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. We focus on the two problems that any cartel faces: deciding on domestic quantitiy as well as on the distribution of rents. Given data on prices, production, and exports, we are able to identify marginal costs as well as the effectiveness of the cartel. We find 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 livestocks, 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[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. 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 classical 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.

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

[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.

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*. In principle the cartel has two problems to solve: first, it needs to decide on the total amount of cement that is sold domestically. Second, the cartel has to decide 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 production (i.e. exports plus domestic sales). An important aspect of the cartel's sharing rule was that total production (or 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.

The sharing rule we focus on in this paper is rather common for cartels. For example, domestic cartels in several Japanese industries during the 50s and 60s used such capacity sharing rules. A more recent example is the Lysine cartel that operated in 1992-95. Other industries where production sharing rules are frequently found include agricultural cooperatives.

Following the institutional set-up for the Norwegian cement industry closely, we consider the two decisions any cartel must address. First, the cartel (through the common sales office) needs to decide on how much of total production to allocate to the domestic market. 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[4].

Second, each cartel member decides on how much capacity to install [5], taking the sharing rule into account, that is each member's domestic quota is based on the members share of total Norwegian production. 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) in order to increase their share of the domestic rent.

Given that exporting takes place in equilibrium (this will be tested below), the cartel's effectiveness will depend on the world market price. In particular, a lower world market price lowers domestic rents, since the cartel allocates more production to the domestic market. In other words, the domestic cartel gets closer to a non-cooperative outcome, to the benefit of domestic consumers. Overall industry profitability is ambiguous however,

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

[5]As we argue below, production is determined by capacities, since marginal production costs are relatively low. In other words firm's always find it optimal to produce up to their capacity.

as the impact on export profitability is ambiguous: when the world price decreases, less is exported, but the loss margin is higher. The overall impact on the cartel's effectiveness is an empirical question.

Another point is worth making at this time. Note that the two decisions faced by the cartel - domestic allocation and distribution of rents - are separable, due to the sharing rule. As long as there is exporting in equilibrium, the individual firm level capacity decisions do not impact on the decision by the common sales office to decide on the domestic allocation. In this sense, the institutional set-up allows us to simplify the analysis considerably. As we will see below this separability - due to an institutional fact - also allows us to identifying marginal costs.

The empirical objective of the paper is to investigated two issues. First, we would like to identify the cartel's effectiveness. Second, we are interested in comparing the impact of the cartel for three alternative market structures: non-cooperative Cournot, cartel, and a merger to monopoly.

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 is increasing over time, that is consumers benefit more (relative to monopoly), while producers are loosing both domestically as well as in the export market. In this sense it is consumers, not firms, that benefit from the sharing rule. Finally, 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! 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 is only second best.

The paper is organized as follows. First we present the Norwegian cement industry and the cement cartel. Then we discuss sharing rules more generally before we in Section 4 presents the model and its comparative statics. The empirical implementation and results are presented in section 5 and concluding remarks finalize the paper in section 6.

2 The Norwegian Cement Industry

The Norwegian cement cartel has several features that makes it interesting to use for understanding more about the workings of cartels. As we argued above, cartels are rare events in particular legal cartels (Bresnahan, 1989). The Norwegian cartel was legal and as a result considerable public information about the functioning and the institutional setting is available.[6] The industry is producing a homogenous product and shares many features with other cartels (not necessarily legal cartels), such as information meetings, domestic price fixing as well as an explicitly known market sharing rule. The Norwegian cement industry has been cartelized through the common sales office since 1923. The sales office determined the domestic sale and set quotas according to each firm's capacity. The residual production was exported at a given world market price.

As already discussed above, one of the issues this paper focuses on is how cartels distribute their rents. The Norwegian cartel used a sharing rule where the domestic market was divided according to each member's capacity. 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. The sharing rule can thus also be considered a production sharing rule[7]. As we discuss in the next section, this market sharing rule has been applied in several other cases.

In Norway, the first cement plant, A/S Christiania Portland Cementfabrikk, called CPC, was established in 1892.[8] At the end of World War I, three new plants were established in Norway: A/S Dalen Portland-Cementfabrikk (1916) (called DPC), CE-NO Portland Cement A/S (1917) and a firm in Northern Norway, Nordland Portland

[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]When the cement kilns first are installed they will be used up to their capacity. 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."*

[8]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 now, that constitute a frog leap compared to the older technology, with a capacity of more than 1 million tonnes per kiln was not installed in Norway before 1990.

