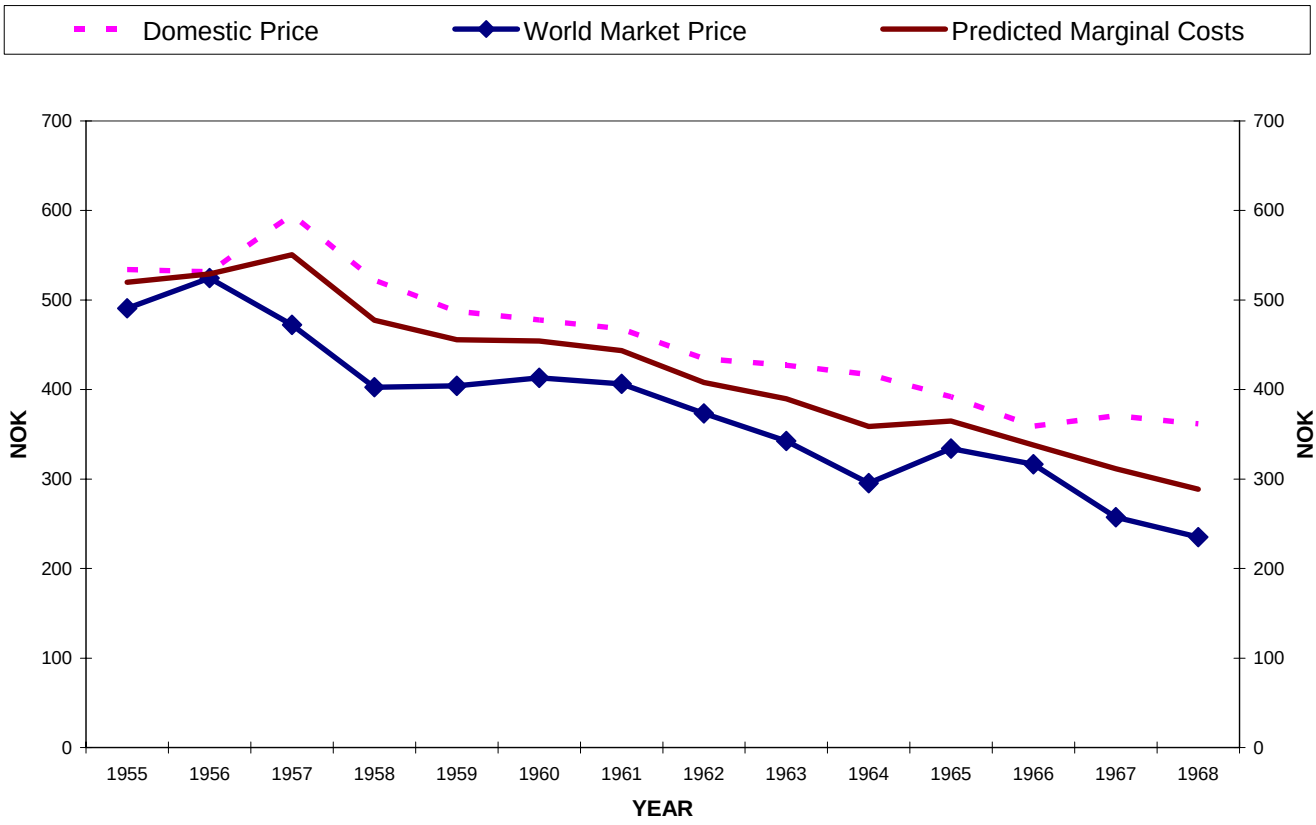

**Figure 5**
The development in the marginal cost predicted from the models first order conditions and the factor prices for the period 1955 to 1968 (all prices and MC as NOK per ton)

