ENTRY GAMES

— in —

THE NORWEGIAN CEMENT MARKET

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The origin of this thesis can be traced back to 1986, when I wrote my master thesis about strategic interaction in the Norwegian cement market. That study became substantially revised and extended in 1989, when I focused on the consequences for the Norwegian cement market of the internal market in EC. A substantial part of the work included in this thesis was initiated during the process of writing that last report at Centre for Research in Economics and Business Administration (SNF), where I was working until December 1989. The last three years I have been working at Norwegian Research Centre in Organization and Management (LOS-senteret), except for nine months in 1991 when I was a visiting scholar at Scandinavian Consortium for Organizational research (SCANCOR) at Stanford University. I am thankful to all three institutions for excellent working conditions.

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Chapter 1:

INTRODUCTION AND SUMMARY

> Econometric analysis certainly isn't the only way of doing empirical research in IO. Because of unsatisfactory data, many applied researchers are paying more attention to the development of evidence on firm and industry behaviour and performance through detailed case studies of firms or industries.
>
> Jean Tirole (1988), p. 4

1. The background

Industrial Organization (IO) has undergone a tremendous change the last 10-15 years. From the pioneering work by Joe Bain (see Bain 1956) and until the mid '70s IO literature was dominated by empirical studies. The single most important issue was to test the relationship between market structure, conduct and performance, assuming causality from structure to conduct to performance[1]. This was called the structure-conduct-performance paradigm. Regressions were run on cross-sectional data for a large sample of industries to test the theory. This traditional IO literature, however, often lacked a precise theoretical model (see Schmalensee 1989). In particular, it lacked a theoretical model for the firms' conduct, making testing of the causality troublesome.

A growing dissatisfaction with the structure-conduct-performance paradigm, as well as the introduction of noncooperative game theory, changed the IO literature dramatically from the mid '70s. The bias towards empirical studies disappeared, and the IO literature became instead heavily biased towards theory. Game theory has provided us with tools which suit well for analysing strategic interaction in a market. A large number of theories have been developed, and new textbooks with a game-theoretic foundation have been introduced, e.g.,

[1]Number of sellers, product differentiation, and cost structure are examples of market structure parameters; price and advertising are examples of conduct parameters; and price-cost margins and profit are examples of performance parameters.

Tirole (1988). Paradoxially, the rapid development of theory created its own problems. The large number of theories made it possible to explain almost every observation, and there would often exist competing theories that explained the same observation. There are few results that hold across a broad range of model specification. According to the modern theory of oligopoly, anything can happen. This made it natural to ask whether we in explaining everything have explained nothing (see Sutton 1991).

A natural response to such ambiguity is to focus on one industry for which we can tailor the theory. One way is to undertake econometric studies that reveal cost function, demand function, and behaviour. The last years we have seen numerous examples of this approach (for a survey, see Bresnahan 1989). In some industry studies the data are not detailed enough to provide us with any econometric results that are statistically significant. A rich case study with detailed firm and industry information might in such cases provide a more complete picture of the firms' strategies than what statistics about profits, advertising etc. can do[2].

The purpose of this thesis is to undertake a detailed case study of the strategic interaction in the Norwegian cement market. The main focus will be on the strategic interaction between the dominant firm, Norcem, and potential entrants. We formulate entry games that are tailored to fit the features in this market. In particular, we are careful about the specification of Norcem's alternatives for action. The derived equilibrium outcomes of these models are contrasted with the observed behaviour. Such a comparison makes it possible to discuss the firms' rationale for the observed behaviour. In addition, the specific models we construct are of general interest for cases where a high cost entrant plans to penetrate a market with a dominant incumbent that holds idle capacity.

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[2]This is the viewpoint of, among others, Jean Tirole in his IO textbook, see Tirole (1988), p. 4. In the strategic trade policy literature a similar kind of argument has been put forward: '... optimal trade and industrial policies are qualitatively sensitive to the nature of competition. .. This points to the importance and need for industry case studies in future research' (Cheng 1988, p. 757). The need for industry case studies is also stressed by Carl Shapiro: 'For the theory of business strategy ultimately to demonstrate its utility and stand the test of time, it must prove helpful in analyzing particular industries or identifying behavioral regularities that apply across industries' (Shapiro 1989b, p. 134).

2. Summary

In *chapter 2* we present facts about the cement market. The cement industry is a typical oligopolistic industry in many European countries, with a limited number of sellers in each domestic market and limited intra-European trade. The prices on cement to consumers in Norway, as well as in other Northern European countries, are more than twice as high as the prices on the international cement market where European cement producers trade cement. In Norway the domestic producer, Norcem, has a market share that exceeds 95 per cent. Viking Cement, a small importer in one part of Western Norway, is the only rival that have succeeded in permanently establishing itself.

How can we explain that Norcem has maintained its dominant position? It cannot be due to transportation costs alone, because the high price-cost margin in the Norwegian cement market far outweighs the transportation costs from the Continent to Norway. Norcem says that the reason for the limited intra-European trade is 'balance of deterrence between the producers'. It refers to the risk of retaliation if one producer starts exporting. However, Norcem's high market share is partly the outcome of its own actions. Its response to import penetration from Poland and East Germany in the early '80s was to purchase the exclusive rights to import cement from those two countries. The firm is a subsidiary of Aker, a corporation which is a dominant firm in the domestic construction and offshore industry. The demand for cement from the subsidiaries of Aker amounts to about one fifth of the total consumption of cement in Norway. In addition, Aker plus the Swedish firm Euroc is the fifth largest cement corporation in the world. The consortium trades cement internationally through Scancem Group Ltd., a subsidiary in Aker and Euroc, and has direct ownership in British cement industry. In addition, it had until recently direct ownership in Spanish cement industry as well. Scancem purchases cement from, among others, European producers. It has been suggested that the close links between the Scandinavian producers and the European cement market can explain why some potential importers of cement to Scandinavia have had difficulties in finding producers in Europe that can deliver cement.

2.1 Strategies: Some evidence and existing theories

The oligopolistic structure of this market makes it plausible that the firms' investments are influenced by strategic considerations, i.e., every firm anticipates its rivals' reactions to its own action and take this into account when decisions are made. In part II we therefore discuss strategic interaction between an incumbent and entrants. It is reasonable, however, to ask how conscious the actors are about their mutual interdependence. In *chapter 3* we analyse an internal Norcem report, written jointly by persons in Norcem and the Swedish cement producer Cementa, which presents scenarios for the Scandinavian cement market 1990-95. We contrast Norcem's way of thinking as stated in this internal report with the basic assumptions of a rational choice model. The findings are, not surprisingly, ambiguous. On one hand Norcem is forwardlooking, constructs distinctly different scenarios, and is well aware of rivals' and government's possible responses, and exploits its private information to put rivals' products at a disadvantage. On the other hand, the firm's judgement is in some cases biased, cost reductions are mentioned in some scenarios but not in others, i.e., not always cost minimization, and some of its planned public statements are apparently just idle talk, that is, they have no decision relevance.

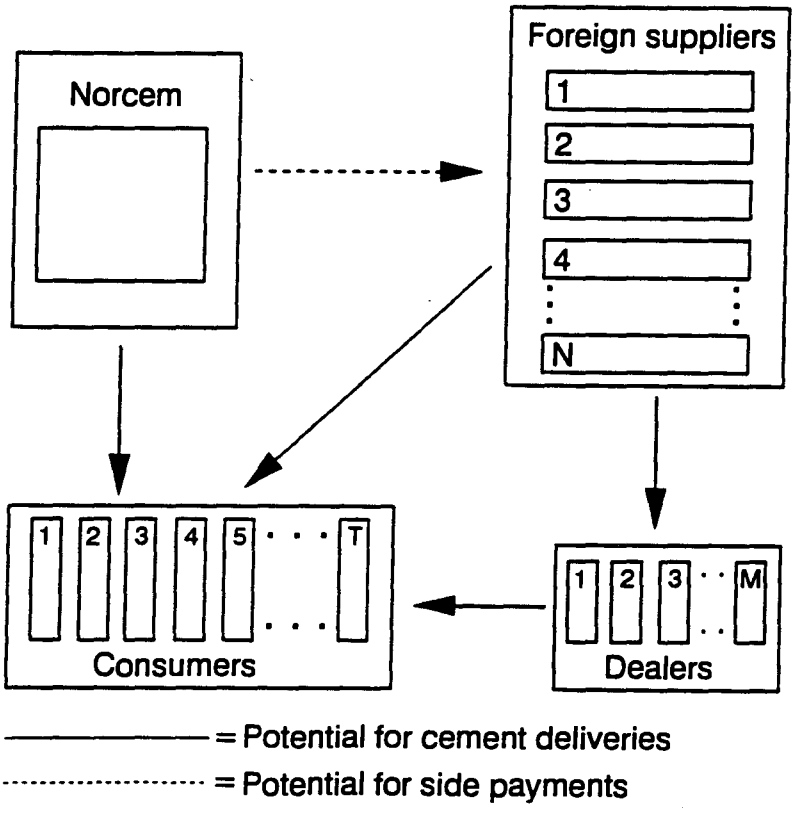
The fact that Norcem is conscious about rivals' reactions to its own action makes it natural that game theory be the theoretical foundation for our analysis. In *chapter 4* we present a survey of the game-theoretic literature concerning entry games, in particular discussing the role of undertaking investments that are credible commitments for the future. Our framework is the business taxonomy distinguishing between 4 different strategies, first introduced in Fudenberg and Tirole (1984) and Bulow et.al. (1985b). An important insight from this literature is that 'overinvestment', i.e., investing more than without any strategic considerations, may not be the optimal strategy for an incumbent (or an entrant). It could be that the incumbent should 'underinvest' in advertising to deter entry, or 'underinvest'in cost reductions to accommodate entry. The contributions in the literature are placed within the four strategies described in the business taxonomy.

2.2 High cost entrant: Models and applications

In part III, which is the main part of this study, we construct theoretical (and in some cases numerical) entry game models that are tailored to fit the characteristics of the Norwegian cement market. Three of the models analyse entry attempts in the past, while the fourth analyses a conceivable future entry game. In all four models the following assumptions are made:

A1: The entrant has higher marginal costs than the incumbent
A2: The incumbent holds idle capacity
A3: The firms are price setters (not quantity setters)

Figure 1.1 An outline of the strategic interaction in the Norwegian cement market

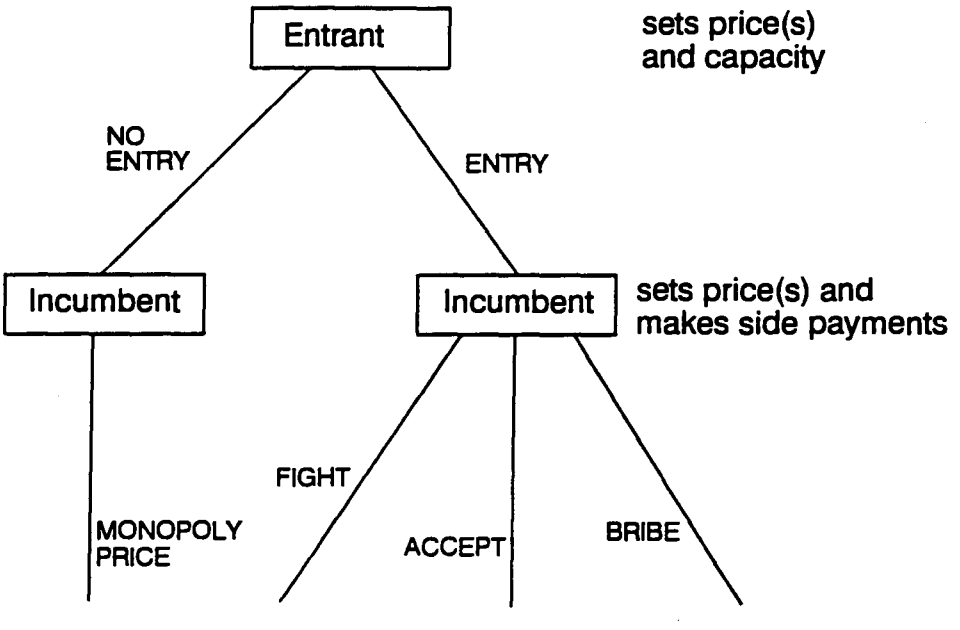


The rationale for A1 is that all entry attempts in the past take the form of import penetration, where the entrant has a disadvantage with respect to transportation costs. A2 is in line with observations during the '80s (except 85-88), and the expected situation for the '90s. A3

follows from the observation that firms in this market are providing price lists valid for a certain period of time and thus can be characterized as price setters. The entry games we will investigate are illustrated in Figure 1.1, which outlines the strategic interaction in the Norwegian cement market.

Buyers or consumers of cement can receive cement either from Norcem or from foreign suppliers. In the latter case a buyer can either start own import, or purchase cement from an importer, i.e., a cement dealer. Norcem can prevent all import by making side payments to the foreign suppliers, that is, 'bribe' the foreign producers. The signing of long term, explicit contracts for exclusive rights to import from Poland and East Germany are two examples of such side payments. We assume that Norcem can bribe only foreign suppliers, not domestic importers or consumers. This is because the Norwegian anti trust authorities have a tradition of intervening against anticompetitive action by Norcem in the domestic market, while it has, for unknown reasons, not banned Norcem's exclusive agreements with foreign producers. A general picture of the sequence of moves and the response alternatives in the basic entry game model is shown in Figure 1.2.

Figure 1.2 The basic entry game model



In the basic entry game model, the entrant has a first mover advantage. He sets price and capacity at stage 1, and the incumbent responds at stage 2 in one out of three ways: accept entry and maximize profits from residual demand (ACCEPT); match the entrant's price and thus prevent all import (FIGHT); compensate the foreign producers for the profit loss from no deliveries, so they have incentives not to export to the incumbent's home market (BRIBE).

We distinguish between two types of entrants. The first type is called a consumer, and is a large buyer who undertakes a sunk investment in a silo terminal which enables him to import directly, i.e., second sourcing. The 'consumer' will typically be a construction firm, for which cement is one important input to production. The second type is called a dealer, and it is a firm that imports from a foreign supplier and is a rival to the domestic incumbent. It is an independently owned company that undertakes a sunk investment - the silo terminal - and receives cement from a foreign supplier.

Table 1.1 The main differences between the specific models

	Chapter			
	5	6	7	8
Incumbent can bribe foreign producers as a response to entry?	YES	NO	NO	NO
Incumbent can invest in cost reductions before entry?	NO	YES	NO	NO
Incumbent has a high and a low quality product?	NO	NO	YES	NO
Prices are set simultaneously for an infinite number of periods?	NO	NO	NO	YES
Prices are set sequentially and once and for all?	YES	YES	YES	NO

In chapter 5, we compare the two types of entrants. In the remaining chapters in part III (chapter 6-8) we focus on the type called 'dealer', and analyse more in detail what will happen if some of the assumptions in chapter 5 are relaxed. In chapter 6, we analyse what happens if the incumbent is allowed to preempt the entrant, in particular invest in cost

reductions. In chapter 7, we extend the model from a single product to a multi product model, assuming that the incumbent produces both a high quality and a low quality product initially and the entrant penetrates the low quality segment. In chapter 8, we construct a dynamic model (a repeated price setting game), and thus relax the price commitment and sequential price setting assumptions.

2.2.1 A consumer as an entrant

In *chapter 5*, we assume that the incumbent has all three response alternatives to entry: accept, bribe, and fight. The main purpose of the chapter is to focus on the distinction between an entrant that is in fact an established consumer of the incumbent's product (called a 'consumer'), and an entrant that sells to the same customers as the incumbent (called a 'dealer'). The consumer will, in contrast to the dealer, welcome price cutting as a response to entry, because his only concern is to ensure a low input price. The consumer has therefore no reason to limit his capacity and set a low output price, as Gelman and Salop (1983) have shown that the dealer must do to avoid triggering off price cutting as a response to entry. The 'low' output price makes it costly for the incumbent to match the dealer's output price, while the 'limited' capacity limits the incumbent's loss from accommodating the entrant. The predictions from the theoretical model is consistent with observations in the Norwegian cement market. A 'dealer' that entered in the early '80s restricted his supply and set a low output price. A 'consumer' that entered in 1990 by installing a silo terminal for receiving imported cement triggered off price cuts. It closed down its silo terminal less than two years later, and signed a long term contract with the domestic monopolist for cement deliveries.

Another feature in the Norwegian cement market is the fact that the incumbent has purchased the exclusive right to import from foreign producers and has thus cut off some of the entrants' potential sources for input supplies. The theoretical model predicts that an entrant that imports from a foreign producer will accept a 'high' input price. This will make a purchase of the exclusive right to import from foreign producers unprofitable for the incumbent, and thus ensure that the entrant's input supplies is not cut off. Both types of

entrants that were observed in the Norwegian cement market in fact accepted a high import price compared to the international price of cement.

In addition, we have shown that if regional price cuts are banned, which was the case in the Norwegian cement market in the mid eighties, this might increase the consumer's input price. Price cutting will become less profitable for the incumbent, because he will lose profit nationwide. The consumer has to accept a high input price in order to prevent the incumbent from bribing foreign producers to stop deliveries. The dealer, on the other hand, will be better off. Fighting is made less profitable for the incumbent, and the dealer can exploit this by, for example, increasing his capacity.

In the last few years the Norwegian Price Directorate has gradually changed its policy by not only allowing regional price cuts, but also by allowing signing of contracts between Norcem and some of its consumers. This suggests that in the future it is less likely that a consumer will install a silo terminal, as done by the consumer in the past. The consumer and Norcem can now bargain in advance of the investment, and the incumbent has the option to price discriminate. If so, the large consumers can face a lower price from the incumbent, the consumers' sunk investment can be prevented and so also the import of cement at a higher price than the domestic incumbent's marginal costs. Consequently, by allowing the incumbent firm to price discriminate the domestic welfare can increase.

2.2.2 The incumbent's choice of technology

In *chapter 6*, a joint work with Steinar Vagstad, we focus on the incumbent's strategic decisions before entry. In particular, we analyse the incumbent's investment in marginal costs reduction before a 'dealer' decides to enter, assuming that the incumbent's response to entry is either to accept entry or to match the entrant's price. We construct a model where the high cost entrant, in accordance with the preceding chapter and Gelman and Salop (1983), limits his capacity and sets a low price to ensure a friendly welcome. If the incumbent had no first mover advantage, i.e., the incumbent's marginal cost and the entrant's price and capacity was set simultaneously, we show that there would exist no equilibrium in

pure strategies. This illustrates that the results in Gelman and Salop (1983) are sensitive to an extension of their model.

We have compared the case of accommodation with the monopoly equilibrium. We have distinguished between a cost effect and a strategic effect. Without any strategic considerations, how should the incumbent invest to minimize costs in the post entry equilibrium (cost effect)? How should the incumbent invest to soften the entrant (strategic effect)? We have shown analytically that an increase in marginal costs will reduce total costs when entry has taken place. Put differently, cost considerations instruct the incumbent not to invest in lower marginal costs when accommodating entry.

Intuitively, we expect that a lower marginal cost will soften the entrant. We can, however, only prove analytically that this is the case if the entrant has a cost advantage, i.e., the entrant's marginal cost is lower than the incumbent's marginal costs. The reason for a possible counter-intuitive sign of the strategic effect is that the entrant can respond by reducing his price and increasing his capacity. Such a response to the incumbent's investment will reduce the incumbent's profit from accommodating entry, and the incumbent will thus be better off if he does not invest in a reduction in marginal costs. Results from numerical simulations suggest that even if the entrant has a cost disadvantage, a reduction in marginal costs will soften the entrant, i.e., induce him to set a lower capacity than what he else would have done.

Results from the simulations suggest that the strategic effect wipes out the cost effect. If so, the optimal accommodation technology has higher fixed costs and lower variable costs than the optimal monopoly technology. If entry is not blockaded when the incumbent has the monopoly technology, we have shown analytically that the incumbent has to choose a technology with lower marginal costs to deter entry.