Cementfabrikk A/S (1918) (called NPC). 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.

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 again 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.

After World War II the cement industry was regulated. The firms had to ask for permission to undertake capacity investments, and this regulation lasted until the mid 50s. The 1953 annual report for CPC, the largest domestic cement producer, states (p.14): '*...the negotiations about increased production capacity have still not succeeded...*'. However, the 1956 annual report states: '*As is well known, the Norwegian producers have maintained an agreement on market sharing, but two of the producers have in the post-war period not been able to exploit their quotas. These circumstances have now changed...'*.

In this paper we will focus on this large capacity built up after 1955. We will argue that this is due to "overproduction" stemming from the sharing rule and explore its implications for welfare. In principle, there may be other reasons for the observed capacity increase (see Steen and Sørgard (1999) for details). Amongst those are that the Norwegian producers built up such high capacity levels due to unrealistically high anticipation of increased future demand, or to deter entry. However, these explanations are unlikely to be responsible for the large built up.

In 1957 the CPC undertook a very comprehensive and detailed ten year forecast of Norwegian cement consumption (annual CPC-report 1958 pp.14-28). They included a number of different trends, e.g., fertility, householdsize, average number of rooms per house, building and construction trends, GNP, population growth etc. to make their ten year consumption projection. Comparing the forecast with realized demand, it turns out that the forecast's margin of error was always below 5%, except for 1959. The ten year forecast for 1967 (made in 1957), predicted a Norwegian consumption of 1 350 000 tonnes in 1967. In 1968 actual consumption was 1 358 000 tonnes! Hence, the industry's ability to predict future domestic demand was surprisingly good, suggesting that the lack of precise demand forecasts cannot be responsible for the dramatic capacity built

up. Regarding entry deterrence, incentives to deter entry were equally present in many European countries, without generating such a dramatic capacity built up. We therefore conclude that the incentives determined by the sharing rule is the most likely explanation for the large capacity investments.

3 Sharing rules in practice

The Norwegian cartel had very formal agreements with regard to the market sharing rule. This is illustrated in the 1964 annual report for CPC where we can read the following: *"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)[9]

The sharing rule we focus on in this paper is rather common for cartels. For example, 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 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.[10]

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 and much lower prices) in world market. Since the cooperatives usually cannot restrict their members production, the incentive structure is analogous to our set-up.[11]

[9]Data for each firm's annual production in the period 1913 to 1982 shows a very parallel development in production for all three firms in the cartel period. In particular, all three firms expand production substantially from 1955 on. This is consistent with a hypothesis where all three firms had the same incentives to expand capacity to have a large quota in the domestic market

[10]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).

[11]In several countries as e.g., Denmark, Finland, Sweden, France, Germany and Netherlands the

There are, of course, other sharing rules, most notably geographic market segmentation. However, geographic sharing rules are easier to enforce when transportation costs are high and transport easily detectable. Take, for instance, the so-called *heavylifter cartel,* where two firms owned all (six) heavy-lifter vessels in the world. In 1997 the two firms were accused of regional market sharing and price fixing. In this market, vessels are observable and the markets they operate in are far apart. It takes a vessel on the order of 40 days to move between the Mexican Gulf and the North Sea, making geographical market sharing easier to enforce. By contrast, once cement is loaded onto a boat or truck, it is relatively cheap to move.[12]

An additional complication for the geographic sharing rule exists when economic growth varies considerably across regions (e.g., NPC was located north and thereby in a less growing region). Since cement plant production is observable, it can be measured and the market can easily be divided. 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 such that the domestic cement industry can be characterized by a demand curve, $P(Q^D)$, where Q^D is the domestic quantity and P is the domestic price. In addition, we assume that the world market for cement is perfectly competitive, with a 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 has two problems to solve: first, it needs to decide on the total amount of domestically sold cement, Q^D. Second, the cartel has to decide 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

agricultural marketing cooperatives are explicitly exempt from some of the prohibitions that regulate other firms (Bergman, 1997).

[12]"*Cement, which is heavy and cheap, was transported in all directions throughout Norway.* [prior to the joint sales office was established in 1923]. *Cement from Slemmestad was for example sold in the Skien district, while that from Dalen was sold in large quantities round and about Oslo. In the same way cement from Kjøpsvik* [In the North] *was sent round the coast and sold as far as in Olso. All this was quite uneconomical, and it was therefore natural that the companies...*[formed the joint sales office and later included also the Northern firm] *...and shared the market so as to ensure efficient transportation*" (Annual report from NORCEM 1968 p.3-4)

view: the cartel decides to reward domestic market shares based on the members share of total Norwegian production (i.e. exports plus domestic sales).