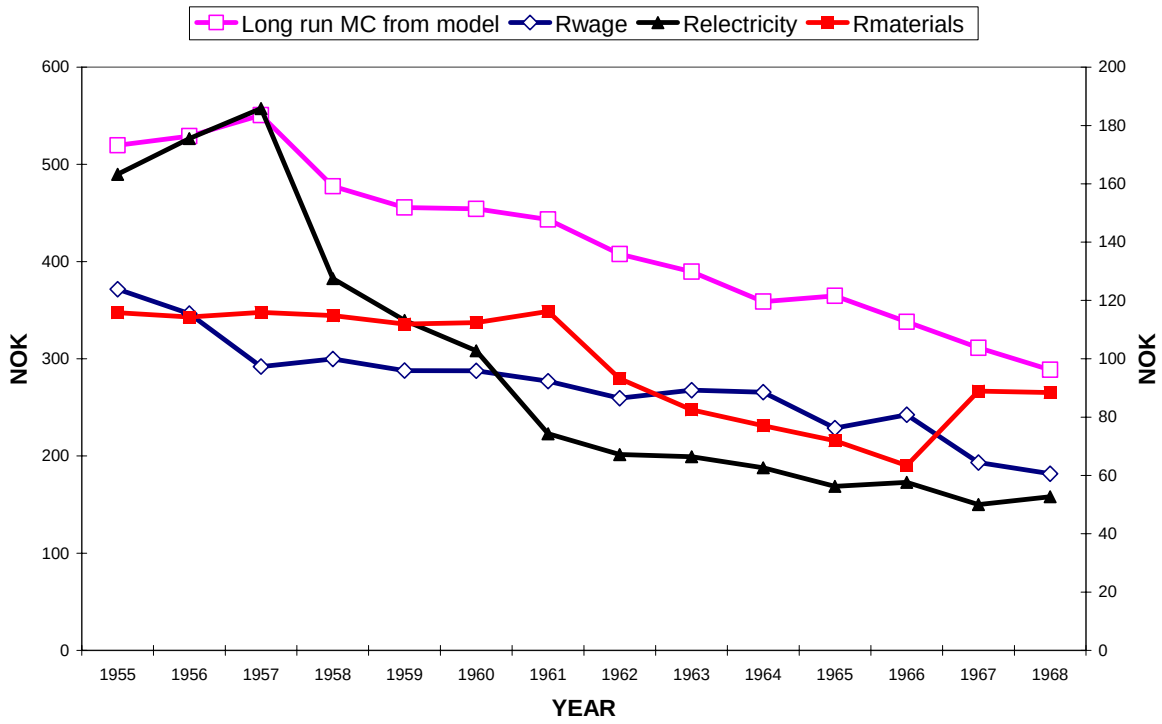

**Figure 6**

The development in the marginal cost predicted from the models first order conditions and the development in short run average costs (AC) from data for the period 1955 to 1968 (wage, electricity and fuel, and materials, all prices and MC as NOK per ton)

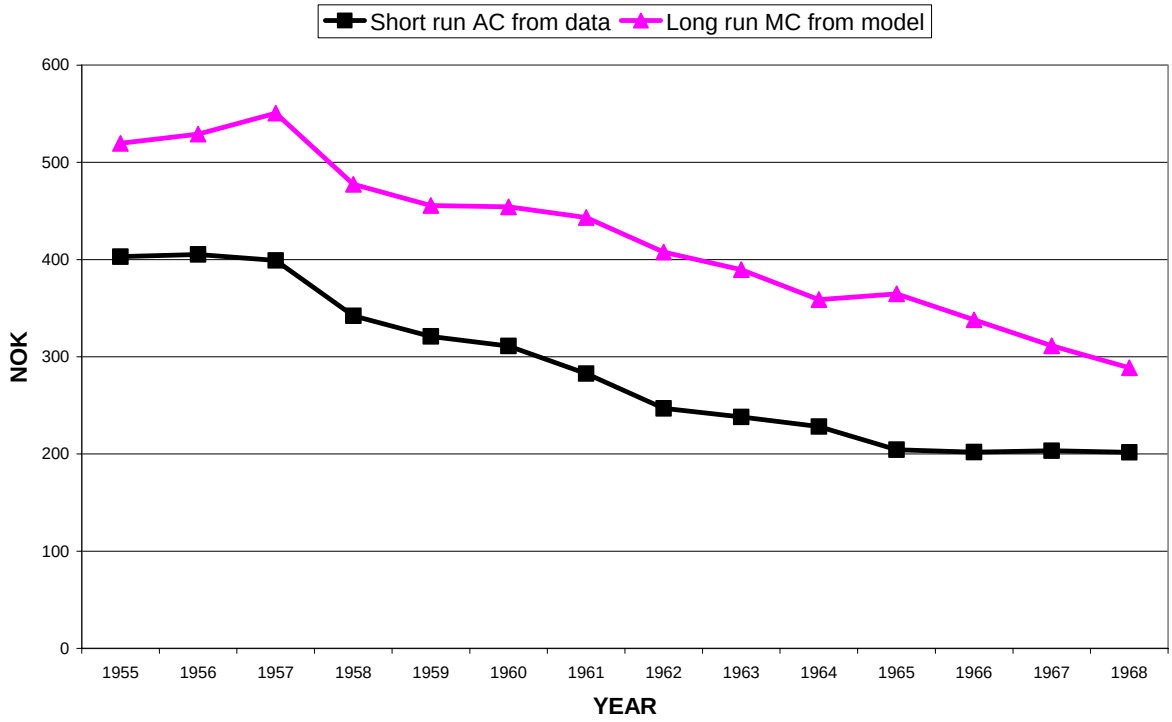

**Figure 7**
Impact of moving from a cartel to monopoly