In an extended version of our model we have shown another reason why the incumbent should invest in cost reduction when facing an entry threat. If the owner sets a certain profit goal the manager must achieve to receive a high payment (low payment otherwise), the

manager will invest in cost reduction when facing entry simply to maintain the firm's profitability and thereby maintain his own high payment.

Our specific entry game was motivated by some characteristics of the Norwegian cement market. It is reasonable to ask what was the main driving force behind Norcem's investment in cost reductions during the '80s. Was the driving force strategic considerations as highlighted in the basic version of our model, or was the driving force to maintain profitability as highlighted in the extended version of our model? The information we have, which is a combination of official statements, internal reports etc., suggests that both motives had importance.

2.2.3 A multiproduct incumbent

In *chapter 7*, the focus is shifted from the past to the future. The internal report we describe in chapter 3 shows in detail what Norcem expects to happen in the '90s. One important aspect is the standardisation for cement for all EC and EFTA countries, which will come into effect in the early '90s. Such a common standard, called CEN-standard, is expected to be less restrictive than the Norwegian standard for cement at present. It is likely that this will result in a high and a low quality segment of cement in Norway. In the high quality segment, which consists of e.g. cement used for construction of large buildings, strength requirements will exceed the CEN-standard. According to Norcem, there will probably be no imports to the high quality segment. The reason is that Norcem, the domestic producer, is closer to the market and is able to 'tailor' the quality to each customer's need.

In the low quality segment, the CEN-standard requirements are sufficient and will define a minimum quality. Norcem expects that importers therefore can mimic their quality in this market segment, which will increase the prospects for imports of low quality cement to Norway. We ask what might happen if imports of low quality cement takes place. In the model it is assumed that the incumbent initially is a monopolist in both a high and a low quality segment initially, and that an entrant, which is a 'dealer' according to our terminology, penetrates the low quality segment. The entrant sets capacity and price in the

low quality segment, the incumbent observes this and set his prices in both segments. The incumbent's response alternatives are thus either to set a high price (accept) or set a low price (fight). As shown in Gelman and Salop (1983), the optimal strategy for the entrant is to limit his capacity and set a low output price.

In contrast to the results for the single product case reported in Gelman and Salop (1983), we show that the incumbent in some cases will have an incentive to raise his prices as a response to such an entry. Some of the customers that the entrant captures did initially buy the incumbent's high quality product, and the loss of their demand can change the incumbent's own and cross price elasticities in the high quality segment. The price change in the high quality segment will induce the incumbent to change his price in the low quality segment in the same direction.

We construct a numerical model with both data and behavioural assumptions based on information about the Norwegian cement market. Our simulations show that the entrant's optimal capacity is very sensitive to some of the assumptions, in particular those concerning the length of the fighting period and Norcem's discount rate. The simulations indicate that as long as no rent seeking takes place, as is the assumption used in most trade policy literature, entry will reduce domestic welfare. The modest enlargement of the market results in only a minor reduction in dead weight loss, and the incumbent's price change due to entry is minor and can even be positive (increased price). According to our simulations, this modest gain for the consumers is wiped out by the domestic incumbent's profit loss. Assuming no rent seeking, the optimal public policy would be to use a domestic production subsidy to deter entry. If entry is allowed, domestic welfare might be improved if the government supports resale of the entrant's quantity. The reason is that the entrant's quantity then will be efficiently rationed, and the incumbent would have an incentive to lower his post entry price.

2.2.4 Capacity limitation and collusion

Throughout chapter 5-7 we assume that (1) prices are set sequentially and (2) once and for all. In *chapter 8* we relax these assumptions, analysing entry by a 'dealer' and assuming the incumbent's response alternative 'bribing' is ruled out. The entrant sets capacity before simultaneous price setting in an infinite number of periods. Our model has many similarities with the entry game in Benoit and Krishna (1991). In contrast to them, we assume that the incumbent holds idle capacity and that the entrant has a cost disadvantage. The main question is whether voluntary capacity limitation by the entrant makes sense in a dynamic setting.

Assuming an initial collusive outcome, how can the entrant facilitate collusion? We have shown that if deviation triggers off optimal punishment paths, a capacity limitation will neither facilitate nor violate the collusive outcome. The intuition for our result is that a capacity limitation by the entrant has two effects on the incumbent's incentive to support a collusive outcome, and those two effects work in opposite directions. On the one hand, a capacity increase by the entrant will reduce the entrant's profit in the collusive outcome. On the other hand, a capacity increase will reduce the incumbent's profit in the non-collusive outcome. The latter effect will induce him to maintain the collusive outcome, while the former effect will induce him to deviate. We have shown that the former effect exactly wipes out the latter effect, so that voluntary capacity limitation by the entrant makes no sense if we assume optimal punishment paths with a stick and a carrot structure.

However, capacity limitation by the entrant makes sense if deviation triggers off single-period Nash equilibrium for infinity. The reason is that a capacity increase by the entrant will have no effect on the incumbent's profit in the non-collusive outcome, and thus have no effect on the punishment towards the incumbent if he deviates. Because of this, the incumbent has no reason to let the entrant's market share in the collusive outcome increase when the entrant increases his capacity. Entrant's capacity increase will thus have no effect on entrant's income. This is true when the entrant's capacity is so large that the Nash equilibrium is in pure strategies, and thus instructs the entrant not to expand his capacity beyond a certain

level. Consequently, our results are in line with the results in the static model in Gelman and Salop (1983) and the dynamic model in Maskin and Tirole (1985) with alternating price setting only if we assume trigger strategies.

The basic mechanism of a repeated game is that a deviation from an ongoing path will trigger off retaliation, and this might deter a firm from deviating. We have information that suggests that the way of thinking in the cement market is influenced by such stategic considerations. When Norcem was asked to explain the limited intra-European trade, it replied that the reason is 'the balance of deterrence between the producers'. This refers to the risk of retaliation if one producer starts exporting. We have shown that Viking Cement's voluntary restriction on its supply, which the firm said was done 'for fear of Norcem', will make sense in such a dynamic context only if the firms have trigger strategies. Unfortunately, we have not inside information that is detailed enough to answer whether the firms deliberately behaved in accordance with trigger strategies.

In contrast to the results from the single-period model, the entrant need not set a low price in the collusive outcome we have specified in our dynamic game in chapter 8. The reason is that price is not a commitment, and the entrant has the option to cut prices later on if that is needed. However, the conclusion in chapter 7, that entry probably will reduce domestic welfare, will not change. Indeed, it becomes even less likely that import penetration improves domestic welfare. Entry will have no or only a limited effect on prices. The consumers gain from import penetration will thus probably be negligible, while the domestic incumbent firm will lose profit to a foreign producer.

3. Some final remarks

Although this primarily is a detailed case study of entry in the Norwegian cement market, the analysis should also be applicable to cases where a high cost entrant plans to penetrate a market where the single dominant incumbent holds idle capacity and where the firms are price setters. The analysis in chapter 8 of the rationale for an entrant voluntarily limiting its own capacity, and the advantage of a consumer as an entrant compared to an ordinary entrant

(see chapter 5), are both results of general interest[3]. Results from theoretical models are sensitive to behavioral assumptions, such as the sequence of moves and the set of options for action. At some point in a detailed case study we are ineluctably forced to take into account the specific characteristics of the particular industry. An example of such 'tailoring' of the theory in our case study, is when we combine a consumer as an entrant with the possibility that the incumbent can bribe foreign producers not to deliver to the consumer (see chapter 5).

Although we 'tailor' the theory to a particular context, no theory is ever going to encompass all the complexity in the real world. The aim of theorizing should thus be to find fruitful simplifications and abstractions. Constructing a formal model where we specify assumptions explicitly, makes it possible to deduce in a consistent manner which decision would have been made if the decision maker was governed purely by the economic incentives encompassed in the formal model. This helps us to push intuition into slightly more complex contexts, and discloses some effects that we failed to see through in advance. Examples from our study are that an incumbent's best accommodation of entry can be to invest less in a reduction in marginal costs (see chapter 6), his best response to entry can be to raise his price (see chapter 7), and that a voluntary capacity limitation by an entrant makes sense in a dynamic setting if there are trigger strategies but not if there are optimal punishment paths (see chapter 8). While the systematic effects which are the central idea of the rational choice model might predict quite well the behaviour on average, it might fail to explain specific decisions. This is a good reason to acknowledge the limitations of the rational choice theory when studying a particular case, and use this theory only as a first approximation for

[3]For example, the analysis in chapter 8 is relevant for understanding entry into the US phosporus industry in the early 1990. The incumbent firms did not respond to entry by cutting prices. According to Benoit and Krishna (1991), the large amount of idle capacity implied that the equilibrium price in the non-collusive outcome was low and this deterred the incumbent firms from cutting prices. Our model in chapter 8 suggests another, complementary argument for why the incumbent firms did not respond by price cutting. The entrant's limited capacity, only 10 per cent of the market, limited the incumbents' loss from accommodation. While Benoit and Krishna (1991) emphasizes how idle industry in the industry could make price cutting as a response to entry unattractive for the incumbent firms, our model thus emphasizes how capacity limitation by the entrant could make collusion more attractive for the incumbent firms.

discussing why things went this way rather than that.

Acknowledging the limitations of each model, how can one gain further insight? By comparing the derived equilibrium outcomes of different models that analyse different aspects of one specific case, one can have a more complete picture of what is going on in that particular case. For example, the static model in chapter 5 with sequential price setting and the dynamic model in chapter 8 with simultaneous price setting can jointly shed light on the entry strategy of Viking Cement in 1983, who set a 'low' price and a 'limited' capacity. A low price makes sense if there are price rigidities and the incumbent has a pioneering brand advantage (from chapter 5). The voluntary capacity limitation is the crucial element of the entry strategy even if prices are totally flexible and products are identical, but only if the firms follows trigger strategies (from chapter 8).

Chapter 2:

THE CEMENT MARKET

In this chapter we will briefly describe the main characteristics of the European cement market in general, and the Norwegian cement market in particular. In section 1 we describe the product and the production process, reporting empirical estimates of minimum optimal scale. Some characteristics of the European cement market are described in section 2, in particular, capacity utilization, seller concentration and prices. The Norwegian cement market is described in section 3. We report data for sales and imports, and we discuss the costs of production and transportation as well. In section 4, we sum up the information, arguing that the Norwegian cement market can be characterized as a market where a single dominant firm faces a threat of entry.

1. The product and production process

Cement is a mineral that forms a strong mass when it reacts with water. In the first half of the last century a chemical process was invented that produced a material with characteristics similar to those of natural cement. This material was Portland cement. By far the most important factor influencing demand for cement is the construction industry, which uses cement largely in the form of concrete products. There are large differences in per capita consumption of cement. Among other things, the level of urbanization, building traditions, and climate influence per capita consumption (see Bianchi 1982).

Portland cement is produced from limestone, cement rock, clay, and iron ore in four major phases. The critical process is the operation of the kiln, where the mixture of materials is heated so it transforms to the new material clinker. The final step in the production process is to grind the clinker and mix it with small amounts of gypsum.

There are two quite different production processes that are in use. In a wet process the raw materials are blended together with water before feeding it into the kiln, while in the dry process no water is added. The dry process uses less fuel in the kiln, is easier to proportion,

but is more difficult to achieve uniformity in the blending process.

The production process employs a technology based primarely on the use of tubes (kilns, grinders, etc.). The capacity of a tube is related to volume, while the cost of building such a machine is related to the surface area. From physics we know that a 1 per cent increase in volume is brought about with a 2/3 per cent increase in surface area. McBride (1981) finds support for this 'two-thirds' rule when estimating the capital cost for building a kiln, estimating the elasticity of the unit cost of production with respect to capital to be approximately 2/3. In addition to capital, studies indicate that labour inputs will bring about economies of scale as well (see Norman 1979). The reason is that some of the labour input is the supervisory labour that is invariant to the produced quantity. Other inputs exhibit constant returns to scale. The fact that the economies of scale is primarely a result of the capital cost indicates that the short run marginal costs are constant. Empirical studies, however, are ambiguous (see McBride 1981).

Table 2.1 Estimates of Minimum Optimal Scale in Cement Production

Study	Years Covered	Min. opt. scale	Country
Loescher (1959)	1949	242'-347'	USA
Weiss (1964)	1939-53	263'	USA
Bain (1956)	1955	367'-470'	USA
Battara (1965)	1960	300'	Italy
Allen (1971)	1965	611'	USA
Weiss (1968)	1966	1.128'-1.504'	UK
Scherer et.al. (1975)	1965	1.200'	USA
Norman (1979)	1960-71	1.600'	UK
Pratten (1971)	1970	2.000'	UK
Carlsson (1978)	1970-75	600'-800' (wet) 1.000' (dry)	US/Sweden
Schwalbach (1984)	1972	1.000	West Germany
Schwalbach (1988)	1982	1.3	West Germany

Source: Bianchi (1982), Table 1.1, and Schwalbach (1988).

In Table 2.1 we have reported several studies of the minimum optimal scale. These studies

indicate that the minimum optimal scale has been increasing over time, from an output of approximately 300.000 tons annually in the early fifthies to about one million tons (or more) in the '70s and early '80s. One reason for the gradual increase in minimum optimal scale is the transformation from wet to dry process. The latter is said to have a higher minimum optimal scale (see Carlsson 1978).

2. The European cement industry

The intra-European trade of cement is very limited. In 1985, no countries in Western Europe except for the Netherlands imported a quantity that exceeded 7 per cent of their domestic consumption (Cembureau 1986).

2.1 Capacity and seller concentration

From Table 2.2 we see that the four countries Italy, Spain, France and West Germany are the largest producers of cement in Western Europe.

Table 2.2 Production and Capacity Utilization in 1985 and 1989 (Million tons of cement)

	Production		Capacity Utilization	
	1985	1989	1985	1989
Italy	37.3	40.5	69%	69%
Spain	24.1	28.2	58%	71%
France	23.5	26.8	70%	78%
West Germany	22.9	26.5	55%	n.a.
Greece	13.5	12.4	82%	81%
Great Britain	13.4	15.7	91%	n.a.
Portugal	5.4	6.7	64%	81%
Sweden	2.1	2.3	87%	86%
Finland	1.6	1.6	76%	74%
Denmark	1.4	1.6	60%	64%

Source: Cembureau (1986), (1989-1990).

The total idle capacity in those four countries was 60 million tons in 1985, which equals 1/3 of the total consumption of cement in Western Europe in that year (see Cembureau 1986). During the second half of the '80s the consumption of cement increased in Europe, and the excess capacity decreased in most countries (see Table 2.2 for 1989).

The seller concentration is high in domestic cement markets in Europe. In the countries Norway, Sweden, and Denmark one domestic producer has a market share in excess of 90 per cent, while the Finnish cement market is a de facto cartel consisting of two domestic producers. In Table 2.3 we have reported the three-firm concentration ratios (CR_3) in 1976, as well as the Herfindahls index for 1985. The de facto figures are the de jure figures adjusted for cement producers' direct ownership in other domestic cement producers that are reported in Cembureau 1987.

Table 2.3 Seller concentration in four countries in Western Europe

	CR_3 1976	Herfindahls index 1985	
		De jure	De facto
Italy	60.8	0.07	0.15
France	80.8	0.22	0.30
West Germany	48.0	0.11	0.11
United Kingdom	85.0	0.33	0.33

Source: Bianchi (1982), Table 2.2, and Cembureau (1987).
The CR_3 for 1976 is estimated from production figures, while the Herfindahls index for 1985 is estimated from capacity figures.

The seller concentration in Western Europe is in fact higher than reported in Table 2.3. First, each national market is divided into regional markets. These regional markets are to some extent divided natuarlly because of transportation costs, as the price wars that took place in North Rhein and Westphalia 1967-69 and 1973-75 but not in Southern Germany illustrate (see Bianchi 1982, Figure 6.3).

Second, several firms have direct ownership in other countries' cement firms. One example is the Swiss firm Holderbank, which in 1990 had direct ownership in cement firms in Spain, France, Belgium, Netherland, West Germany and in other countries outside Europe (Holderbank annual report 1990). The Norwegian cement producer, jointly with the Swedish cement producer, is a shareholder in the second largest British producer Castle Cement and was until early 1992 a shareholder in the Spanish cement producer Valenciana[1]. Scancem Group Ltd., which is owned by the Norwegian and the Swedish cement producer, trades cement internationally. The firm owns plants and silo terminals in Western Africa, the eastern United States and the Caribean. The Norwegian and the Swedish cement producers are together the fifth largest cement corporation in the world.

Third, a secret market sharing agreement was disclosed in 1988 between 11 German cement producers in Southern Germany and one subsidiary of the French cement company Lafarge. They were accused for having a market sharing agreement since the early '80s, and the German firms have accepted fines totalling 224 million DM[2]. Although the Western European cement industry is accused for collusive behaviour, this is the only case where collusion has been proved. There are several empirical studies of collusive behaviour in the American cement industry (Rotemberg and Saloner 1986; Koller and Weiss 1989; Iwand and Rosenbaum 1991). There exist no such studies of the European cement market.

2.2 Prices

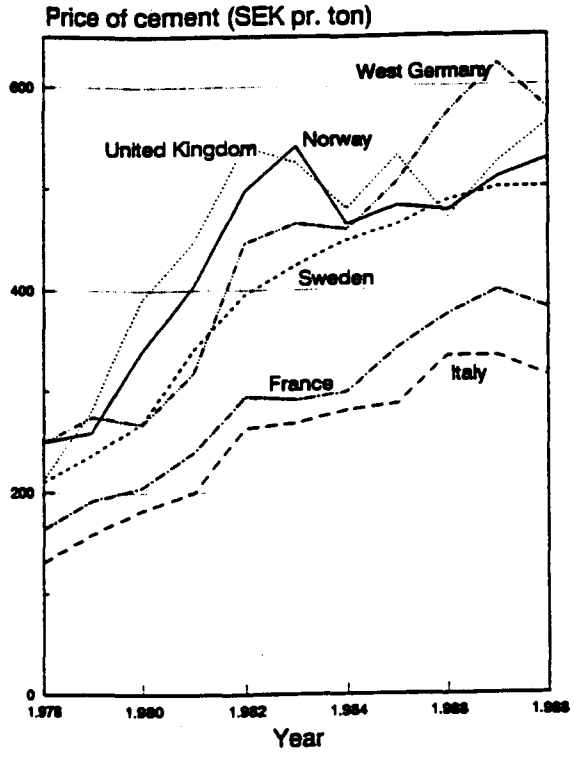
In Figure 2.1 we have reported cement prices in some domestic markets in Europe for the years 1978-88. There are some potential errors from possible differences in discounts and year-to-year exchange rate fluctuations. Despite this, the general picture seems to be that

[1]The corporation Aker, where the Norwegian cement producer Norcem is a subsidiary, is jointly with Euroc, where the Swedish cement producer Cementa is a subsidiary, the owner of the firm Scancem Group Ltd. This firm is the owner of the British cement producer Castle Cement Ltd., and held until early 1992 a 26.1 per cent share in the Spanish cement firm Valenciana de Cementos Portland S.A. (see Aker annual report 1991).

[2]According to letter received from Bundeskartellamt in West Germany, dated January 17 1990.

the price level of cement is higher in Northern than Southern Europe.

Figure 2.1 Prices of Cement 1978-88



Source: SPK (1989), table 10.2. The reported prices are nominal c.i.f. prices in the capital for standard quality and exclusive discounts and taxes.

There exists no public prices of cement traded in the international cement market. In 1983 Norcem estimated that the c.i.f. export price of cement in 1985 would be approximately NOK 150 per ton[3]. In connection with the public support to a new cement plant in Northern Norway, Norcem in 1989 reported to the government that they expected a c.i.f. export price of cement of NOK 150 the next years. This indicates that the price of cement that is traded from producer to producer is below the price of cement to consumers in Southern Europe, and thus substantially below the consumer price of cement in Northern Europe. The figures reported in Table 2.4 support this conclusion.

[3]The reported price was NOK 134 per ton klinker (see Norwegian Ministry of Industrial Affairs 1983, p. 88). The costs of transforming clinker to cement is reported to be NOK 19 per ton (see Norwegian Ministry of Industrial Affairs 1983, p. 81).