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. The cartel does not restrict individual capacity decisions. In other words, firms decide on how much capacity to build non-cooperatively. 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. 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.

The Domestic Allocation Decision (The Common Sales Office) When setting domestic quantity, the cartel solves $\max_{Q^D} \sum \pi_i$. Assuming that $Q^D < \sum q_i$, we arrive at the following first-order condition for the domestic market allocation,

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

In words, the cartel allocates output to the domestic market until the marginal revenue in the domestic market equals the world market price.

There are a number of implications. Note that the cartel's decision to set domestic sales is not affected by the individual capacity decisions of firms (q_i) as long as capacity is high enough, i.e. $Q^D < \sum q_i$ such that there is exporting in equilibrium. Given that the individual capacity decisions have no impact on the cartel's domestic allocation decision our results are robust with respect to the timing of the two decisions. In particular, a sequential set-up where Q^D is decided after the q_i's, or the other way around, would not yield any different results.

A further implication of (1) is that the domestic and the foreign markets are interrelated through the world market price (R), which is the opportunity cost of not exporting, while the marginal cost of capacity (c) does not matter for the domestic market. Implicitly differentiating (1) it is straightforward to show that $\partial Q^D / \partial R < 0$. This implies that domestic consumers surplus is decreasing in R. Accordingly, the lower R, the lower the domestic price. In particular, when R is below c, a cartel finds it optimal to price below the domestic 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 domestic profits[13].

Moreover, 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 in the domestic market. Let q^C denote the firms' symmetric Cournot output defined by,

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

Then, 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, $(1/2)(a-R) > (N/(N+1))(a-c)$, where a is the demand intercept. As can be seen this condition can hold even for $N \to \infty$, which implies that a cartel is pricing at competitive levels. Overall, the conditions for when a cartel is more pro-competitive (in the sense of lower equilibrium prices) are: a low world market price (low R), a concentrated domestic market structure (low N), and high marginal cost of capacity (high c). We therefore find that a cartel using a production-based sharing rule may even result in lower domestic prices than a non-cooperative Cournot market. We will test whether this is the case in the empirical section below.

Overall, we find that the effectiveness of a cartel using a production-based sharing rule crucially depends on the relative magnitudes of R and c, as prices fall below monopoly prices when R is below c. In terms of welfare, the positive domestic welfare effects have to be traded-off against potential 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.

Firm's Capacity Decisions Firms decide on their individual capacity by solving $\pi_i = \max_{q_i} \left\{ P s_i Q^D - c q_i + R \cdot (q_i - s_i Q^D) \right\}$. The first-order condition is

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

where the last term, $R - c$, represents the marginal loss/gain from exporting. 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 installing more capacity (c) are below R for all

[13]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.

capacity levels, then (3) can never be satisfied and capacity investments tend towards infinity. To concentrate on interior solution we will assume that c is above R.

We have already seen that the impact of R on domestic profits is negative. By contrast, the impact of R on profits in the export market is ambiguous. To see this, 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. Recall that the loss from exporting (induced by the sharing rule) is given by $EL = (Q - Q^D)(c - R)$. Implicit differentiation yields $\partial EL/\partial R = \frac{\partial(Q-Q^D)}{\partial R}(c-R) - (Q-Q^D)$. The first term, which is positive, is the increase in loss from exporting due to the increase in exports. The second term, which is negative, is due to the increase in export price R.

In sum, we find that even though the impact of R on domestic profitability is positive, the effect on total profitability is ambiguous, while the impact on domestic consumer surplus decreases with R. This implies that a cartel using a production-based sharing rule leads to higher domestic consumer surplus, but the impact on profitability is ambiguous, relative to a monopoly.

This trade-off can also be represented graphically. We illustrate a cartel and monopoly equilibrium in Figure 1. 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- and producer surplus from moving from cartel to monopoly can now be illustrated. The loss in consumer surplus is given as the sum of the areas A and C. The difference in producer surplus is given by A minus B plus the saved export loss, D. The change in welfare is therefore given by D-B-C, which is ambiguous.

Given that the effectiveness of the cartel is theoretically ambiguous, we now turn to the data and evaluates the trade-off empirically.