We have to be cautious when interpreting the prices reported in Table 2.4. The product can be either clinker or various types of cement. As far as we know, the imports from Sweden to Norway will typically be very limited and consisting of high quality cement products at a high price. In the years 1986-88 the boom in the Norwegian cement market forced the Norwegian cement producer to import large quantities of Portland cement from Sweden. We see that the import price from Sweden on average was NOK 253 per ton in 1987, which is approximately half the consumer price of cement that year in Norway.

Table 2.4 Export and Import Prices for Sweden and Norway (NOK per ton)

	1985	1986	1987	1988	1989	1990
To Norway from:						
Sweden	330	264	253	330		
West Germany	335	445	440	457	429	500
Belgium	215	229	230			
Poland	315	361	324	392	424	410
East Germany	452	380	347	321	340	330
United Kingdom						510
From Sweden to:						
Saudi-Arabia		133				
USA		311	248			
Bahamas		168	120			176
Egypt		228				
Nigeria		169	121			148

Source: Statistisk Sentralbyrå: "Utenrikshandel 1986-1991 hefte I", tabell 2, varenr. CCCN 2523.2900. Statistiska Centralbyrån: "Utrikeshandel 1987,90 Årsstatistikk, import och export, fordelning land/vara enligt SICT", tabell 7, varenr. SITC 661.
Export prices from Sweden are f.o.b., while import prices to Norway are c.i.f., i.e., only the import prices includes freight costs.

As far as we know, the remaining prices in Table 2.4 are for clinker or standard cement. Standard Portland cement is imported from West Germany (see Guthus 1984, p. 18), and as we see at a rather high price. The price of imported cement from East Germany and Poland to Norcem, which according to our information is of the same type as the cement imported

from West Germany, is somewhat lower[4]. It is probably clinker that is imported from Belgium. Adjusted for the cost of grinding and mixing gypsum into it of approximately NOK 20 per ton (see Norwegian Ministry of Industrial Affairs 1983, p. 81), the c.i.f. price is about NOK 250 per ton. Assuming the lowest export prices from Sweden is for clinker, the corresponding f.o.b. price for cement is approximately NOK 150 in 1987 and NOK 170 in 1990. That is in line with the export price reported by Norcem of NOK 150.

3. The Norwegian cement industry

The first Norwegian cement plant was established in 1892 in Slemmestad, close to the capitol Oslo in Eastern Norway. At the end of World War I three new plants were established: Dalen in Southern Norway in 1916; Lier in Eastern Norway in 1917; Kjøpsvik in Northern Norway in 1918. In the early '20s the four firms established a joint sales office, and signed a market sharing agreement concerning both domestic sale and export. Each firm's sales quota was determined partly by its own capacity (see Gartmann 1990, p. 185). In the late '20s the firm located in Lier went bankrupt. The three remaining firms maintained their joint sales office for several decades. However, excess capacity became a problem. In the '60s Norway became the largest exporter of cement in Europe. The expansion in each firm's capacity was partly explained by the fact that each firm's domestic quota was, among other things, determined by each firm's capacity (see Gartmann 1990, p.239-248). In 1968 the three firm merged and established the firm Norcem. The domestic capacity has the last 20 years fallen from 2.7 million to 1.7 million tons annually.

The domestic firm, Norcem, is now the single dominant firm and has a market share that exceeds 95 per cent. The government imposed maximum prices of cement until 1983. 1983-1987 Norcem had to report all price increases to the authorities. After 1987 the government

[4]We have been told by Norcem that the firm imported 86.000 and 13.000 tons of Standard Portland cement from Poland and East Germany, respectively, in 1987. These quantities are in line with the figures from official trade statistics (see Table 2.7 in Sørgard 1989). The imported quantity from Poland was only 5.500 tons in 1989, which might explain why the import price from Poland is higher that year than else.

once again imposed maximum prices of cement, and this public policy is still in force.

3.1 Demand and supply

We see from Table 2.5 that the sale of cement fluctuates much from year to year. The economic activity was high in Norway in 1986-88, and this caused a boom in the demand for cement. In that time period Norcem had to import cement and clinker. This was due to the boom, as well as the close down of a domestic plant (see section 3.2).

Table 2.5 Cement sale in Norway (1000 tons)

Seller	1984	1985	1986	1987	1988	1989	1990	1991
Norcem								
• Own production	1434	1384	1361	1448	1388	1391	1250	1150
• importation*	37	190	365	267	175	28	13	11
Viking Cement	28	57	58	63	51	37	30	30#
Total	1499	1574	1784	1778	1614	1456	1287	1191

Source: Norcem (and later Aker Norcem and Aker) annual reports, data for importations of clinker, Statistisk Sentralbyrå (1987) (see Table 2.4).
*Includes both clinker and cement.
#Estimate.

About 90 per cent of the sale is in bulk, and somewhat less than half the total sale is delivered directly to consumers (see Cembureau 1989-90). The largest buyers of cement are shown in Table 2.6. Norcem has a well established distribution network, with more than 20 silo terminals throughout the country. The qualities Standard Portland, Modified Portland and Rapid Portland cement account for more than 90 per cent of the total sale (see Cembureau 1989-1990).

Norcem is a subsidiary in the corporation Aker, which is a dominant firm in the domestic

construction industry. Other subsidiaries of Aker include Norwegian Contracters (building offshore platforms in concrete), Aker Betong (producing ready-made concrete and concrete products), and Aker Ex-Clay (producing light clinker products such as leca). At present the demand for cement from these companies amounts to approximately one fifth of the total demand for cement in Norway, a share that has increased during the '80s[5].

Table 2.6 The largest buyers of cement January-December 1990

Aker betong	96.000	Ølen Betong	29.000
Spenngruppen	52.000	Norw. Contractors	28.000
Franzefoss bruk	47.000	Neumann Bygg	21.000
Zanda	33.000	Trondheim Mørtelverk	20.000
Leca	32.000	Stoltz Betong	16.000
Svelvik Sand	31.000		

Source: Norwegian Price Directorate (Prisdirektoratet).

3.2 Production and costs

Until 1985 Norcem produced clinker at three plants in Norway: Dalen in Southern Norway; Slemmestad in Eastern Norway; Kjøpsvik in Northern Norway. At each plant the firm had several kilns. In 1985 the clinker production in Slemmestad was closed down, and the plant was rebuilt to a silo terminal. The plant in Dalen was modernized in the years 1985-90, an investment amounting to approximately NOK 500 million (see Aker annual report 1990, p. 28). There is now at Dalen one kiln with a capacity of 1 million tons of clinker annually, and another kiln with a capacity of 100.000 tons. A new plant has been built in Kjøpsvik, which will begin operations in 1992. This new plant has only one kiln, with a capacity of 500.000 tons of clinker annually. The firm's total clinker capacity is thus 1,6 million tons annually, which amounts to an annual capacity of 1,7-1,8 million tons of cement (see Stene

[5]Aker Betong has increased its market share compared to the figures for Jan. - Dec. 1990 referred in Table 2.6, partly because Stoltz Betong in 1991 became a part of this firm. Norwegian Contracter almost doubled its sale from 1990 to 1991, and has thus increased its demand for cement substantially (se Aker annual report 1991).

1991). From Table 2.5 we see that except for periods of extraordinary booms, such as 1986-88, this capacity will exceed the total domestic demand for cement.

The producers will not find it profitable to sell cement unless the price is equal to or above marginal costs of production. The referred export prices for Sweden of about NOK 170 per ton in 1990 can thus indicate that the marginal costs of production in Sweden are not higher than NOK 170 per ton in the late '80s. This is identical with estimate of the Swedish Price authorities for marginal costs in Swedish cement industry (see SPK 1991, p. 37). Data for the Norwegian cement industry for the year 1982 shows that the firm's most efficient plant (Dalen) had a cost of production that year of approximately NOK 140 per ton if labour costs and capital costs are excluded, and approximately NOK 200 if we exclude only capital costs (see Norwegian Ministry of Industrial Affairs 1983, p. 81). In the early '80s Norcem was a high cost producer compared with the Swedish cement producer (see Førsund et.al., p. 72).

In the second half of the '80s the plant in Dalen was modernized, which indicates that the marginal costs fell during the late '80s. In Norcem annual report 1988 it is stated that 'the operational profit from importation is lower than the operational profit from own production, so that the large sale has not the same effect on profit as if it was from own production' [my translation]. Table 2.4 indicated that the import price of cement was approximately NOK 250 per ton in the second half of the '80s. If the profit is larger for own production than imported cement, the marginal costs of production must thus be lower than NOK 250 per ton. For comparison, the f.o.b. price of cement in 1987 was higher than NOK 500 per ton (see Figure 2.1).

Although the price-cost margin is high, the firm's profit could be low because of large fixed costs. Data for return on total capital would adjust for firms' differences in capital intensity and debt. However, we have only figures for return on sale for the Norwegian industry, and therefore we compare those data with the data for Norcem. In Table 2.7 we see that Norcem has a higher profit than the average for the Norwegian industry. This can partly be the result of the extraordinary boom in the years 1986-88. However, Norcem's profit has been high in the years after the boom as well. This is in line with the findings in Sweden, where the

return on total capital in the cement industry is reported to be larger than the average profit for the industry (see SPK 1988:5, tabell 8.3 and SPK 1991:21, tabell 9.2).

Cement is a heavy bulk commodity, and the transport costs are high relative to the production costs of cement. Scherer et.al. (1975) has calculated a freight index based on the freight costs relative to production costs. Among 101 industries they found that cement had the second highest relative freight costs. The transport costs from Poland to Norway is found to be NOK 80 per ton in 1984 (see Guthus 1984, p. 17). The cement was shipped to Sweden and then sent by rail to Norway, which is not the most cost efficient transportation. The transport costs from Dalen to Sør-Trøndelag, the longest transport distance inside Norway, was reported to be NOK 60 per ton in 1983 (see Norwegian Ministry of Industrial Affairs 1983, p. 58). The transport costs from the Continent to Norway by ship should not be larger than NOK 100 per ton[6].

Table 2.7 The profit in Norcem a.s and Norwegian industry

	1984	1985	1986	1987	1988	1989	1990
Norcem a.s.	6.7%	9.5%	13.1%	12.5%	9.5%	11.9%	9.5%
Norwegian industry*	4.0%	4.0%	2.3%	2.9%	4.2%	5.2%	3.5%

Source: Norcem (and later Aker Norcem and Aker) annual reports, and Statistisk Sentralbyrå: "Regnsskapsstatistikk 1990, industri og varehandel", Tabell 1.
The profit is defined as the result exclusive extraordinary items as a percentage of annual income.
*Bergverk og industri.

[6]According to information from persons in Norcem, as well as persons in firms that planned to import cement to Norway.

3.3 Entry attempts

Despite the high transport costs of cement, imports of cement to Norway has been a plausible alternative for more than 100 years. In 1895, three years after the first Norwegian cement plant was established, Norwegian, Swedish, Danish and German cement producers signed an agreement that banned export to a neighbouring country. This agreement lasted until the beginning of World War I (see Gartmann 1990, p. 91).

In the years after 1914 we have observed entry attempts, among others from Germany in the early '20s (see Gartmann 1990, p. 113). During the '80s we observed some entry attempts from both Western and Eastern Europe. Let us describe in some details these more recent entry attempts.

In 1982 the Swedish firm Scandinavian Cement AB started sale of East German cement in the Eastern part of Norway (Østfold). No silo terminal was built, but the firm planned to sell 300.000 tons of cement annually (see Guthus 1984, p. 16). To meet this threat of large scale entry, Norcem requested the government that it impose an anti dumping duty of NOK 124 per ton. The government responded by imposing an anti dumping duty of NOK 170 beginning in the summer of 1984. The duty was abolished one year later (see White Paper no. 12 1984-85). In the autumn of 1984 one of the subsidiaries of Euroc, a firm where Norcem had a minority share at that time, acquired a share in the firm that imported cement from East Germany[7]. Finally, Norcem purchased the exclusive rights to import cement to Norway from East Germany. Norcem accepted to import a minimum amount of cement (or clinker) annually at a price well above the lowest alternative import price. From Table 2.3 we see that the import price from East Germany is NOK 380 and 347 per ton in 1986-87, compared to the adjusted import price from Belgium of NOK 250 in 1987. This suggests that the price from East Germany is 40-50 per cent higher than the lowest alternative import price.

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[7]Euroc's subsidiary Annetorp AB bought 70 per cent of the shares in Skandinaviska Cement AB october 27, 1984. Later the same year the Swedish price authorities required that Euroc's subsidiary should own no more than 33 per cent of the shares in Skandinaviska Cement AB (see SPK 1985, p.7).

In 1983 Nordic Industrial Cement (NIC), a firm located in Sweden, started sale of small quantities of Polish cement in Eastern Norway. In the autumn of 1983 Norcem acquired a 40 per cent minority share in Conus Trading AB, the holding company where NIC is one of the subsidiaries (see SPK 1985, p. 6). Norcem signed a contract with Poland that was similar to the one with East Germany. The firm purchased the exclusive right to import from Poland and agreed to import a minimum amount of cement (or clinker) annually. The import prices in the years 1985-88 were slightly below the one from East Germany, and the years 1989-90 slightly above (see Table 2.4).

In the autumn of 1983 Viking Cement A/S started importing cement to Stavanger, in western Norway. The firm received deliveries from the small West German producer Gebr. Seibel (see Guthus 1984, p. 18). Its sale was in 1987 approximately 60.000 tons (3 per cent of total domestic sale of cement), but in all other years the sale has been lower. The import price has in all years been higher than the import price from East Germany and Poland, except for the import price for East Germany in 1985 (see Table 2.4). In 1991 Norcem rented the terminal Sola Blandeverk, the silo terminal that Viking Cement had rented for receiving the imported cement. This forced Viking Cement to install its own silo terminal (see Dagens Næringsliv 27.02.1991).

In the autumn of 1985 the firm Nordsement A/S was founded, and they planned to set up silo terminals on several locations in Norway (see Dagens Næringsliv 24.03.1988). It signed in 1985 a contract for possible cement deliveries with the spanish producer Expocemsa. This contract was cancelled one year later (see Dagens Næringsliv 28.06.1988). In the autumn of 1986 Nordsement signed a contract for deliveries with the Spanish firm Aslan, but right afterwards Aslan cancelled the contract (see Dagens Næringsliv 22.04.1988). Nordsement accused Norcem of causing these cancellations, which Norcem denied[8]. The firm never

[8]Other persons are also accusing the cement producers for restricting the intra-European trade. For example, a managing director in a Norwegian construction firm (see Guthus 1984, p. 28): '[He] has at several occasions stressed the problems of finding cement producers in Europe which are willing to deliver cement in Norway. .. One reason for the difficulties is probably agreements or tacit understandings between European producers' [my translation]. The director of Noco Betong A/S, a firm that was involved in importing cement (see next paragraph), have said that 'the cement industry

succeeded in its attempt to start importing cement. A Swedish firm, Svensk Cement Import AB, faced similar difficulties in 1991. It purchased cement from a Greek producer, but had to switch to a French producer. According to the Swedish price authorities the Greek producer 'could not deliver cement to them any more, because the firm had got a large order for deliveries to Scancem International' [my translation] (see SPK 1991, p. 31). Scancem International is jointly owned by Aker and Euroc. Norcem and the Swedish cement producer Cementa are subsidiaries in each of them[9].

In the summer of 1990 the firm Concord Vige Cement Trading started to import cement to their new silo terminal in Kristiansand, Southern Norway. The firm had a contract for deliveries with the British producer Blue Circle. The largest shareholder in the firm is the holding company Hübert-gruppen, a construction firm that uses cement as an input in its own production. The holding company is among other things producing ready-mixed concrete at Noco Betong A/S. The firm also planned to sell cement to other consumers than Hübert-gruppen, but they did not succeed in that attempt. According to the firm, this failure forced it to close down the imports. The silo terminal is now owned by Leif Hübert, the majority shareholder in Hübert-gruppen, and rented by Norcem. Hübert-gruppen has signed a long term contract for cement deliveries from Norcem.

Norsk Cement Import (NCI), a subsidiary of the firm Embra, became a majority share holder in Viking Cement in 1990. The major shareholders in Embra is Selvaag-gruppen, a construction firm located in Eastern Norway, and Blue Circle. NCI plans to import for own consumption, as well as to be a rival to Norcem. The firm plans to import 120.000-150.000 tons of cement annually (see Dagens Næringsliv 24.08.1990 and 27.01.1991). It has built a silo terminal at Sjursøya, Oslo. The firm has a contract for deliveries with Blue Circle,

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is to a large extent governed by a cartel. It is difficult to get access to producers' [my translation] (see Fædrelandsvennen 28.04.1990).

[9]In an internal report written jointly by Norcem and Cementa, which presents scenarios for the Scandinavian cement industry, it is written that 'Norcem and Cementa's strength on the domestic market will be increasingly more dependent on the Scancem-family's position in the European market' (see chapter 3, where this internal report is described).

but so far the imported quantities have been very limited.

4. Some concluding remarks

The characteristics of the European cement industry, and in particular, the Norwegian cement industry, suggest very strongly that this is not a competitive industry. The economies of scale in production combined with the limited size of the Norwegian market makes it very difficult for an entrant to start producing cement in Norway and be a rival to the established domestic firm. A more plausible entry threat is import penetration, i.e., an importer that receives cement deliveries from an established cement producer abroad. There have been several such attempts during the '80s, but so far the imports of cement to Norway has been very limited.

The prices to consumers, especially in Northern Europe, far exceed the prices of cement exchanged between the producers. The price-cost margin in the Norwegian cement market far outweighs the transportation costs from Europe to Norway, so transportation costs cannot be a genuine reason for the very limited quantities of import to Norway. Norcem's dominant position is partly the outcome of the company's own actions. In particular, Norcem has purchased the exclusive right to import from some Eastern European countries. The Norwegian cement market can thus be described as a market with a single dominant firm that is threatened by import penetration, but where the incumbent has so far succeeded in maintaining its dominant position.

Chapter 3:

NORCEM'S WAY OF THINKING

The traditional way to test an economic theory is to confront the predictions from the theoretical model with observed behaviour. Some kind of rational behaviour will be the starting point for almost all economic models. A natural question is whether the actors in fact are that rational. Could it be that we rationalize decisions that in fact became successful by sheer accident? Honda's successful entry in the US motor cycle market in the early '60s has been explained as the outcome of an indepth analysis of all choices they would have to make, say concerning product mix and advertising (see Boston Consulting Group 1975). A closer investigation shows that there were some rather peculiar reasons for some of their decisions. In particular, the reason for the initial emphasis on heavy bikes was the following:

> '.. the shape of the handlebar on these larger machines looked like the eyebrow of Buddha, which he [Mr. Honda] felt was a strong selling point. Thus, after some discussion and with no compelling criteria for selection, we configured our start-up inventory with 25 percent of each of our four products. In dollar value terms, of course, the inventory was heavily weighted toward the larger bikes.' (Pascale 1984, pp. 84-85).

The example illustrates that it is important to make the distinction between action and strategy. The former is observable, e.g., investment in a new plant or entry into the US motor cycle market. A strategy, on the other hand, is unobservable or mental. In the economic theory literature it is defined as 'a complete set of instructions, which tells him what actions to pick in every conceivable situation' (Rasmusen 1989, p. 24). This suggests that a strategy is explicit and might be very sophisticated in terms of specifying actions in every conceivable situation. However, a strategy can be implicit. The extreme version of the latter type of strategy would be if a firm's set of actions are governed by a completely random process[1].