5 Empirical Implementation

As is often the case in empirical studies of market behavior, we do 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).

Note that our identification of marginal costs rests on the existence of the cartel's sharing rule. We have already discussed this institutional fact above. Furthermore, identification depends on the assumption of Nash equilibrium in capacity choices, which produces an incentive to export. Below we will test this assumption by checking whether exporting takes place in equilibrium (one of our specification test). Finally, we assume that the domestic market is cartelized, i.e. that the Common Sales Office does its job properly.

5.1 Demand

While marginal costs are not needed for the estimation of the domestic market equilibrium (1)[14], 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,

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

where Z is an exogenous variable affecting domestic demand of cement. We use a Norwegian construction and building index (BC) as a Z variable and various cost shifters as instruments (see Appendix A for a detailed data description and summary statistics). Specification (5) 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

[14]Recall 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.

of habit formation in demand make static models inadequate (Lucas, 1967; Pollak and Wales, 1992).

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

The results for demand estimation are presented in Table 1. 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 indicating 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 the year there is relatively little scope for adjustment, whereas between years this scope increase substantially; new contracts can be negotiated and other building materials chosen.

5.2 Costs and Specification Tests

As already discussed, we can identify marginal costs from (3), due to the sharing rule, such that $c = (1 - s_i) \frac{Q^D}{Q} (P - R) + R$. Using the capacity incentives through 3 to identify marginal costs rests on the correct specification. In order to test our structure, we perform two specification tests.

The first test is based on $c > R$, which ensures an interior solution for (3). Figure 2 plots the computed 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, satisfying the specification test.

The second specification test is based on $Q^D < \sum q_i$, i.e. that there is exporting in equilibrium. This will be the case whenever firms find it optimal to install more capacity than Q^D. Substituting $Q = Q^D$ into (3) and using symmetry such that $q_i = Q^D/N$ and $s_i = 1/N$, yields

$$P \cdot (\frac{N-1}{N}) + R/N - c \tag{5}$$

That is, exporting in equilibrium takes place whenever (5)>0,which is the marginal incentive to export.[15] Consequently, we can use $5>0$ as a specification test for our model[16], which is given in Figure 2. As can be seen, the condition is met over the entire sample, which implies that our specification correctly predicts exporting to take place in equilibrium. Moreover, the incentive to export increases over the sample period. As we will see next, this has important welfare implications.

5.3 Welfare Analysis

Using our demand and cost estimates we first compare the cartel situation to that of a hypothetical merger to monopoly - assuming no adjustment costs. 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 $\beta_0^* = \frac{\beta_0}{1-\gamma}$.

Figure 3 takes our estimates, computes the monopoly equilibrium and compares moving from the cartel to a monopoly equilibrium for each of the years 1955 to 1968. As can be seen, the cartel is not effective at all. In particular, losses from exporting are very large by comparison with the losses in the domestic market (see Figure 3). Apparently, the sharing rule creates a considerable incentive problem, leading to significant overproduction and exporting below marginal costs.[17] 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. In this sense, the cartel's ineffectiveness is to the benefit of consumers.

[15] Inspecting the condition, we find that exporting occurs when the world market price R is high, the domestic market structure is not very concentrated (high N), and marginal production costs (c) are low.

[16] For completeness, we can also report the comparative statics with respect to c. Consumer surplus is unaffected, while domestic profitability is reduced when c increases. As before, the export market is subject to two opposing effects. Implicit differentiation of (3) yields that $\frac{\partial(Q-Q^D)}{\partial c} < 0$, that is exports are declining in c. We also have that $\partial EL/\partial c = \frac{\partial(Q-Q^D)}{\partial c}(c-R) + (Q-Q^D)$, where the first (negative) term is due to the reduction in exports, while the second (positive) term is due to the increase in c. In sum we find that the impact of c on cartel profitability is ambiguous, while domestic profitability is negatively effected. Domestic consumers are not effected by c.

[17] 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.

Figure 3 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.

Insofar our results suggest that the timing of the merger took place exactly 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. One possibility is that the Norwegian competition policy authority may have acted in the best interest of Norway. However, in 1968 Norway had no merger control, which was introduced only in 1988. Another explanation for the timing of the merger is that firm's losses were simply getting so large that political pressure to merge to monopoly was becoming decisive. Note that consumers are being hurt by the merger, and would be lobbying against the merger. Overall, our empirical estimates are consistent with the view that lobbying was efficient, insofar as the merger took place when the net benefit of consumers and firms was becoming positive.

The previous findings seem to suggests that the merger took place exactly at the welfare optimal time. However, this conclusion is premature, as it ignores the possibility of Cournot competition. Table 2 presents the comparison with Cournot competition for the year 1968, as well as the accumulated rents over the sample period 1955-1968.

As can be seen in Table 2, domestic consumers would have benefitted 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 other words, competition is first-best for consumers and the worst market outcome for firms. In terms of welfare, however, it is clear that Cournot competition is best.

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. In other words, 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).

Table 2 also reports estimates for the welfare loss due to this apparent public policy failure. 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 loose from the merger (some 37 million NOK, see Table 2 again), our model suggests that they would benefit 237 million NOK from competition in 1968 alone.

Table 2 also reports on the accumulated rents. As can be seen, the accumulated domestic welfare from moving from cartel to merger already in 1995 is negative (some 96 million NOK), which implies that a merger in 1955 would have not been desirable from a Norwegian point of view, if the alternative is to keep the cartel. If, however, the alternative is competition, then a break-up of the cartel in 1955 would have resulted in a welfare gain to Norway of some 799 million NOK (with some 1.5 billion NOK in benefits to the Norwegian consumers).

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 of competition is included. 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 classical 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 loosing both domestically as well as in the export market.

The domestic welfare implications of a merger to monopoly - which are theoretically 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 summary statistics of our data can be found in Table A1.

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 (W) 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 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.

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 A1 Summary Statistics for the main variables and the cost shifters for the period 1955 to 1968. (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 1:
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	0.457*	(0.265)

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

Table 2:
Impact on Producer Surplus, Consumer Surplus, and Welfare (1000 NOK).

	1968	*Accumulated 1955 to 1968*
Cartel to 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