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[1]Although no one disputes the referred quote from Pascale (1984), it has been argued that Honda's entry strategy in fact was a rational strategy. It is argued that such a thing as product mix can be adjusted after entry, as it was in the case of Honda. They changed emphasis from heavy to light bikes. The important thing is that the irreversible decisions, such as whether to enter the market or

In line with Friedman (1953) we can argue that only firms that maximize profit survive in the long run, and thus that the established firms always behave as if they maximize profit. However, market imperfections can lead to supranormal profit, and that a firm that makes mistakes can survive. This makes it in some cases difficult to reveal a firm's strategy the traditional way, i.e., by confronting a theoretical model with the observed behaviour[2]. In particular, if we have only one observation that is consistent with the hypothesis from the theoretical model, we cannot reject the hypothesis that it turned out the way it did by sheer accident. Almost any outcome in an oligopolistic market can be an equilibrium according to new oligopoly theory, which implies that the easy task is to rationalize an observation[3]. This justifies another methodology for revealing a firm's rationale (if any) for a specific action. That would be to do an indepth analysis about their way of thinking in the specific industry. A priori we would expect that a firm's public statements can be biased, either from ex post rationalizations of past decisions or a strategic use of information. An indepth analysis of their way of thinking would thus demand some kind of inside information from the particular firm, i.e., unbiased information about their way of thinking.

In this chapter we will use inside information from the dominant firm Norcem to analyse its way of thinking in the Norwegian cement market, in particular concerning the interaction between Norcem and potential entrants. The data used for this analysis is an internal report in Norcem that presents some scenarios for the future development in the Scandinavian cement market[4]. This internal report will shed light on the question whether Norcem's way

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not, are based on an indepth analysis. Ghemawat (1991, chapter 3) argue that this was the case for Honda in the early '60s in the United States.

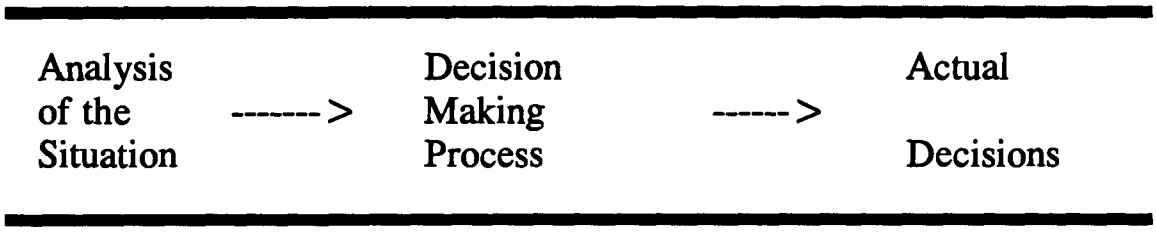
[2]In the last decade we have seen a renaissance for empirical studies of firm's behaviour, the new trend in empirical research called New Empirical research in Industrial Organization (NEIO) (for surveys of NEIO see Bresnahan 1989; Sutton 1990; Sutton 1991).

[3]The multiple of equilibria is best described with the Folk theorem for repeated games: If the discount factor is close to one, all prices such that every firm has a positive profit and the combined profit is equal to or less than monopoly profits can be an equilibrium. Tirole (1988) characterizes the large set of possible equilibria as 'an embarrasment of riches' (chapter 6, p. 247).

[4]Be aware that the internal report is written jointly with the Swedish cement firm Cementa AB. Only six persons were involved in the writing of the internal report (see Appendix A).

of thinking is consistent with the behavioural assumptions in a rational choice model[5]. Unfortunately, an answer to this question will not reveal how decisions actually are made. As shown in Figure 3.1, our data will only shed light on the first phase of the process from analysis to actual decisions, i.e., analysis of the situation[6]. In part III (chapters 5-8) the focus is shifted from the way of thinking to the actual decisions. We construct theoretical models that are tailored to this specific market, and confront the predictions from the models with the observed behaviour in this specific market.

Figure 3.1 From Analysis to Decisions



The chapter is organized as follows. In section 1, we describe very briefly some theories for decision making. In section 2, we contrast the theoretical models of decision making with the way of thinking in this particular industry. In section 3, we discuss briefly the underlying assumptions in game theory, the kind of rational choice model that seems best suited for this particular market. The discussion is summarized in section 4. In Appendix A, we present a short summary of the internal report that is evaluated in section 2.

[5]We will not discuss the term rationality in detail. For a discussion of the distinctions between rationality and the assumptions in a rational choice model, see Elster (1990).

[6]When Jørn Lindstad in Norcem a.s., the chairman of the committee, was asked to comment on this chapter, he strongly pointed out that this internal report could be characterized as the outcome of a brain storming or supposition ('tankeeksperiment'). According to him, the internal report has never been discussed internally in the firm, and it has not been of any importance when specific decisions have been made.

1. Some theories for decision making

There are numerous theories for decision making that deserve attention. For convenience, we have chosen to mention only a few. In particular, we will make the distinction between two polar cases; intended rationality models (section 1.1 and 1.2) and the garbage can model (section 1.3). In the former decisions are the outcome of some consequential decision rule, while in the latter problems and solutions are linked temporally rather than consequentially. We distinguish between two types of intended rational models: the traditional rational choice model where the actors maximize utility and have an objective (unbiased) judgement (section 1.1), and the bounded rationality model where actors' perceptions are subjective and each person's goal is to satisfy certain targets (section 1.2). The description of the different models in this section draws heavily on March and Sevón (1988).

1.1 Model of rational choices

The standard assumption made in most economic theory is that decisions are the result of rational choices. The important elements in such a model are (1) alternatives for action and (2) actors' preferences (see Elster 1990). Each actor will choose the action that is best in accordance with his preferences, i.e., maximize his utility. The alternatives are objective so that a person's judgement is not biased but known unambigously. In line with March and Sevón (1988), we can set up four assumptions that must be satisfied to ensure a rational choice:

1. Decision makers have a set of alternatives for action, and these are known unambigously.
2. The decision makers know the consequences of each particular action (or more precisely the expected consequences).
3. The decision makers have a consistent set of preferences.
4. The decision rule is to choose the decision that maximizes the utility.

An example is a firm that evaluates all kinds of alternative actions for entry into a market For example, how large a plant to build and which product quality to choose. The firm

implements the action that maximizes its profit. These types of decisions are governed by the anticipated consequences of it. Consequently, the decision maker looks into the future when decisions are made[7].

Within this theoretical tradition there are several extensions of the most simple version of the model. One of the most important stems from the fact that information is uncertain and not equally distributed among the actors. One example is a employee-employer relationship, where the employer, called agent, has information about its own effort that the employer, called principal, has no access to. The principal-agent theory has discovered in detail how private information of one agent will influence the decisions. In particular, how a principal can construct contracts so that the agent which assesses private information has incentives to tell the truth and make high effort rather than cheat. The decisions are, in line with the traditional version of the rational choice model, assumed to be optimal. Put differently, the actor chooses the alternative that maximizes his own utility.

Another important extension of the simple model, or more precisely an elaboration of the original model, stems from the fact that one actor's behaviour in many situations will affect other actors' choice of action. This brings us to game theory, which is concerned with the 'actions of individuals who are conscious that their action affect each other' (Rasmusen 1989, p. 21). If there exists a mutual interdependence, this complicates the analysis of the consequences of each alternative (assumption 2 in the rational choice model). The actor must anticipate other actors' responses to its own action. In the literature it has been shown that there will exist a large set of outcomes that is an equilibrium in the way that no one regrets his own action when he observes the rivals' action (Nash equilibrium). In some cases an actor would even prefer to be a crazy player rather than a sane player that has performed all

[7]An alternative would be that decisions are made on the basis of what one did in the past. The decision maker asks what would be the appropriate decision in this particular situation, comparing with similar situations in the past. This implies that people do what they are supposed to do even if this is in conflict with their self-interest. Cultural norms within a society will for example restrict a person's alternatives for action, and rules and standard procedures will have similar effects within an organization. For more details concerning such a logic of appropriateness, see March and Olsen (1989).

the required computations (see Tirole 1988, p. 260). This illustrates that optimal behaviour in a rational choice model might be to behave as if you are an 'irrational' player, and thereby induce the rival to act in a certain way.

1.2 Model of bounded rationality

In contrast to the rational choice model is the theory of bounded rationality, first introduced in Simon (1955) and Simon (1956) and elaborated further in Cyert and March (1963). The starting point is that there are boundaries set by humans' cognitive limitations. This has several implications.

First, these cognitive limitations might result in biases in human judgement. The actors have perceptions about which alternatives that exist and what the consequences of the alternatives are, and these perceptions might conflict with the reality. One example of such subjective judgement, compared to the objective (unbiased) judgement which is the assumption in the rational choice model, is people's judgement of the likelihood of an event (for a survey, see Machina 1987). For example, it is found that the bias towards wishful thinking is more serious the more uncertain people feel about their probability judgement, and the more desirable the positive outcome is. Such biased judgement violates the first and the second assumption in the rational choice model. It is irrational behaviour, because it makes it more difficult to achieve long term goals (see Elster 1990). Another example of biased judgement is the money illusion, that is, your willingness to pay for an item is less than the minimum compensation for selling the same item (see Knetsch 1989).

Second, information is uncertain and has to be discovered through search. The decision maker decides to search until it reveals an alternative that satisfies some specific goals. This implies that search for new alternatives only takes place when performance fails to achieve the goals, i.e., only when performance is bad. The decision maker's choice is governed by the wish to satisfy a certain goal rather than maximize, for example, profit.

Third, the decision maker's goals (or performance targets) are not exogenously determined.

They tend to be negatively correlated with search: when performance is bad, the goal is adjusted downwards and search for new alternative solutions is increased. This profit seeking rather than profit maximization behaviour is presented formally in among others Nelson and Winter (1982) and Radner (1975)[8]. The decision rule to satisfy a goal rather than maximize utility violates the fourth assumption in the rational choice model.

1.3 Garbage can model

The theories of rational and bounded rational choices present decisions as logical outcomes of some specific decision rules. The other extreme is that no such order exists, and that decisions are not linked to problems. The argument for the plausibility of this extreme outcome is the complexity and confusion surrounding actual decision making. Many things happen simultaneously, which makes it impossible to reveal the connection between alternatives for action and outcomes. It could be that an organization where decisions are made in reality is a network of relations, where persons are active in several decision arenas at the same time and their decisions are influenced by this fact. It could also be that actual decision are not so important for the decision makers, but rather that the decision making process itself has a genuine value for them.

One way to model apparent disorder is to assume that decision processes are affected by timing, not by their consequential connections. This logic of temporal ordering is the main assumption in the garbage can model, which was first introduced in Cohen, March and Olsen (1972) (see March and Olsen 1986). In the pure garbage can model it is assumed that problems, solutions, decision makers and choice opportunities are exogenously determined and can be viewed as a stream flowing through the organization. The link between these independent factors are their timing, i.e., the simultaneity between the different factors. The outcome of the process, i.e, the actual decision, apparently has no close relation to the explicit intentions of actors in the pure version of the model.

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[8]The existence of slack need not be inconsistent with a rational choice model, see for example Scharfstein (1988) and von der Fehr (1992).

There are numerous studies of how garbage can processes affect the decision making. In Powell (1978), for example, it is found that timing, as well as other factors as company tradition and author's academic status, were important for the decision to publish a book. In Weiner (1976) it is found that imposing deadlines could make a difference concerning the decision that was made.

Despite the apparent disorder of the garbage can process, the outcome of a garbage can process can be understood and to some extent predicted. The outcome of the process can be manipulated by rational actors. For example, by the timing of the actor's proposals for solutions to a problem. The decision process itself is in conflict with the assumptions made in the models of intended rational choices. All four assumptions in a rational choice model are violated.

2. Evaluation of an internal report

The question is whether Norcem's way of thinking is in fact consistent with a rational choice model. To answer the question, we will evaluate an internal report written jointly by persons in Norcem and Cementa, the only Swedish cement producer. This report, written late 1989 and early 1990, analyses the Scandinavian cement industry's development 1990-95. In Appendix A a short summary of the internal report is presented. We will first contrast Norcem's way of thinking with the assumptions in the rational choice model (section 2.1). In section 2.2 we discuss in more detail one particular issue that in fact is incorporated in the first issue, whether the internal report indicates that Norcem's public statements are deliberately biased.

2.1 Rational way of thinking?

In section 1 we presented four basic assumptions for the rational choice model: knowledge of alternatives; knowledge of consequences; consistent and stable preferences; decision rule to maximize utility. The internal report says nothing about whether the third assumption is satisfied, that is, consistent preferences. However, the first and the second assumption are

important aspects in the internal report. In addition, the internal report indicates implicitely which decision rule the firm is pursuing. Let us therefore discuss knowledge of alternatives, knowledge of consequences, and decision rule.

2.1.1 Knowledge of alternatives

For decisions to be rational, the alternatives for action must be related to the specific environmental situation. The internal report describes four scenarios, and within each scenario there are mentioned numerous alternatives for action. It seems as though the alternatives are usually related to the specific environmental situation. For example, action to persuade the government to restrict imports is mentioned in scenario II. In that scenario the Scandinavian countries are isolated, and Sweden and Norway have the option to impose restrictions on imports (see scenario II, p. 4 in the internal report). Imposing specific standards is also mentioned as an alternative:

> National supplementary provisions which impair the EC-standard are created, and the Scandinavians actors exploit this at a maximum to protect their own interests (scenario II, p. 6) [my translation]

Another example is in the case where the cement standards are made less restrictive to differentiate the product (see scenario I, p. 1). When the internal report says that

> '[T]he development in the market opens the possibility for Scandinavian cement industry for further vertical integration' (scenario II, p. 6) [m.t.],

then the relationship between the specific alternative and situation becomes clear. A final example is the link between the institutional setting and the investments in cost reductions (see the discussion concerning decision rule below).

The construction of four scenarios out of the infinite number of possible outcomes is a pragmatic way to deal with uncertainty. To be as much as possible in line with what is theoretically correct, the scenarios should be possible but extreme (see Ghemawat 1991,

chapter 6). This will broaden the considerations of uncertainties. A common mistake is that there is a bias towards constructing success scenarios (see Ghemawat 1991). This is apparently not the case in this internal report. Two of the four scenarios are rather pessimistic concerning the institutional setting. In scenario II, Norway is not integrated into the rest of Europe. As a result of that, domestic demand is stagnating. In scenario III the Scandinavian cement industry faces restrictive emission controls, and therefore its costs increase. On the other hand, the scenarios seem to be rather optimistic about how much Norcem/Cementa can influence the future market outcome (see below).

2.1.2 Knowledge of consequences

Analysing the consequences of actions implies that the actor is forwardlooking when decisions are made. The idea of constructing scenarios is in itself forwardlooking, and the way of thinking presented in the internal report is in that respect consistent with the rational choice model. However, a common mistake in such studies is to neglect rivals' responses, i.e., neglect the second order effects of its own actions (see Ghemawat 1991, chapter 5). This aspect is not neglected in the internal report. For example, they describe the consequences of exportation to EC countries as follows:

> 'The imports to Scandinavia from EC countries are .. a result of Scancem/Castle activities in Europe' (scenario IV, p. 4). [m.t]

Another example is their anticipation of the effect of price competition:

> 'Cementa and Norcem have adjusted to the competitive situation by .. price competition locally to keep geruilla competition from EC-delivers out.' (scenario II, p. 1). [m.t.]

In addition, they anticipate the future governmental responses to its own action. One example is the threat of active anti-trust policy:

> 'Improper competitive action to maintain the monopoly position can be

investigated by the EC-commission' (scenario I, p. 7). [m.t.]

However, the scenarios seem to be rather optimistic about the Scandinavian producer's market dominance, e.g., how large market share the firm will maintain. In the worst case, they predict a market share of 85-95 per cent. Presently, Norcem's market share is 97 per cent. Moreover, they assume control over exports from Eastern Europe to Scandinavia in all four scenarios. They have also an apparently optimistic perspective on how their action will influence the government's behaviour. For example, when they say that:

> 'Cementa/Norcem accuses importers for dumping sale to achieve restrictions on import' (Scenario II, p. 4). [m.t.]

The exclusive right to import from Eastern Europe, as well as the call for anti dumping duties, were successful strategies in the past. However, there are reasons to believe that these strategies will be less successful in the future than they were in the past. The Norwegian Price Directorate, as well as the Norwegian Ministry of Finance, will, as far as we know, now more strongly oppose anti dumping duties than what was the case in the past. The Eastern European countries' economic systems had changed dramatically towards a free market system already before the internal report was written. This makes it less likely that the Scandinavian producers can make an exclusive agreement with those countries' authorities, as they did in the past. It suggests that the prospects for the future are biased towards the same alternatives that happened in the past. This phenomen is in line with the findings in the study of Fischhoff (1975).

The analysis of the consequences of each alternative is verbal, except for the quantification in each scenario's appendix. In each appendix there is data for the market size in different segments, the Scandinavian producers' expected market shares, and the types of cement produced. However, there is no detailed analysis of how the reported market shares actually are determined. There are no analysis of the consequences of price competition: how long must they compete on prices to force an entrant out; how large price reduction; how large increase in sales if prices are cut? Moreover, there are no discussion of the rivals' costs,

e.g., transportation costs to Norway. An exact understanding of the consequences would ideally include some simulations of the dynamics of the rivalry, and these would be based upon some estimates of costs and demand. Such simulations are used in Smith and Venables (1988) for ten European industries. They analysed the consequences for each particular industry of the establishment of an internal market within the EC on behalf of the EC-commission. The lack of detailed quantification in the internal report suggests that the analysis relies more on rules of thumbs than detailed calculations. According to information we have received from Norcem, the firm is undertaking more detailed calculations when the firm is in a specific situation, for example faces one particular potential entrant[9]. If that is the case, the firm uses rules of thumb less often than what the internal report indicates.

2.1.3 Decision rule

In the internal report there is no explicit discussion of the firm's goal: is it to maximize profit, maximize size (market share), or to satisfy a certain goal, e.g., a certain annual profit? The fact that market size and market shares are reported in the scenarios' appendix, suggests that a large sale rather than high profit is the firm's goal. However, in the internal report it is stated the following:

> 'If the price and production costs are set correctly, it will be possible to avoid permanent establishments of large importers. However, it is likely that one must/should allow suppliers in time-specific projects, .. , where price/quality can be unsuitable for Scandinavian suppliers.' (scenario I, p. 7) [m.t.]

This suggests that the firm will accept entry if that is more profitable than serving the whole market. It excludes the possibility that the firm's goal is to maximize its market share. Their statement is consistent with a profit maximizing goal. However, it is also consistent

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[9]The investment plan in the early '80s illustrates this. In the early '80s Norcem planned to modernize their plants (see chapter 2). In the initial analysis the firm formulated 46 alternative investment plans. The number of alternatives were later reduced from 46 to 10, and finally from 10 to 8 (see Norwegian Ministry of Industrial Affairs 1983, p. 85). As shown in Norwegian Ministry of Industrial Affairs (1983), each of the 8 final alternatives is quantified in detail.

with a goal where both profit and market share matters, i.e., a situation where there exists a trade off between market share and profit.

Assuming a model of rational choices, the firm will minimize their costs in all four scenarios. An alternative might be a goal of satisfying certain goals, e.g., annual profit, rather than maximize profit. If that is the case, the firm will search for measures that reduce costs only in periods when performance is bad, i.e., when there exists a mismatch between goal and performance. In all four scenarios, there are adjustments in the production techniques to take into account the changes in the market situation. In Scenario I the production techniques are modified to handle the expected increase in product differentiation.

There is some evidence indicating that measures to reduce costs are more important in some scenarios than others. In scenario II it is said that

> '[A]fter 1992 there have been allocated few funds to investments, and few measures to improve productivity have taken place' (scenario II, p. 2). [m.t.]

Scenario IV, on the other hand, reports numerous ways to reduce costs, such as for example:

> '• Exploitation of new raw materials (e.g., lime as a by-product from other industries)
> • Further development of computer-based systems in order to have a stable operation, and lower temperatures
> • New fuel combinations (e.g., increased exploitation of waste, gas etc.)' (scenario IV, p. 6) [m.t.]

The question is why these cost reduction measures are mentioned in scenario IV, and not in scenario II (or any other scenario). It has apparently no connection with the general macroeconomic development or with changes in the institutional setting. In both scenario II and IV Norway is not a member of EC, and the domestic demand is stagnating (marginal increase in scenario II, and marginal decrease in scenario IV). Neither are there any indications that the cost reduction in scenario IV is due to strategic considerations. There are no arguments in the internal report, scenario IV, suggesting that the cost reduction will

affect rivals' action, e.g., deter potential entrants. One reason might be that the goal is more ambitious in scenario IV, both concerning size of the sale and profit, and the firm has to export and reduce its costs to achieve its goals. If that is the case, the firm's decision rule is to satisfy a goal rather than to maximize profit.

2.2 Strategy of biased information?

The existence of private information implies that the firm with access to the private information would try to exploit this to its own advantage. A rational firm would according to the rational choice model seek to manipulate its rivals' and other actors' information in order to influence their behaviour. The internal report offers some examples that suggest that Norcem's public statements can be viewed as investment in biased information. One example is Norcem's description of the quality differences between imported cement and domestically produced cement:

> '• The importers offer cement that is as far as possible identical with Norcem/Cementa's quality
> • Quality information and education become an important part of the product
> • It is argued that the domestic produced cement is A-quality, while the imported cement is B-quality' (scenario II, p. 4) [m.t.]

This can be interpreted as though Norcem will argue that the imported cement is inferior to the domestically produced cement even though the firm is aware that the products can be virtually identical (if the importers succeed in mimicing Norcem's quality). It is of interest to note Norcem's public response in the autumn of 1990 to the fact that a potential entrant planned to penetrate the Norwegian cement market. Norcem argued that the entrant would find it difficult to receive high quality deliveries of imported cement (see Dagens Næringsliv, 28.08.1990).

There are also other indications that Norcem is prepared to supply biased information to put rivals' products at a disadvantage. One example is research related information:

> 'Scandinavian cement industry has been active concerning research related information, where own product development has been pointed out and explained. Due to this Scandinavian construction companies and consultants are sceptical to some of the mixed cement types that have been imported, both concerning durability and other characteristics. .. The effect is that imported cement has mainly been pure Portland cement of Central European quality.' (scenario IV, p. 5) [m.t.]

Both this and the preceding quote suggest that the firm exploits the advantage of being the pioneering brand. The consumers know what they have, and the incumbent can gain if the consumers become more uncertain about the quality of a potential entrant's product. This aspect is analysed in Schmalensee (1982). It is shown that the consumers' search procedure can be advantageous for the incumbent's product. The reason is that the consumers that face the choice between the existing product, which quality is certain, and a new product, which expected quality is the same but uncertain, will choose the existing products if the prices are identical. The larger the uncertainty, the larger the price difference between the incumbent's and the entrant's product before the consumers switch to the new product.

Other examples suggest that Norcem intends to inform the customers about quality changes so that the incumbent maintains his advantage of being first even though the incumbent's quality is changing:

> 'New types of cement are developed where the amount of substitutes that are mixed into the cement are at a maximum compared to the standards. ... The introduction of such changes demands extensive testing, information and marketing.' (scenario III, p. 5) [m.t.]

The supply of information is also anticipated to be of importance for the relationship between Norcem and the government. One example is restrictive emission control:

> '. A public proposal for more restrictive emission control (or higher taxes on pollution) is not accepted by the industry. The industry argues that the Scandinavian producers will have a competitive disadvantage, many domestic workers will be fired, and the industry demands restrictions on imports of cement from foreign industry which

have less restrictive emission control.

- We accept some 'cheap' measures which have no serious impact on neither the production nor the product.
- More restrictive emission control is postponed to the end of the '90s.' (scenario II, p. 5) [m.t.]

This suggests that Norcem is anticipating the negotiation process between itself and the government, and that the firm is very deliberate about which arguments to stress. One could interpret "accept some 'cheap' measures" as though Norcem has private information about how expensive a measure is, and thus has the option to present measures as expensive even though they in fact are cheap. However, Norcem has explained the term 'cheap' as measures that are cheap for the industry but also cheap for the politicians. Because, Norcem argues, the politicians will succeed in introducing emission control, without any reduction in the industry's competitive position or the number of jobs[10].

In all the referred cases Norcem has private information about costs. For example, it has private information on the costs of rebuilding the plant to satisfy restrictive emission control, and Norcem exploits the consumers' lack of information about potential entrants' product. Such an action is consistent with the rational choice model, where the actor is expected to exploit all sources of asymmetric information. However, Norcem's information strategy contains elements which are inconsistent with the rational choice model as we described it in section 1.1. If information can be shown to be without any influence on the actors' behaviour, the rational choice model tells us that the actors will not spend time and money in gathering or presenting such information. There are several examples showing that Norcem is concerned about whether the arguments they put forward are accepted or not by consumers and rivals. In scenario III when Norcem modernizes the plant:

> 'The main argument, that the modernizing is the result of introduction of restrictive emission control, is accepted' (scenario III, p. 6). [m.t.]

In the same scenario increased prices are explained in the following way:

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[10]According to private communication with Jørn Lindstad, Norcem a.s.

> 'It is argued that the price increase is from future investments that are needed because of restrictive emission control' (scenario III, p. 5). [m.t.]

If consumers and the government act in accordance with a rational choice model, such arguments put forward by Norcem will not influence consumers and government's actions. A consumer's decision to buy a product will for example depend upon the price and quality of this product, price and quality of substitutes, etc. The question why the producer increases his price is not relevant for the buyer's decision, and must therefore be regarded as idle talk.

There is a rationale for apparently idle talk if we assume that actors' judgement are biased. We can see information as developing and sharing interpretation of reality, clarifying and elaborating arguments for a specific decision (see March and Sevón 1984). In the particular case referred to here this implies that the consumers are not indifferent to which arguments the producer puts forward concerning a price increase.

Such idle talk can also be irrational in the way that it is without any decision relevance. It could be that it is a tradition in our society to explain the decisions, to argue about why a decision was made. Even if Norcem's argument has no influence on the consumer's choice, the idle talk can be viewed as an appropriate behaviour. Put differently, it is in accordance with the norms in the society to present arguments for why a decision has been made.

3. The basic assumptions in game-theoretic models

One central finding in the preceding section is that Norcem is well aware rivals' responses to its own action. Game theory is by definition (see section 1.1) well suited for analysing such mechanisms. However, it is reasonable to question the rationality assumptions in game theory. In all game-theoretic models the underlying assumption is that the actor's behaviour is based on a very sophisticated way of thinking, far beyond the assumptions used in the traditional theory of competitive markets. In the latter model the actors face exogenous prices, and decide which quantity to sell at the existing market price.

In contrast to the competitive model, in game-theoretic models the actors can by assumption influence rivals' behaviour and they are conscious about this mutual relationship. The models require that the players act as if they anticipate fully the often complex reasoning which the rivals' decision is based on, that they understand that the rivals understand that they are conscious about this and so on ad infinitum. Are actual individuals so sophisticated? If the answer is yes, why do people play the game of chess where the outcome according to game theory is totally determinate and obvious? According to Paul Milgrom and John Roberts, who have published seminal works in applied game theory (industrial organization), 'the descriptive nature of the super-rationality assumption [in game theory] does seem minimal ..., this lack of descriptive accuracy is troubling' (Milgrom and Roberts 1987, p. 188). It is not just that people are not always so clever as the game theorists who construct models, but it is also unrealistic to assume that transferring information, assimilating it, calculating and deciding can be done instantaneously and without cost.

In all game-theoretical models it is assumed that the game is common knowledge in the way that every player knows the game, everyone knows that everyone knows it at so on ad infinitum. The mathematical description of the game is common knowledge, as well as the logical or mathematical theorems that can be proven about the game (see Sugden 1991). Although this assumption is realistic in some circumstances, there is reason to question the common knowledge assumption if the game is detailed and complicated. In particular, in models with asymmetric information the calculations each player must execute to find the equilibrium of the game are typically very complicated, and according to Paul Milgrom and John Roberts it 'strains the limits of credibility' to assume that real people make such calculations (see Milgrom and Roberts 1987, p. 189). Even if we assume no asymmetric information, one can still seriously question the empirical validity of the common knowledge assumption. One example is models with mixed strategy equilibria.

In contrast to the pure strategy, where the player has a rule telling him what single course of action to choose, the mixed strategy is a rule telling which dice to throw to choose an action. The reason for randomizing is to keep its rival guessing, and so prevent the rival from benefiting from pursuing a single course of action. If one randomizes in such a way

that its rival is indifferent between pure strategies, and vice versa for its rival, none of them have incentives to deviate from such an equilibrium. Put differently, both players randomize in such a way that the rival is indifferent between pure strategies. If we allow for mixed strategies, this will guarantee that it exists at least one Nash equilibrium (see Kreps 1990a, section 12.5).

Many game-theoretic models have equilibrium in mixed strategies, and this raises several questions about those models' empirical validity. First, will real individuals decide what to do by throwing a dice? It is of interest to note that in text books in Industrial Organization the examples of mixed strategies are typically from card games or sport, not from decisions made by business executives[11]. Second, why should one spend resources in order to calculate the right randomization if one believes the other player is doing so? As long as the other player is fulfilling his part of the equilibrium, there are many best responses for the first player. David Kreps admits that mixed strategy equilibria are often not very intuitive, but his final argument for using mixed strategies is that 'it gives a rather nice mathematical result' (Kreps 1990a, p. 409).

The underlying assumptions in mixed strategy equilibria illustrate that the equilibrium concept in game-theoretic models in some cases apparently lack empirical validity. A natural response to this would be to model the behaviour more in line with what we actually observe. For example, to take into account humans' cognitive limitations, i.e., bounded rationality. Paradoxially, moving in the direction of models of bounded rationality is difficult because researchers themselves have cognitive limitations. Even simple models of bounded rationality can be almost impossible to solve analytically (for an example of the complexity, see Kreps 1990a, section 19.3). We thus see that there can be a trade off between

[11]Rasmusen (1989) presents an example from American football, where the offensive team has to decide whether to pass or to run. Dixit and Nalebuff (1991) illustrates the idea of mixed strategies by a tennis player's choice between playing left or right. In Kreps (1990b) poker is the example where the players are apt to follow mixed strategies. In several books auditing (or quality inspection) is mentiond as an example where mixed strategies are used. However, that instance is a special case where one player checks the other one. The only example from business in the referred books is in Dixit and Nalebuff (1991), who very briefly mention discount competition between Pepsi Cola and Coca Cola.

descriptive accuracy and tractability. The need for tractable models can justify even the use of models with mixed strategies. It has been shown that randomized strategies can be thought of as pure strategies in games where players hold private information (see Harsanyi 1973). It is argued that each person has private information about his own preferences, such as what side of the bed he gets out off. Such details are hard to model, but they determine how an individual chooses between strategies. We can take such details into account, although imperfectly, by allowing for mixed strategies.

The specification of the game-theoretic models can also be seen as a response to the fact that individuals are boundedly rational. In a rational choice model the players are in principle well aware all alternatives for action. In reality, their cognitive limitations limit the number of alternatives they are aware. Such cognitive limitations are often incorporated in the game-theoretic model by the fact that the number of alternatives for actions specified in the model are limited. For example, in some models the incumbent has only two response options to entry: accept it and do nothing, or start price cutting. This illustrates that even if we start out with a rational choice model, the process of simplifying the mathematical structure will imply that the model in reality describes a boundedly rational player, i.e., a player with a limited number of alternatives for action. It is a natural response to the fact that no model can ever encompass all the complexity in the real world. All essential elements cannot be identified a priori, but require some study of the situation being modelled. This highlights how important the first phase of the modelling work is: what are the alternatives for action; what are the sequence of moves; and so on. To simplify the model one has to treat unimportant subcomponents of a model in a cursory way or leave them out completely, and highlight the elements one has decided to focus on. Such a methodology, called no-fat modelling in Rasmusen (1989), will enable us to deduce analytically which outcome that follows as a logical consequence of the explicit assumptions that are made.

4. Some final remarks

How can we characterize Norcem's way of thinking? To answer the question, we confronted Norcem's way of thinking as written down in an internal report with the basic assumptions

in a rational choice model. We have to be cautious when interpreting the internal report, because it is written by a committee with only six members and thus not a complete picture of the way of thinking in this particular organization and an even less complete picture of the decision making. Such a report will not shed light on potential conflicts of interest between actors. For example, there can exist conflicts of interest between persons within the organization or between the firm's manager and the owners of the firm which the internal report says nothing about[12].

Keeping the reservation in mind, the findings can be summed up as ambiguous. On one hand Norcem is forwardlooking, constructs scenarios that are distinctly different, is well aware rivals' responses, and exploits its private information to put rivals' products at a disadvantage. On the other hand, their judgement is in some cases biased, cost reductions are mentioned in some scenarios but not in others (i.e., not cost minimizing all the time), and some of their public statements are apparently just idle talk (no decision relevance).

Alhough we did not find any indications that any decisions would be the outcome of a garbage can process, i.e., affected by timing rather than the consequential connections between different factors, we cannot rule out that such a mechanism is of importance. Note that although a firm intends to act rationally and its plan for the future indicates so, the timing can influence the decision process. For example, timing was decisive for the choice of technology when A/S Dalen Portland-Cementfabrikk was established in Dalen in 1917. The founder of the plant, Alfred Holter, was educated in Hannover and had relations to persons in the German firm Krupp. The firm's choice of technology has been explained as follows (se Gartmann 1990, p. 279):

> 'By a strange twist of fate, Krupp had a cement plant ready for shipment to Russia. Because of the war, the firm was not allowed to export to Russia. One can say that it was chance more than conviction that led to Dalen having a machinery for dry process. .. It turned out to be a foresighted decision,

[12]For an up to date survey of the theory concerning conflicts of interest within an organization, see Milgrom and Roberts (1992). For a critical survey of the literature concerning the conflicts of interest between owners and manager, see Mueller (1992).

although one could hardly know that when the decision was made' [m.t.].

It has been argued than one important reason why the plant in Dalen survived in the long run, while a plant located in Lier went bankrupt after ten years in operation, was that the two firms had chosen different technologies (see Gartman 1990, p. 45).

Although the above example illustrates that decisions in this industry not always are the outcome of a detailed and rational planning process, there are some arguments in favour of rational choices in this particular market. First, this market is fairly easy to analyse. The products are virtually homogenous, with no role of advertising. The production process is well known, with only minor differences in technology between firms. Second, the market is highly concentrated on the seller side. This is in particular the case in Scandinavia, where a single incumbent has a dominant position in Norway and Sweden, respectively. Third, there are large sunk costs in this industry. This is an argument calling for careful calculation before investment decisions are made, especially before a firm enters the market. The number of parameters that each firm has to watch carefully are therefore very limited: limited scope for technological difference; limited scope for product differences; no scope for advertising; limited number of rivals, and their investment decisions are commitments for the future. On the other hand, an incumbent that makes mistakes might survive in the long run because of supranormal profits in this industry. The latter implies that the process of elimination of irrational actors is imperfect.

The internal report shows that there are a multiple number of factors influencing the way of thinking in Norcem, and the decision making process itself is probably even more complex. How should one proceed to gain further insight into such mechanisms? One approach would be to classify different decisions, for example, whether specific decisions seem to be strongly influenced by either norms, incentives, timing or other factors. Such an analysis would obviously provide us with more knowledge about the rationale (if any) for different decisions. One could object that such an approach would not disclose in detail each of the underlying mechanisms that is in force. For example, what decision would have been made if the decision maker was governed purely by economic incentives or purely by some particular

norms?

This brings us to a second approach, and that is to focus on certain phenomena and causal factors and neglect others. Such an approach is a response to the fact that no theory is ever going to encompass all of the complexity in the real world and thus be exactly and completely right (whatever that might mean). The aim of theorizing should thus be to find fruitful simplifications and abstractions. Such an approach will make it possible to link assumptions and outcomes explicitly. By constructing a theoretical model with certain behavioral assumptions and alternatives for action one can deduce mathematically what outcome that is a logical consequence of the explicit assumptions, and how sensitive the outcome is to alternative model specifications.

In the remaining chapters we will follow the second approach, focusing on certain factors and neglecting others. Our starting point will be one of the findings in this chapter; that the firms are well aware of rivals' responses to its own action. When firms are conscious about rivals' responses, the game-theoretic approach is (by definition) well suited for analyzing such mechanisms. Game theory will thus be the basic framework for the analysis in Part III (chapter 5-8), as well as in the next chapter (chapter 4) where we present a survey of the entry game literature. However, it is important to acknowledge the limitations of game theory. It is a rational choice model, in which the underlying assumption is that the players' behaviour is based on very subtle inferences about rivals' responses to its own action. To take into account humans' cognitive limitations, we simplify by neglecting some factors and focusing primarily on the strategic interaction between firms. In particular, we are careful about the specification of alternatives for action and the sequence of moves. Despite this 'tailoring' of the theory to this particular market, we must acknowledge that our models serve as a benchmark or starting point for discussing observed behaviour. The theoretical predictions must not be interpreted as an ultimate explanation of past action, even if the observed facts are consistent with the predictions, and not as a prediction of future action. Moreover, intended rational behaviour might not imply profit maximization behaviour. In chapter 6 we will therefore construct both a rational choice model and a model of bounded rationality for discussing Norcem's investment in marginal costs reduction in the '80s.

Appendix A: Norcem's (and Cementa's) internal report

In the autumn of 1989 Norcem Cementa Coordination Committee, a joint committee between the Norwegian and the Swedish cement producer, decided that a separate committee consisting of six persons (three from each country) should analyse the future of Scandinavian cement industry. The leader of the separate committee was Jörn Lindstad, Norcem, who afterwards became the director of marketing in Norcem. The committee was asked to present their analysis in scenarios, and delivered a 90 pages report in the spring of 1990. They presented 4 scenarios, each of them with 1995 as the time horizon. In addition, there were 7 appendices. In the appendices there it was discussed questions such as the expected standardisation of cement and concrete products, and forecasts for the cement demand in Norway and Sweden were provided. Although the report is not marked 'confidential', it is no doubt that it is an internal report and no one outside the organization was supposed to read it.

All four scenarios are organized in the same way. Part 1 is called 'Scandinavian Cement Industry 1995', and describes the expected situation in 1995 within areas such as the market situation, product characteristics, promotion and production. Part 2 is called 'development towards 1995 - its dynamics [drivkraft], direction and consequences', and describes among other things the interaction between the firms and between Norcem and the authorities (e.g., the development of environmental standards). Part 3 describes production techniques, and part 4 the development in the market for concrete products. At the end of each scenario there are tables listing the expected size of the market, the plant capacity and characteristics for the different cement qualities in 1995.

The report starts out with a two and a half pages executive summary, and it has a section called highlights from the scenarios. In that section there is one page with summary of some trends that are common for all four scenarios, and two pages of summary for each of the four scenarios. Then follows each scenario, which each consists of 9-10 pages including two pages of tables.

The apparent distinction between the first three scenarios is the institutional framework. In scenario I, it is assumed that Scandinavia is an integrated part of the EC-market; in scenario II Scandinavia is not part of the EC-market; in scenario III Scandinavia has implemented restrictive emission control for the industry. The differences in institutional setting are assumed to influence the development, for example the rivalry in this market. The fourth scenario is somewhat different. It is called 'Scandinavian cement industry acting aggressively [på offensiven]', and the institutional setting is a combination of scenario I and II. In contrast to the other scenarios, the Norwegian and the Swedish cement producer are cooperating very closely in many areas and are jointly penetrating some domestic markets in Europe.

In scenario I, where Scandinavia integrates towards EC, the competition in Scandinavia is becoming

tougher. The Scandinavian producers are losing market shares, and their main strategies are described as (1) price competition/cost optimization, (2) product adaption and product cooperation, (3) imports agreements (Eastern European countries). They anticipate a segmentation of the market into two parts; low quality and high quality. In the low quality segment they are prepared to compete with new entrants on prices (see strategy 1), while they expect to 'tailor' the quality to the customers in the high quality segment and thereby exclude entrants from that segment (see strategy 2). In addition, they expect to exclude the Eastern European exporters by purchasing the exclusive rights to import from those countries (see strategy 3).

In scenario II, where Scandinavia is not part of the internal market in EC, the demand for cement is stagnating. There are examples of 'hit and run' entrants, who sell cement to a low price for a short period of time and then disappears. The Scandinavian companies's main strategies is to (1) maintain their old quality sortiment, (2) cut prices locally where imports are taking place, and (3) sign exclusive agreements with Eastern European countries.