Welfare Analysis- Cartel and Monopoly

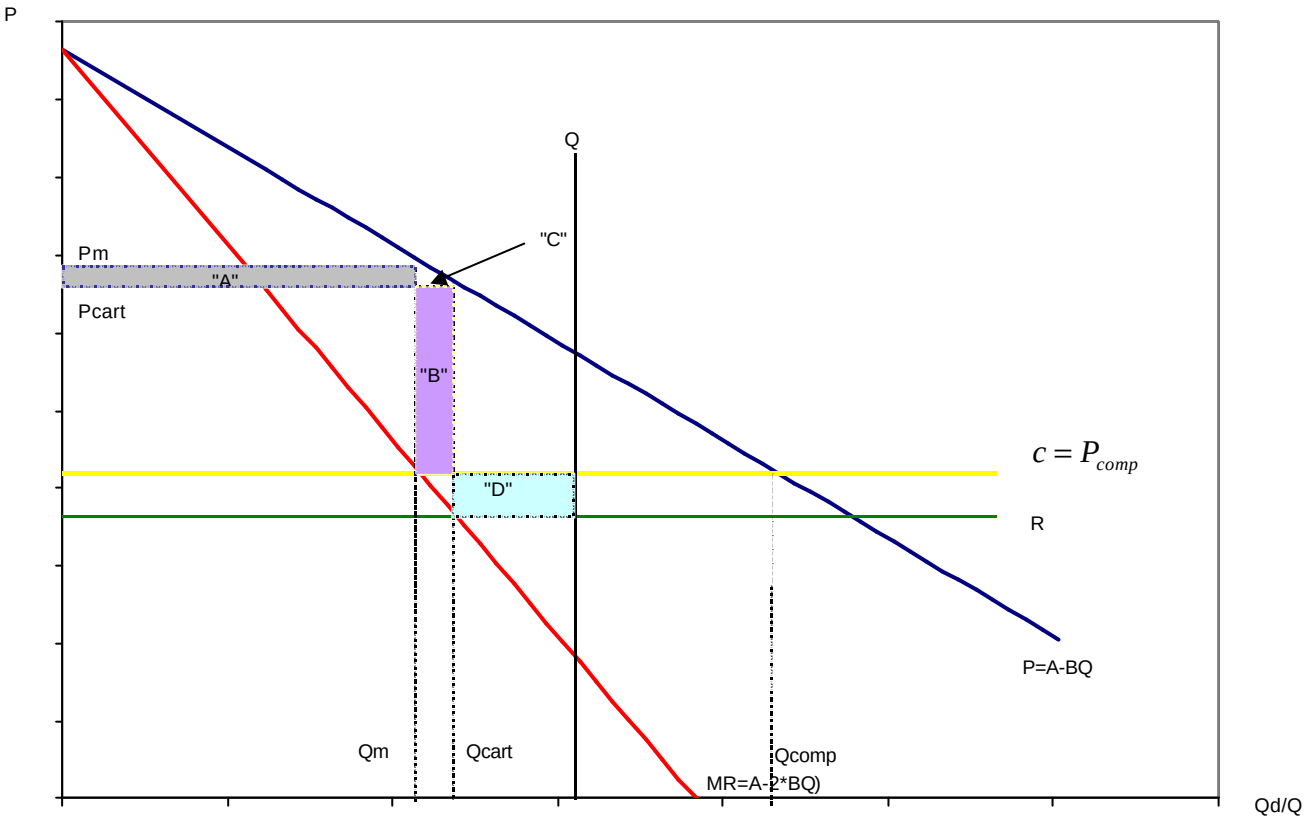

Figure 2 Specification Tests

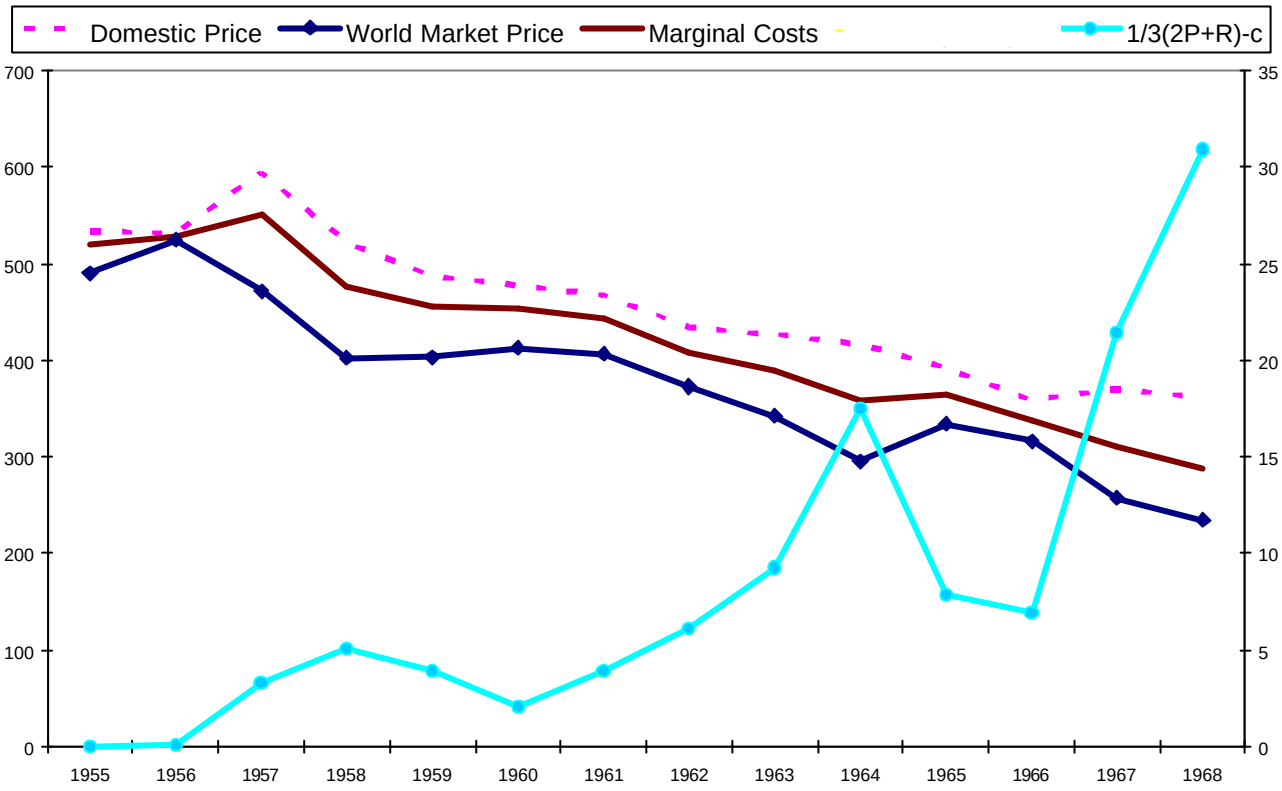

Figure 3
Impact of moving from a cartel to monopoly