In scenario III, where Scandinavia introduces restrictive emission control, they face cost disadvantages relative to foreign producers. Their main strategies are to (1) request the authorities to impose restrictions on imports and to allow price increases, and (2) to mix substitutes into cement to reduce costs.

In scenario IV, where they have decided to act aggressively, the two producers are cooperating very closely on areas such as product harmonisation, distribution, production and export. Their main strategies are to (1) sell a low quality standard cement to the domestic segments where imports take place, (2) sell a high quality to the rest of the domestic market and to the domestic markets in Europe.

Chapter 4:

A SURVEY OF THE ENTRY GAME LITERATURE

The pioneering work concerning entry is Bain (1956). Entry has since then been an important issue within the Structure-Conduct-Performance (SCP) tradition (for a survey, see Schmalensee 1989; Scherer and Ross 1990). According to this tradition, the causality runs from structure to conduct to performance. This implies that structural parameters such as number of sellers, cost structure etc. determine pricing, advertising and other choice variables (conduct), and thereby determine the firms' profits, price-costs margins etc. (performance). A typical regression would be that

$$\text{Profits} = f(\text{number of sellers, advertising outlay}),$$

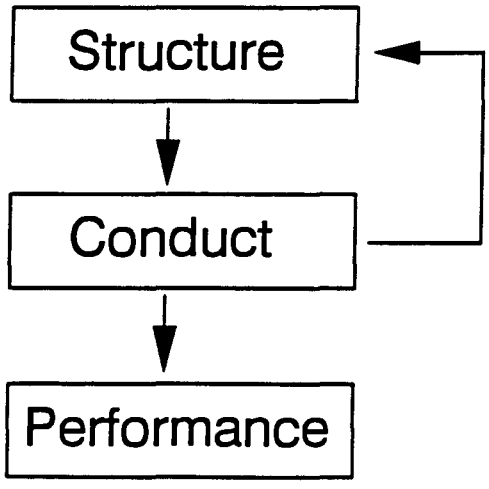
where the profits are explained by the number of sellers and the size of the advertising budget. The causal links in the SCP tradition are illustrated in Figure 4.1.

Critics of the SCP tradition argue that although the empirical studies reveal correlation between these factors, the SCP tradition lacks precise models of how firms behave. Because of lack of precise models, the empirical studies cannot reveal the causal links. A positive correlation between profit and advertising budget could be due to, for example, a fixed share of the profit being allocated to advertising outlay. This is the opposite causality to the one in the SCP tradition.

The introduction of game-theoretic models made it possible to build more precise models of firms' conduct. Two sets of game-theoretical models have proved to be especially important for analysing strategic interaction. First, the theory of repeated games sheds light on the dynamics of competition, in particular the rationale for maintaining a collusive outcome. Second, the theory of strategic commitment, pioneered by Schelling (1960), points out the gain from restricting one's own future action or, more precisely, future action rules. The first approach analyses in detail the box named 'conduct' in Figure 4.1. The commitment-based theories introduce a new causality compared to the SCP tradition, namely that conduct influences structure (see Figure 4.1). One example is that an incumbent's conduct can deter

entry and thus maintain his dominant position. Both sets of models draw on one of the other important developments during the '80s, the introduction of asymmetric information and how the actors can gain from exploiting the advantage of having private information. In addition, the last years we have seen examples where both sets of models are combined, i.e., dynamic models with commitments (see for example Maskin and Tirole 1987,1988a,1988b).

Figure 4.1 The Structure-Conduct-Performance Model



There exists many up to date reviews of the IO literature raising modelling issues of importance for the game between an incumbent and an entrant (Gilbert 1989; Liebermann 1988; Neven 1989; Ordover and Saloner 1989; Shapiro 1989a; Tirole 1988, chapter 8-9; Wilson 1990). Anticipating what follows in Part III (chapter 5-8), in this review of the literature we have chosen to focus primarely on the commitment issue. In particular, we have chosen as our starting point the entry game between one incumbent and one entrant, assuming no private information. After discussing their optimal strategies, we discuss whether the conclusions will change if we relax the assumptions concerning one entrant, perfect information, and non-collusive outcome.

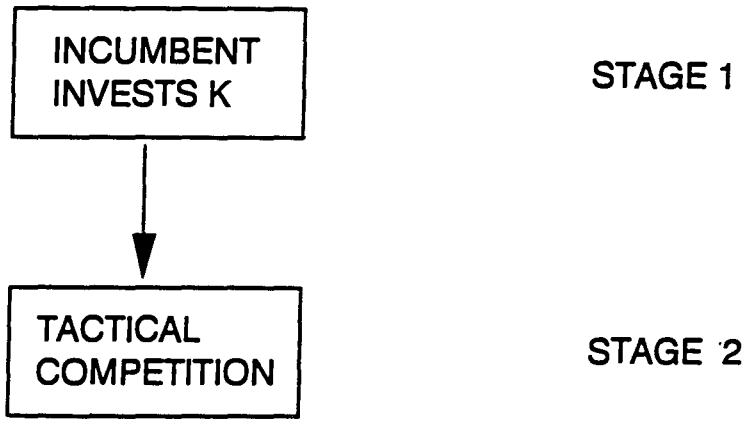
The chapter is organized as follows. In section 1, we set up a simple model that serves as a framework for analysing the interaction between the incumbent and one entrant. In section 2, we discuss various types of investments that the incumbent (or the entrant) can undertake.

In section 3, we discuss briefly how robust the results are, relaxing three of the assumption made in section 1 and 2. The chapter is summarized in section 4.

1. A theoretical framework[1]

To simplify, assume there is one incumbent (denoted 1) and one potential entrant (denoted 2). Further, assume that the incumbent has a first mover advantage. At stage 1, he can undertake a credible commitment, i.e., undertake an irreversible investment. The investment can take various forms such as capacity, advertising or R & D. At stage 2, the entrant decides whether to enter or not. If he enters, tactical competition will prevail at stage 2 between the incumbent and the entrant. The tactical competition will be either simultaneous quantity setting (Cournot competition) or simultaneous price setting (Bertrand competition). This entry game is illustrated in Figure 4.2.

Figure 4.2 An entry game



[1]This theoretical framework was first introduced in Fudenberg and Tirole (1984) and Bulow et.al. (1985b). Our presentation draws heavily on Tirole (1988), chapter 8.3.

The investment that the incumbent undertakes at stage 1, will influence his behaviour at stage 2. If investment reduces marginal costs, he will increase his optimal choice of quantity (or reduce his optimal price) at stage 2 for every choice that the rival makes, i.e., the investment will shift the incumbent's reaction function. The entrant observes the incumbent's investment and takes this into account when he decides whether to enter or not and how large quantity he should sell or at which price if he enters (stage 2). Put differently, the incumbent's commitment at stage 1 influences his own future behaviour and thereby influences the entrant's future behaviour. Being able to influence the entrant's behaviour, the incumbent has the option either to deter or to accommodate the entrant. In the former case his investment level at stage 1 is chosen such that the entrant's profit is non-positive if he enters. In the case of accommodation, he invests in such a way that the entrant will behave non-aggressively by setting a low quantity (if quantity is the choice variable) or setting a high price (if price is the choice variable). The incumbent will choose the one of these two strategies that maximizes his profit. Let us analyse each strategy separately.

1.1 Deterrence

Denote K as the incumbent's sunk investment at stage 1. The potential entrant observes K before he decides to enter or not (stage 2). The choice variables at stage 2 is X_1 and X_2 for the incumbent and the entrant, respectively. X can be interpreted as either price or quantity. Assuming deterrence, the incumbent will choose a level of K so as the entrant's profit (π_2) equals zero:

$$\pi_2(K,\ X_1^*(K),\ X_2^*(K)) = 0 \tag{4.1}$$

To understand how the incumbent can make entry unprofitable, we take the total derivate of π_2 with respect to K:

$$\frac{d\pi_2}{dK} = \frac{\partial \pi_2}{\partial K} + \frac{\partial \pi_2}{\partial X_1} \cdot \frac{dX_1^*}{dK} + \frac{\partial \pi_2}{\partial X_2} \cdot \frac{dX_2^*}{dK} \tag{4.2}$$

The effect of K on π_2 through the entrant's second-period action equals zero (from the envelope theorem), so the third term on the righthand side can be ignored. The first term

on the righthand side is defined as the direct effect, which can take two forms. First, the investment K can influence the market size relevant for the entrant. One example is that the incumbent integrates downstream, acquiring buyers of the final product. This would reduce the entrant's relevant market size and thereby reduce the entrant's profit regardless of how such an investment would influence the tactical competition (see section 2.2.1). Second, the investment K can directly influence the entrant's costs. One example is an incumbent that purchases the exclusive right to trade with the low cost producer. This can force the entrant to buy its input from a high cost producer (see section 2.1.2).

The second term on the righthand side is defined as the strategic effect. It says that the investment K changes the incumbent's behaviour at stage 2, and thereby the entrant's profit from entering the market. One example is investment that reduces marginal costs. Reduced marginal costs will increase the incumbent's optimal quantity (or reduce his optimal price) for whatever quantity (or price) the entrant sets, and thereby influence the entrant's optimal behaviour (see section 2.1.1).

The total effect of the investment K is the sum of the direct and the strategic effects. Let us assume that the investment K reduces the entrant's profit; $d\pi_2/dK < 0$. According to the terminology of Drew Fudenberg and Jean Tirole (1984), an increase in K will in that case make the incumbent tough. In the opposite case, where investment K increases the entrant's profit ($d\pi_2/dK > 0$), an increase in K makes the incumbent soft[2].

Assuming a deterrence strategy, it is obvious that the incumbent wishes to change K compared to the non-strategic choice of K in such a way that it makes him tough. This implies that if investment K makes him tough, he must 'overinvest' relative to a situation with no entry threat to deter entry. On the other hand, if investment K makes him soft, he must 'underinvest' to deter entry. The former is characterized as a Top Dog strategy: be big

[2]Put differently, tough and soft is defined according to the sum of the first and second term in (4.2). This is in line with the definition in Tirole (1988), chapter 8. Be aware that to be in line with the terminology Top Dog and Lean and Hungry Look (see next paragraph), tough and soft should be defined from only the sign of the second term in (4.2), i.e., according to only the strategic effect.

or strong to look tough or aggressive. The latter is characterized as a Lean and Hungry Look strategy: be small or weak to look tough or aggressive.

We thus see that in some cases the incumbent must underinvest to deter entry. A Lean and Hungry Look strategy can be an optimal deterrence strategy for the incumbent in the case of investment in advertising that increases own customers' brand loyalty (see section 2.2.2). Investment in marginal costs reductions, on the other hand, is an example of a Top Dog strategy when deterring entry (see section 2.1.1).

1.2 Accommodation

If the incumbent decides to accommodate the entrant, he will choose the level of K that maximizes his own profit taking into account that the entrant will actually enter. The total derivative of the incumbent's profit (π_1) with respect to K is:

$$\frac{d\pi_1}{dK} = \frac{\partial \pi_1}{\partial K} + \frac{\partial \pi_1}{\partial X_2} \cdot \frac{dX_2^*}{dK} + \frac{\partial \pi_1}{\partial X_1} \cdot \frac{dX_1^*}{dK} \tag{4.3}$$

From the envelope theorem we know that the effect of a change in K on the incumbent's second-period action can be ignored, i.e., the third term equals zero. The first term on the righthand side is the direct effect, also called cost minimizing effect. This effect exists regardless of the entry threat, and we have therefore chosen to ignore it in our discussion. The second term is the strategic effect. We decompose the second part to discuss the sign of the strategic effect[3]:

$$\frac{\partial \pi_1}{\partial X_2} \cdot \frac{dX_2^*}{dK} = \frac{\partial \pi_1}{\partial X_2} \cdot \frac{dX_2^*}{dX_1} \cdot \frac{dX_1^*}{dK} \tag{4.4}$$

Assuming that $\partial\pi_1/\partial X_2$ have the same sign as $\partial\pi_2/\partial X_1$, the product of the first and the last part of the term on the righthand side has the same sign as the strategic effect in the case of

[3]Be aware that we compare the open loop equilibrium with the accommodation equilibrium. The former is the equilibrium if there are no temporal linkages, i.e., the incumbent's investment before entry has no influence on the entrant's decision.

deterrence, i.e., in (4.2). If the direct effect in the entry-deterrence case equals zero, we can translate the terms tough and soft to the case of accommodation. If the sign of the product of the first and the third part is negative, investment K will make him tough. Conversely, a positive sign implies that investment will make him soft.

The second part of the righthand side of (4.4) is the derivative of entrant's reaction function with respect to his rival's choice variable, or more precisely the derivative of his best response function: How will the entrant's choice variable change if the incumbent's choice variable changes? If $dX_2^*/dX_1 > 0$, the choice variables are defined as strategic complements. If $dX_2^*/dX_1 < 0$, X_1 and X_2 are termed strategic substitutes. Assuming that the choice variables are prices, they will typically be strategic complements; the entrant's optimal price is increasing in the incumbent's price. On the other hand, the choice variables are typically strategic substitutes if the firms are setting quantities: the entrant's optimal quantity is decreasing in the incumbent's quantity[4]. Then we have four possible cases, dependent on whether investment makes the incumbent tough or soft, and whether the choice variables are strategic complements or strategic substitutes. The optimal strategy in each of the four cases is reported in Table 4.1. A denotes accommodation, and D deterrence.

Let us briefly describe each strategy:

(1) Top Dog: Be big or strong to look tough or aggressive
If investment makes the incumbent tough and the choice variables are strategic substitutes, it should 'overinvest'.

(2) Puppy Dog: Be small or weak to look soft or inoffensive
If investment makes the incumbent tough and the choice variables are strategic complements, it should 'underinvest'.

(3) Lean and Hungry Look: Be small and weak to look tough or aggressive.
If investment makes the incumbent soft and the choice variables are strategic substitutes, it should 'underinvest'.

[4]This is not generally true, but holds for a large number of demand and cost functions (see Bulow et.al. 1985b and Tirole 1988, p. 336-7).

(4) Fat Cat: Be big and strong to look soft or inoffensive.
If investment makes the incumbent soft and the choice variables are strategic complements, it should 'overinvest'.

Table 4.1 Optimal Business Strategies

	Investment makes the incumbent	
	Tough	*Soft*
Choice Variables		
$dX_2^*/dX_1 > 0$ *Str. complements*	*A: Puppy Dog* *D: Top Dog*	*A: Fat Cat* *D: Lean and Hungry Look*
$dX_2^*/dX_1 < 0$ *Str. substitutes*	*A: Top Dog* *D: Top Dog*	*A: Lean and Hungry Look* *D: Lean and Hungry Look*

A = Accommodation *D = Deterrence*

Thus, we can see that the incumbent's investment strategy, i.e., whether he should over- or underinvest to accommodate entry, is ambiguous in theory. In particular, note that the nature of the tactical competition is crucial to the choice between over- and underinvestment. One example is investment in marginal cost reduction, which makes the incumbent tough. If the choice variables are strategic complements, a Puppy Dog strategy is optimal. If the choice variables, on the other hand, are strategic substitutes, then a Top Dog strategy is the optimal accommodation strategy for the incumbent (see section 2.1.1).

The presented model is static because the sunk investment is set once and for all. A more realistic case would be a repeated game where the investment depreciates over time. If the investment has a finite lifetime, the incumbent must renew it earlier than what would have been the case without any strategic considerations in order to deter entry (see Eaton and Lipsey 1980). It can be shown that the general results from the static models hold when we

extend them to a dynamic model where the firms set prices or capacities asynchronously and they are fixed for two periods (Maskin and Tirole 1987, 1988a). The question whether one should 'overinvest' or not still depends crucially on whether the choice variables are strategic substitutes or complements. If, on the other hand, we assume a collusive outcome is attainable, the conclusions can be reversed (see section 3.1).

2. Examples of strategic commitments

Numerous types of strategic commitments can be encompassed in the theoretical framework we described in section 1. Let us distinguish between factors that affect the cost and the demand characteristics (see sections 2.1 and 2.2). In addition, we will discuss other types of commitments, in particular signing of contracts that influence the rival's behaviour without affecting costs or demand directly (section 2.3).

2.1 Investment influencing costs

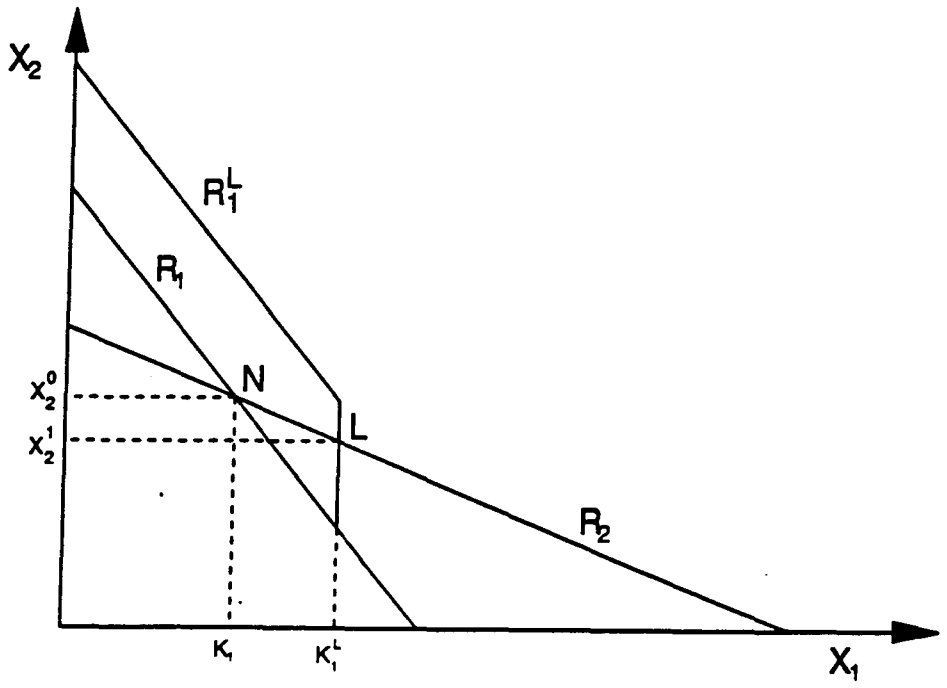
The discussion concerning the theory of contestability has highlighted the point that sunk costs, i.e., investments that are irreversible, are a barrier to entry because they create an asymmetry between an incumbent and an entrant (Baumol et.al. 1982,1986; Weitzman 1983; Shepherd 1984; Schwartz 1986; Seabright 1990). The incumbent can exploit this fact by undertaking a commitment prior to the entrant's entry decision. It is natural to distinguish between investments that influence own costs, and investments that influence rival's costs.

2.1.1 Own costs

The first analysis of strategic commitments concerned investment in capacity (Spence 1977, 1979; Dixit 1979, 1980). During the '80s we have witnessed several other interpretations of K: investment in marginal costs reduction (Dixit 1986; Seabright 1990; Schwartz 1989), investment in inventory holding (Ware 1985; Arvan 1985; Saloner 1986; Basu and Singh 1990), investment in learning by doing (Spence 1981; Fudenberg and Tirole 1983), investment in cost-reducing research and development (Brander and Spencer 1983; Spence

1984), or investment in debt (Brander and Lewis 1986). We have chosen to focus on the investment in capacity, and we use Figure 4.3 to illustrate some of the strategic considerations that an incumbent threatened by entry is facing.

Figure 4.3 Investment in capacity



For the moment, let us assume accommodation and that the choice variables are strategic substitutes, i.e., downward sloping reaction curves. Let R_1 and R_2 be the reaction curves of firm 1 and 2, respectively. X_1 and X_2 are the quantities supplied by each of them. First, let us assume that both set quantites simultaneously. The Nash equilibrium of the one-shot quantity game is marked with N in Figure 4.3. None of the firms will thus have no reason to build a capacity larger than K_1 and X_2^0, respectively, the quantity supplied in Nash equilibrium. Let us now assume that firm 1 has the option to invest in capacity before they set quantites simultaneously. Let us denote firm 1 as the incumbent, and firm 2 as the entrant. The incumbent invests K_1^L. Investment in capacity is a sunk cost that lowers the ex post marginal costs for the first K units, and thus shifts the incumbent's reaction curve outwards. This is illustrated with the reaction curve R_1^L, which coincides with the initial reaction curve above the capacity K_1^L. The shift in the reaction curve shifts the Nash

equilibrium, from N to L in Figure 4.3. We see that the incumbent's quantity increases, while the entrant's quantity is reduced. According to the terminology from the preceding section, the incumbent should thus follow a Top Dog strategy in order to soften the entrant (see Table 4.1).

There are several extensions of this simple model. First, introduction of entry costs will imply that the potential entrant will decide not to enter if the incumbent has commited himself to be sufficiently tough (see Schmalensee 1981). This illustrates the point from the preceding chapter, where the incumbent must choose either to deter the entrant or to soften him.

Second, the incumbent should underinvest and thus follow a Puppy Dog strategy if the choice variables are strategic complements and the incumbent decides to accommodate entry. Assuming choice variables are strategic complements, for example, Bertrand competition where they set prices, a more aggressive behaviour by the incumbent will result in a more aggressive behaviour by the entrant as well. If the incumbent 'underinvests' in such a case, he will credibly commit himself to a less aggressive pricing policy. This will induce the entrant to behave less aggressively as well in setting a higher price than otherwise, and thus soften the post entry rivalry. One example of a Puppy Dog strategy is presented by Bagwell and Ramey (1990) [referred in Wilson 1990]. An incumbent who anticipates that an entrant is prepared to serve the whole market restricts his capacity so that the entrant is better off sharing the market than initiating price cutting to serve the whole market. Conversely, a high cost entrant can soften the incumbent if he sets a limited capacity and a low price (Gelman and Salop 1983). The former, limited capacity, limits the incumbent's loss by accommodating entry, while the latter, low price, makes it costly for the incumbent to match the entrant's price.

Third, in some cases the incumbent will hold idle capacity after deterring entry. This is not the case in Figure 4.3. If we have an iso-elastic demand function and Cournot competition, the reaction curve turn inwards near the x-axis. Holding idle capacity after deterring entry can be shown to be a subgame perfect equilibrium in such a case (see Bulow et.al. 1985a).

On the other hand, if it is in the incumbent's interest to utilize all his capacity, 'overinvesting' in capacity can serve as a commitment to buy large quantities of input or sell large quantities. This commitment can induce upstream and downstream firms to invest certain specific sunk cost into their relationship with the incumbent firm. The reason is that they are assured that the incumbent firm will not behave opportunistically, such as limiting the quantity he demands (or supplies) at any given price, once the upstream and the downstream firms' sunk costs have been incurred (Ungern-Stenberg 1988).

Fourth, the sequence of moves has an impact on the equilibrium. Dixit (1980) assumed that the incumbent sets capacity at stage 1, and the incumbent and entrant set quantity simultaneously at stage 2. If we let the entrant set his capacity after the incumbent's capacity decision, but prior to the simultaneous quantity setting, i.e., a three stage game, the incumbent's first move is less important for the incumbent, but still beneficial for him (Ware 1984).

Fifth, the incumbent's as well as the entrant's number of possible response alternatives will be of importance. If the incumbent has the option to buy out an entrant, a threat of aggressive response to entry might not be credible, and an excess capacity policy can fail and even work against the incumbent (Rasmusen 1988). The intuition is that the entrant anticipates that the incumbent's best response to entry is buyout. As a consequence, the potential entrant decides to enter even when his profit in the non-cooperative, i.e., no buyout, equilibrium is negative. If the incumbent installs a large capacity prior to entry, the price in the non-cooperative equilibrium is low and hence his gain from buyout is increased. The entrant can thus be in a more favourable bargaining position after entry the larger the incumbent's capacity. This might imply that the incumbent's price for the buyout is increasing in his own capacity. The incumbent's optimal strategy prior to entry in such a case can be to set a lower capacity. This would make buyout less profitable relative to non-cooperative behaviour, and would make it more credible that the incumbent has an aggressive response to entry rather than buyout.

2.1.2 Rival's costs

An alternative to invest in order to change its own costs, is to invest in such a way that it increases the rival's costs. This idea was first introduced in Williamson (1968) and formulated within a game-theoretic setting in Salop and Scheffman (1983) (see also Krattenmaker and Salop 1986a, 1986b; Salop and Scheffman 1987). As shown by Williamson 1989, a capital intensive firm can gain by raising wages. Assuming wages are industry-specific, this will raise rival firms' wages. If the rivals are more labour intensive, the capital intensive firm puts its rivals at a disadvantage and thus softens them. This is an example of a Top Dog strategy by the incumbent. Even if we assume accommodation, this conclusion holds regardless of the the type of tactical competition that prevails. The reason is that an increase in the rival's marginal cost will soften him, regardless of whether the choice variables are strategic complements or strategic substitutes.

Another example of a cost-raising tactic is the signing of an exclusive dealing contract in which the supplier of an input agrees not to supply the rival firms. Although a firm would prefer its rival to be at a cost disadvantage does not mean that such a strategy of purchasing exclusive rights to some of the inputs is feasible and profitable. First, the supplier of the scarce resource the firm wants to exclude its rivals from might anticipate the value of the scarce resource and thereby demand a high price for the exclusive rights to this scarce resource. Second, the rival must not enter into a similar exclusive dealing contract with substitute suppliers that restores its competitiveness. Third, the excluding firm must have some market power if it is to exploit the rival's disadvantage. Whether a cost-raising strategy is profitable will thus depend on the exact nature of the strategic interaction (see Ordover and Saloner 1989).

Let us pay attention to the second issue mentioned in the last paragraph. If the entrant responds to incumbent's upstream integration by upstream integration itself, this will dampen and in some cases even wipe out the incumbent's gain from such a strategy. The reason is that the entrant's upstream integration gives him access to the input supply at a lower price, that is, marginal costs rather than the oligopoly price by the suppliers.

In a model with two upstream and two downstream firms it is shown that a downstream firm that accommodates entry would gain from upstream integration only if the choice variables are strategic complements at both levels (see Ordover, Saloner and Salop 1990). The sum of the two unintegrated firms', the upstream and the downstream, profits increases after the rivals' merger only when the choice variables are strategic complements. The reason is that the price charged by the unintegrated upstream firm increases when his rival merges, and that the downstream unintegrated firm's profit is increasing in his input price, i.e., the upstream firm's output price. The unintegrated firms will not counter the rival's merger with a merger of their own, because they now are better off than prior to entry. On the other hand, if choice variables are strategic substitutes an increase in the unintegrated upstream firm's output price will depress the sum of the two unintegrated firms profit. The unintegrated firms will therefore be better off with a merger of their own as a response to the rivals' merger. The former can be interpreted as a Fat Cat strategy by the incumbent, where his merger will soften the entrant. In the latter case an upstream vertical integration by the incumbent will trigger off a similar investment by the entrant, and the incumbent will thus be better off with a Lean and Hungry Look strategy: underinvest (i.e., no investment) in upstream vertical integration to soften the entrant. Hart and Tirole (1990) criticize the assumptions in Ordover, Saloner and Salop (1990), arguing that their result hings on the firms' ability to credibly commit to set a certain price and not to use a two-part tariff. Hart and Tirole (1990) set up a more general model, and analyse among other things when exit, which is analogous to entry deterrence, is most likely to occur.

Downstream integration is an alternative way to deter entry. If an incumbent owns the retailers, the potential entrant can be forced to set up his own distribution network. This can serve as a barrier to entry (see Tirole 1988, chapter 4). There exists, however, other types of commitments than direct ownership that can force the entrant to set up his own distribution network. In particular, contracts between the incumbent and retailers can also deter entry (see section 2.3).

One particular way to put potential entrants at a disadvantage is to invest in sleeeping patents, first analysed in Gilbert and Newbery (1982) and further discussed in Reinganum

(1983,1984), Gilbert and Newbery (1984a,1984b), Salant (1984), Gallini (1984) and Cave (1985). The incumbent need not adopt a new technology he has developed, because he can deter entry simply by using patent protection to exclude the entrant's choice of alternative techniques and products. There is, however, scope for licensing if the contract is constructed in such a way that both the incumbent and the entrant are better off with than without licensing (Katz and Shapiro 1985).

2.2 Investment influencing demand

As pointed out in Bain (1956), demand characteristics will often favor the incumbent's product. The reason is that consumers facing the choice between the existing product, which quality they know with certainty, and a new product, which expected quality is the same but uncertain, will choose the existing product if the prices are identical (Weizsäcker 1980; Schmalensee 1982; Conrad 1983; Farrell 1986; Besanko and Donnenfeld 1988; Bagwell 1990). In addition, there can exist externalities between consumers. A classical example is the installation of communication networks, where each person's utility from participating increases in the number of persons connected to the network. This is characterized as network externalities, and can deter entrants from entering (see Farrell and Saloner 1987). Let us see how the incumbent can undertake a strategic commitment that exploits such asymmetries on the demand side and the advantage of being first. We distinguish between positioning and clienteles.

2.2.1 Positioning

Positioning can be interpreted as physical location, or as location in a product space in the case where consumers have heterogenous tastes. The issue was first discussed in Hotelling (1929), who showed that two firms would locate in the center if the consumers are uniformly distributed along a straight line segment. If we allow for price competition, there exists no pure strategy equilibrium in such a game (see d'Aspremont, Gabszewicz, and Thisse 1979; Dasgupta and Maskin 1986). The reason is that each firm will capture all the rival's customers if he reduces the price marginally. To soften price competition, the firm will

position itself away from rival's products (the strategic effect). Moving towards the center of the segment, where demand is concentrated, will increase a firm's market share and profit at given prices (the direct effect). These two effects work in opposite directions. Consequently, the degree of product differentiation is ambiguous (Tirole 1988, chapter 7). In line with Tirole (1988), p. 329, we can define a location close to the center of the segment as high capital accumulation, and vice versa for a location away from the center. Product differentiation, where the firm locates away from the center, will thus be characterized as a Puppy Dog strategy: 'underinvest' to look soft. Such a Puppy Dog strategy is more likely to be optimal the larger the incumbent's competitive advantage (Carpenter and Nakamoto 1990).

In the preceding section, we assumed that two firms (or more) were active, which can be interpreted as the accommodation equilibrium. If the incumbent decides to deter the entrant, he can introduce many brands and thus serve all the segments in the market. In that case, the entrant will find post entry price or quantity competition too tough, and therefore decide not to enter (Schmalensee 1978; Eaton and Lipsey 1979). This is an example of a Top Dog strategy to deter entry. As shown in Dixit (1979), a low cross price elasticity will favor accommodation while a large absolute demand advantage for the incumbent will favor deterrence.

Such preemption by the incumbent will be credible only if the introduction of brands are irreversible, i.e., exit after the entrant penetrated the market is not possible (see Judd 1985). The reason is that the incumbent has more to gain from withdrawing a brand than the entrant. The softened price competition from a withdrawal will gain all or many of the incumbent's brands, but only the one brand, by assumption, the entrant is offering. However, if the firm can 'divisionalize' in a credible way so that each division runs its own product independently, none of the divisions have incentives to close down ex post entry even if exit costs are zero (Corstjens et.al. 1987, referred in Neven 1989). In addition, if the withdrawal of a brand signals that the firm's remaining brands have low quality, it can be rational for the incumbent not to withdraw a brand (see Choi and Scarpa 1992).

Another interpretation of multiple brands is that a firm can establish outlet stores throughout the market. The incumbent will then serve all the geographic markets, and the entrant will face tough tactical competition wherever he locates himself. As long as exit costs exist, such an overinvestment in distribution capacity can deter potential entrants. Assuming accommodation, the conclusion hings on the nature of competition. If the choice variables are strategic complements, the incumbent will soften the entrant by using a Puppy Dog strategy, i.e., set up a limited number of retailers to soften the post entry competition. A firm that sells direct to consumers could gain by selling through an independent retailer. The intuition is that both the incumbent and the retailer would then set a price-cost margin, and thereby limiting the quantity sold to the customers (McGuire and Staelin 1983; Bonanna and Vickers 1988; Lin 1988). Conversely, the incumbent should follow a Top Dog strategy if the choice variables are strategic substitutes. He should 'overinvest' in number of retailers, or sell direct to the consumers in order to soften the entrant. The option to sign specific contracts between the manufacturer and the retailer, such as two-part tariffs, can be an alternative to the investment strategies mentioned here (see section 2.3.3).

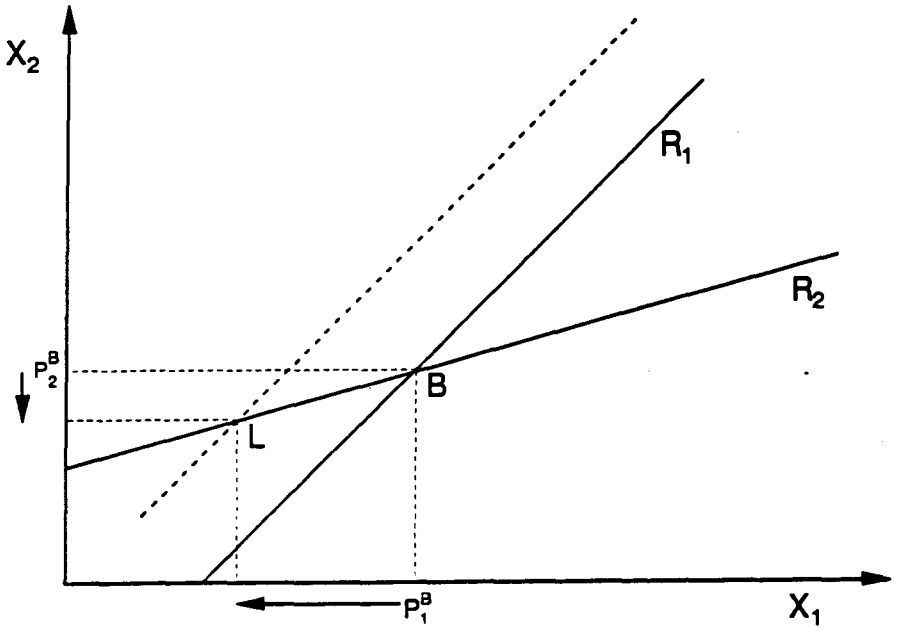
2.2.2 Clienteles

We define clienteles as a group of customers that are strongly linked to one producer, either because their switching costs are high or they have a high brand loyalty for other reasons. The latter can be due to advertising outlays that convince the consumers that this particular product is unique and thus reduces the cross price elasticity of demand. One example of switching cost is frequent flyer plan. The plan makes it costly for a consumer to switch to another airline because he will lose his option to a free flight in the future.

Advertising outlays was long regarded as a sunk cost that acted as a barrier to entry (for surveys, see Schmalensee 1986; Scherer and Ross 1990, chapter 16). The argument was that advertising created brand loyalty, and thus made it difficult for entrants to capture the incumbent's customers. This suggested that an incumbent could deter entrants by 'overinvesting' in advertising outlays, i.e., by following a Top Dog strategy. Schmalensee (1983) shows that this result is not general (see also Fudenberg and Tirole 1984).

High advertising outlays will result in loyal customers, and the incumbent wants to set a high price-cost margin for these captive customers. For those who are not loyal, i.e., are inclined to buy the entrant's product, the incumbent wants to set a low price-cost margin. Assuming that price discrimination is impossible, the firm finds it profitable to set an intermediate price that is higher the more important the captive customers are. This implies that the more the incumbent advertises to gain brand loyalty, the more friendly is the welcome (i.e., the softer the price competition) for an entrant. According to this, an incumbent should 'underinvest' to deter entry, i.e., follow a Lean and Hungry Look strategy and thus be small or weak to look tough. This can be illustrated in Figure 4.4, where we assume strategic complements.

Figure 4.4 Investment in advertising



The incumbent's and the entrant's prices are along the horizontal and vertical axis respectively. We assume that the choice variables are strategic complements, and that the equilibrium without any strategic consideration, i.e., no intertemporal linkages, is in B. Assuming that the entrant will earn profit in that equilibrium, he will enter. A reduction in the incumbent's advertising will shift the incumbent's reaction curve downwards, because his consumers are less loyal and thus not willing to accept the high initial price. The equilibrium will then be L in Figure 4.4. The entrant's price is also reduced due to the incumbent's

more aggressive behaviour, with the result that the entrant's profit decreases. We thus see that 'underinvestment' makes an aggressive behaviour by the incumbent credible and thereby limits the entrant's profit from entering.

On the other hand, advertising outlays can reduce the number of customers that are inclined to shift to the entrant (direct effect). To highlight this point, let us assume that the customers that the incumbent captures due to the advertising are identical with the types of customers he initially serves. Conversely, we assume that the customers that the entrant loses due to the incumbent's advertising are identical with the type of customers that remains loyal to the entrant. If this is true, the advertising will neither change the incumbent's nor the entrant's optimal price. In Figure 4.4 this can be interpreted as though the initial prices (P_1^B, P_2^B) are maintained, but that the entrant's customers at such a price are reduced and thus his profit in B is lower the higher the incumbent's investment in advertising. For a sufficiently large increase in the incumbent's investment, the entrant's number of customers is so low that his profit equals zero. We thus see that if there exists no price effect and thus no strategic effect, the direct effect will induce the incumbent to overinvest in advertising. In reality both effects will work, and the net effect will thus be ambiguous. If the direct effect wipes out the strategic effect, the incumbent should follow a Top Dog strategy to deter entry.

Assuming accommodation, the potential entrant will by definition enter. Advertising will make the incumbent soft, and according to Table 4.1 the incumbent should follow a Fat Cat strategy if choice variables are strategic complements and a Lean and Hungry Look strategy if choice variables are strategic substitutes. In the first case the incumbent's overinvestment will make himself soft and thereby induce the entrant to soften his behaviour as well. In the latter case the underinvestment will make him more aggressive, and this will soften the entrant.

Switching costs will in principle have the same effects as advertising (Klemperer 1987a, 1987b; Farrell and Shapiro 1988). The distinction is that while advertising causes a psychological cost when switching from one brand to another, switching costs are by definition monetary outlays when switching from one brand to another. The latter will make

it costly for the customers to switch to another seller, and by this the firm can set a high price. However, the customer lock-in will make a firm less aggressive in future periods, because its incentive to lower its price is reduced. This is parallell to advertising. A Lean and Hungry Look strategy can thus be the optimal way to deter entry if the strategic effect outweighs the direct effect, and that a Fat Cat strategy can be the optimal way to accommodate entry if choice variables are strategic complements.

Compatibility is also analogous to the case of clienteles. Let us assume there exists price competition, and that an incumbent initially sells two complementary products that are incompatible. One example is a firm that produces two types of cameras and lenses for these two types of cameras, but where the lenses are incompatible. Incompability will hurt a potential producer of one of the lenses in two ways (see Matutes and Regibeau 1988). First, the entrant's sale will be limited because he can only capture customers demanding one of the two systems. Second, incompability leads to a more aggressive price competition, because the incumbent will not affect his own price in the monopoly segment when he lowers his price in the segment where he is challenged. Both effects lead to the conclusion that incompability tends to deter the entrant. Assuming accommodation, the conclusion can be reversed. Compatibility will soften the price competition, because the incumbent's loss by price cutting is larger than what would have been the case if the two systems were incompatible. Similar strategic considerations arises when the incumbent has the option to tie-in several products (see Whinston 1990).

2.3 Investment in contracts

So far we have only mentioned investments where the firms sunk resources, for example, investment in a plant or an advertising campaign. An alternative is that the firms write contracts with some actors, and thereby more directly influence their behaviour. Let us distinguish between contracts with managers, consumers, and retailers.

2.3.1 Contract with managers

The main reason for a strategic commitment is to commit to a certain course of action in the future, and thereby force rivals to change their course of action. One way this can be done is by delegation of authority, as first pointed out in Schelling (1960). The owner can for example sign contracts with managers (Fershtman and Judd 1987) or with the workers (Riis 1989). Let us assume a Cournot duopoly game. As shown in the preceding section, a firm that has the option to commit before the tactical competition would choose to act more aggressively than what would have been optimal without any strategic considerations if the choice variables are strategic substitutes. If the owner of the firm and the manager sign a contract saying that the manager will be paid according to sale and not profit, this firm will behave aggressively in the Cournot competition that follows. This will soften the rival, and the firm will thus increase its own profit by following a Top Dog strategy. If both firms sign such incentive contracts, the competition becomes tougher and both firms have lower profits. The reverse result holds if Bertrand competition prevails, although with one important difference. The follower will increase his profit compared to the no-contract equilibrium, and even more than the leader, i.e., the one that signs a contract. Each of them will thus prefer to be the follower, and therefore none of them will sign a contract with their manager.

There is an additional problem with the signing of such contracts. An owner-manager contract will not be credible, because it is not observable (see Katz 1991). Both the owner and the manager have incentives to cancel the contract once the rival has acted as induced by the contract they believed to apply. It will then be in the owner's and the manager's joint interests to sign a contract that instructs the manager to maximize profit. One way around this difficulty is to hire managers which are known for their commitment to maintain market dominance (Vickers 1985). The type of person hired rather than the contractual arrangements will then be the crucial strategic element.

2.3.2 Contract with customers

A firm might sign contracts that will either commit the firm to an aggressive course of action, or the reverse. One example is a 'meeting competition' clause. It means that the firm signs a contract with a customer saying that this buyer is guaranteed that the price he pays will always match the rival's lowest price. Although such a clause apparently instructs the firm to behave aggressively, the final outcome is that both firms behave non-aggressively. The intuition is that the rival will not capture any new customers by lowering his price, because a price cut will simultaneously lower the other firms price with the same amount. He will therefore have no incentive to deviate from a high initial price (see Salop 1986; Holt and Scheffman 1987). Another form of clause, the most-favoured-customer clause, assures a buyer that if the seller in the future offers a lower price to another buyer he will, retroactively, offer this buyer the same price. This will make it costly for the firm to lower its future price, for example to price discriminate, and thus induce him to act softly (see Cooper 1986).

Neither of the two clauses mentioned above will discourage entry, but rather induce the firms to act non-aggressively. Aghion and Bolton (1987) offers an example where a 'take or pay' clause between an incumbent and a customer can deter entry. The incumbent has a known marginal cost $C_i = 1/2$, while the entrant's marginal cost, denoted C_e, is uncertain but uniformly distributed on the interval [0,1]. If entry takes place, they act as Bertrand competitiors and the price equals the marginal cost of the high cost firm ($P = \max\{1/2, C_e\}$). Entry will occur with the probability 1/2, i.e., only if $C_e \leq 1/2$.

Let us now assume that the incumbent offers the customer a contract which says that he can either buy from the incumbent at the price P, or from the entrant at the price $P_e + P_0$. P_e is the entrant's price and P_0 is the price the customer has agreed to pay to the incumbent if he buys from the entrant. If entry takes place, the highest price that the entrant can set equals $P_e = P - P_0$. At a price above this, the consumer is better off if he buys form the incumbent rather than the entrant. It can now easily be shown that if the incumbent offers a contract where $P = 3/4$ and $P_0 = 1/2$, entry will only occur if $P_e \leq P - P_0 = 1/4$. The

incumbent will be better off, because the probability of entry is reduced (entry only if $C_e < 1/4$, compared to $C_e < 1/2$ if no contract). More surprisingly, the customer is not worse off. The intuition for the latter result is that although the customer benefits from competition and no contract, he will not benefit from the entrant's lower cost (the price equals 1/2 with entry when no contracts). The incumbent can exploit this fact, by offering a contract that ensures that the customer will be guaranteed to benefit from competition if the entrant's cost is sufficiently low (in our case below 1/4). We thus see that the contract implies that the incumbent's price is lowered (from the monopoly level 1 to 3/4), but the probability of entry is lowered as well. The key to entry prevention is the fact that only the incumbent (by assumption) is allowed to sign a contract with the customer. If the entrant has the same opportunity, he could sign a contract where a share of his profit was transferred to the customer. For a different kind of contractual agreement between incumbent and customers to prevent entry, see Rasmusen et.al. (1991). It is, however, doubtful whether contracts between an incumbent and a buyer can be enforced. If the law bans such exclusionary agreement, the incumbent cannot use the court to enforce a customer to act in accordance with the contract.

2.3.3 Contract with retailers

As we mentioned briefly in section 2.2.1, a manufacturer's contract with a downstream firm can dampen the upstream competition between the manufacturers. If the manufacturers can lower the cross price elasticity of demand, the interbrand competition will be dampened and the manufacturers' profit will increase. Both exclusive territories and exclusive dealing can dampen interbrand competition (see Rey and Stiglitz 1988; Lin 1990).

Competition between retailers may prevent the provision of service such as presale product information. The reason is that consumers have incentives to visit the retailer that provides service but have a correspondingly high price, and then to buy from the retailer which offers no presale information and a low price. If a retailer is offered an exclusive territory, the consumer has not the option to buy the same product form another retailer. He will then have incentives to provide presale information, and this may in turn strengthen the product

differentiation and thus dampen the competition. If the retailer in addition is imposed to sell only one brand, the interbrand competition may be dampened further. The intuition is that the consumers' search costs are higher than they would be if a single retailer was to carry several different brands of the product. This tends to discourage the consumers from undertaking the search activity, limiting the extent of interbrand competition.

Let us apply the above results in a game between an entrant and an incumbent, assuming that the incumbent can sign contracts with retailers prior to the entrant's entry decision. Both exclusive dealing and exclusive territories can make oneself more soft in the way of offering a higher price or a lower quantity, all else equal. From Table 4.1 we see that such contracts are optimal only if the incumbent accommodates the entrant, assuming price competition will prevail. Such contracts will then make oneself soft, and thereby induce the rival to behave inoffensive as well. In all other case, deterrence and accomodation combined with quantity competition, the incumbent should 'underinvest' in such contracts in order to credibly commit to an aggressive behaviour in the tactical competition (Lean and Hungry Look strategy).

Alternatively, we could let the incumbent offer the retailer(s) a two-part tariff before entry, consisting of a fixed fee and a price per unit. If he wants to deter the entrant, he should set a low price per unit, in some cases lower than his marginal costs, and thus induce the retailer(s) to behave aggressively (Top Dog strategy). If he wants to accommodate the entrant, the strategy will be to set a low price per unit if quantity competition (Top Dog strategy) and a high price per unit if price competition (Puppy Dog strategy) and thereby induce the entrant to behave inoffensive. Finally, there are other instruments the incumbent can use to deter entry. One example is to exploit retailers' preference for featuring a dominant brand (see Nelson and Hilke 1991).

As mentioned in section 2.3.1, contracts may not be credible because both parties have incentives to rewrite the contract after the rival has behaved in accordance with the contract that he believe is valid. However, Hadfield (1991) proposes a contractual design that makes no renegotiation of the contract credible. The idea is to construct a franchise agreement where the manufacturer is excluded from exerting pricing authority over the franchisee, and

the contract includes a clause saying that the manufacturer must compensate the franchisee by returning the sunk investment in capital and franchise fees if he buys him out. By appropriately selecting a wholesale price, the manufacturer is able to credibly commit himself not to renegotiate the contract.

3. How robust are the results?

Throughout section 2 we have mainly referred to studies that have the simplifying assumptions we specified in section 1. In particular, we have assumed a non-collusive entry game with only one incumbent and one entrant where none of them have private information. Let us here briefly discuss how the conclusions referred in section 2 may change if three of these assumptions are relaxed: there is scope for a collusive outcome; there is more than one entrant; one of them has private information. We discuss each relaxation separately.

3.1 Prospects for collusion

The entry game we specified in section 1 is static, because the choice variables are set in a one-shot game after one (or both) has undertaken a commitment. The one-shot game is typically either a simultaneous price setting game (Bertrand equilibrium) or a simultaneous quantity setting game (Cournot equilibrium). It is well known that if we replicate the one-shot game for infinity, there will exist numerous possible equilibria (see Tirole 1988, chapter 6). One possibility is that the equilibrium from the one-shot game is maintained, i.e., a Bertrand equilibrium if price setting and Cournot equilibrium if quantity setting. More interestingly, a collusive outcome can be an equilibrium if the discount factor is sufficiently high. The prospects for collusion and thus high profits for an entrant penetrating a monopoly market should apparently increase the probability of entry. However, this need not be the case (Stenbacka 1990). The reason is that entry may start the most severe punishment path, as described in the duopoly models in Abreu (1986). In the entry game setting in Stenbacka (1990) the entrant earns zero profit in the post entry competition. Entry will then be unprofitable as long as entry costs exceed zero.

Assuming the strategy profile is such that they start out with a collusive outcome, there is a scope for entry. The prospects for a collusive outcome will reverse some important results reported in section 2. Anything that makes more competitive behaviour feasible or credible will actually promote collusion. The reason is that the firms would prefer the collusive outcome rather than a non-collusive outcome where they both behave aggressively and profits are low. In the 'Orwellian' terminology, 'competition is collusion' according to Avinash Dixit (see Shapiro 1989). If the incumbent invests in excess capacity, the equilibrium price in the non-collusive outcome will be rather low. The post entry equilibrium can then collusion and thus accommodation of the entrant. A limited capacity by the incumbent will make the non-collusive outcome more profitable and thereby make the threat of non-collusive outcome credible. As shown in Benoit and Krishna (1991), entry can in some cases be deterred only if the incumbent sets a capacity below the optimal capacity in the monopoly equilibrium. This is in contrast to the results referred in section 3, where we found that 'overinvestment' in capacity would deter entry regardless of whether the choice variables are strategic substitutes or strategic complements.

3.2 Several potential entrants

Fighting an early entrant may give the incumbent a reputation that he will deter later entrants. One should therefore at first sight expect that the incumbent could find it profitable to fight an entrant that he would have chosen not to fight if this was the only entrant. Selten (1978), using the case where a chain store faces entry in many towns, shows that this argument will be false if there exist perfect information and a finite number of entrants. It is common knowledge that he will not fight the last entrant, because there are no reputational effect in such a case. Then he would not fight the last but one entrant, and so on. This paradoxial result, called the chain store paradox, will not emerge if we assume that there exists some private information about the incumbent's behavioral rule (see section 3.3).

An important question is whether the strategy of entry deterrence is impossible once there are more than one established firm, ie., once one entrant has penetrated a monopoly market and there are several potential entrants left. One could argue that erecting entry barriers is

a public good and each one of them would prefer to be a free rider, i.e., the other established firm erects the entry barrier. Gilbert and Vives (1986) show that the opposite can be the case. Each established firm would prefer to contribute to large capacity in the industry, and thereby deter entry and have a large market share. However, Waldman (1987) shows that the conclusions are ambiguous for more general models.

Assuming sequential entry, the first entrants will have first mover advantages. It is shown in Schwartz and Baumann (1988) that the first mover entrants earn more profit than later entrants, because early entrants can shift the burden of entry deterrence to later entrants. However, the relative size of the entrants are ambiguous, i.e., the first entrant can be either larger or smaller than later entrants. For models analysing the equilibrium number of firms, see Bernheim (1984) and Eaton and Ware (1987).

3.3 Private information

As mentioned in the preceding section, the result characterized as the chain store paradox is no longer true if we assume private information. Milgrom and Roberts (1982a) assume that each entrant entertain the possibility that the incumbent follows some simple behavioral rule such as being a fanatic predator. Put differently, there is a probability that the incumbent behaves irrationally in the way that he responds to entry by preying regardless of what other players do. Alternatively, one can assume that the incumbent is either weak or strong. An incumbent that is a strong type will find it profitable to fight entry in this period, and vice versa for weak (see Kreps and Wilson 1982). In both models the entrant thus believes there is a possibility that the incumbent will actually fight. A rational incumbent will anticipate this and fight if entry actually occurs to maintain the reputation of being a strong or 'irrational' type, even in cases where he actually is the opposite type. If the entrant entertains only a slight probability that the incumbent is such a type, this can be sufficient to induce the incumbent to fight the first entrant.

If the incumbent exhibits private information about his own costs, then a limit pricing strategy can be a rational entry deterrence strategy. This was first shown in Salop (1979),

and shown in a game-theoretic setting in Milgrom and Roberts (1982b). Suppose the entrant can only observe the incumbent's price, not his marginal costs. If the incumbent sets a low price, this can signal that his marginal costs are low and thus that the price in a post entry duopoly equilibrium will be rather low. However, in some cases a high cost incumbent can mimic the behaviour of a low cost incumbent and the low price is in such a case not a credible way to reveal low cost (pooling equilibria). Milgrom and Roberts (1982b) deduce conditions that ensure that a high cost incumbent will not find it profitable to mimic a low cost incumbent (separating equilibria). Whether a limit pricing strategy can reveal information will thus depend crucially on the data of the specific entry game. The conclusion is also very sensitive to the specification of the private information. For example, let us assume that the entrant and the incumbent's cost are equal but unknown for the entrant. In such a case the incumbent can signal that they both have a high cost by setting a price above his own monopoly price and thereby deter entry (see Harrington 1986). For more details about signalling and predation games, see the survey in Wilson (1990).

4. Some concluding remarks

Those who prefer one *general theory of entry games* must have been disappointed by the development in the IO literature over the last decade[5]. Different models developed during the '80s predict strictly opposite results. One example is capacity to deter entry. The two-stage game model predicts that a large capacity by the incumbent will deter entry, while the repeated game model predicts that a low capacity can deter entry. In addition, the predictions from each model depends crucially on the assumptions. One example is investment in cost reductions to accommodate entry. The two-stage game model predicts that the incumbent should 'overinvest' if the choice variables are strategic substitute and 'underinvest' if the choice variables are strategic complements.

[5]One who has been disappointed is Franklin M. Fisher. He argues that little or no progress has been made despite the surge of theoretical activity in IO (see Fisher 1989).

However, the theoretical ambiguity can be a virtue rather than problem. Structural characteristics varies across industries, pointing to the need for different models. The richness of the entry game theory can thus be regarded as a bag of tools that we can use to tailor-make a theoretical model to the specific context. The application of the theoretical model to a specific industry requires specific knowledge about structural characteristics of an industry, as well as the nature of competition in the particular industry. Important questions should for example be: has the incumbent a cost advantage relative to the potential entrant; what response alternatives does the incumbent have to entry; do the firms have excess capacity; will the products be identical? Answer to questions like these should be crucial for the selection of a theoretical model. This brings us back to the old IO tradition, where one had detailed knowledge about specific industries. The main difference is that we now have theoretical models that can specify the firms' behaviour in a precise and consistent manner. According to Carl Shapiro, we will during the next years see 'a marriage of the theory of business strategy and the tools of industry analysis. In other words, I believe that the most useful contributions of the 1990s will come from consolidating what we have learned in the 1970s and the 1980s with the more detailed empirical approach of the 1940s and 1950s' (Shapiro 1989, p. 134).

Chapter 5:

A CONSUMER AS AN ENTRANT

The single dominant incumbent in the Norwegian cement market, Norcem, has during the last decade been challenged by independent firms that have started importing cement to Norway (see chapter 2). Viking Cement became a rival to the single dominant incumbent in the cement market, while Concord initially was a consumer of the incumbent's product and thus started importing cement for its own consumption. In this chapter we will use a simple theoretical model to compare those two types of entrants. Put differently, we will compare the entry strategies of the two types of entrants which we in Figure 1.1 in chapter 1 called a 'consumer' and a 'dealer'. We will show that those two types of entrant will follow quite different entry strategies.

To apply the model to the Norwegian cement market, we have to take into account one more characteristic of this particular market. The incumbent has the option to purchase the exclusive rights to import from foreign producers (see chapter 2, and section 3 in this chapter). He might thus cut off the entrant's imports of cement. Using a theoretical model we will show that both types of entrants must accept a high import price.

The possibility that consumers themselves enter a market was analysed first time in the game-theoretic literature in Sexton and Sexton (1987)[1]. They investigated the specific case where the entrant in fact was an association of an incumbent firm's consumers, i.e., a cooperative. In a recent paper, see Scheffman and Spiller (1992), the scope for limit pricing in markets with strategic buyers has been investigated within a more general framework (see also Instefjord 1991). It is shown that limit pricing can be a rational behaviour of the incumbent firm if buyers can make credible, but costly, commitments to switch suppliers even if there is no private information about, for example, the incumbent firm's cost. The intuition is that current prices and buyer's decision to switch suppliers are related. A low price by the seller will make the buyer's costly commitment, i.e., investment, less profitable and thereby might

[1]Examples of related studies are models of interest organizations for consumers (see Baysinger and Tollison 1980; Ellingsen 1991; Wenders 1987).

deter him from investing. In contrast to them, we focus on what market outcome will prevail if the consumer in fact undertakes a sunk investment. We will show that even if no limit pricing takes place that the 'consumer' can benefit from, the 'consumer' still has an advantage relative to an ordinary entrant.

The potential for an exclusive agreement between the domestic incumbent and a foreign producer is discussed in the theory of exclusionary rights; see for example Salop and Scheffman (1983,1987), and Krattenmaker and Salop (1986a,1986b). Our entry game shares many similarities with Gelman and Salop (1983), where it was shown that the optimal strategy for a high cost entrant is to set a 'low' output price and a 'limited' capacity. In that study, however, the incumbent did not have the option to purchase exclusive rights, and the entrant was a 'dealer' and not a 'consumer'.

Although our analysis is tailored to the characteristics of the Norwegian cement market, it should be of interest in other markets as well where the buyers can undertake sunk investments to have access to secondary suppliers. In fact, empirical studies suggest that buyer power matters in many markets (Brooks 1973; Clevenger and Campbell 1977; Lustgarten 1975; Porter 1974; Round 1984).

The chapter is organized as follows. In section 1, we describe the model and analyse the input price decision of the 'consumer' if he decides to undertake a sunk investment that enables him to receive deliveries from a second source. The entry decision of the 'dealer' is analysed in section 2. In section 3, we formulate two hypotheses based on this model, and compare the hypotheses with the observations in the Norwegian cement market. In addition, we analyse how a ban on regional price cuts will influence the market outcome. The results are summarized in section 4, where we also briefly discuss how sensitive the results might be to some of the specifications in our model.

1. A model of a strategic consumer

To set up a simplified model, we assume that there exists a domestic monopolist selling to several small and one large consumer. An example of a large consumer in the cement market is a construction firm that uses cement as an input in its own production. The large consumer, from now on called the consumer, can undertake an investment, that is, a sunk cost that will enable him to receive deliveries from a foreign producer. The foreign producer's product is identical to the domestic monopolist's product. We assume that the monopolist's marginal costs of delivering are lower than the foreign producer's because of transportation costs. Furthermore, we assume that domestic competition policy forbids any bargaining between the consumer and the initial monopolist. This excludes the monopolist from paying the consumer for not investing, i.e, forbids preemption.

It is well known that simultaneous price setting and homogenous products can lead to an equilibrium in mixed strategies (see Kreps and Scheinkmann 1983). To avoid mixed strategies, we assume sequential price setting. We allow the incumbent to respond to the consumer's price setting and thus to have the second mover advantage. The incumbent's second mover advantage can be interpreted as a way to model the incumbent's pioneering brand advantage. Indeed, it is a rather arbitrarily, but simple, way to model such an advantage, which has been shown to be important even if the expected quality is identical for the two producers' products (see Schmalensee 1982).

At a certain point in time the consumer has the option to undertake a sunk investment (stage 1). If he invests, he announces an input price P_I which he wants to agree upon with either the domestic monopolist or a foreign producer (stage 2). The monopolist observes the sunk investment and the price announcement and responds in one out of three ways: accept, bribe or fight (stage 3).

At stage 3, the monopolist's first alternative is to accept that the consumer is importing directly and maximize his profit from the residual demand. Denoting D_M as the monopolist's total demand, and ξ as the consumer's share of the monopolist's market, we can define the

consumer's demand for input as $D_G(P_1) \equiv \xi \cdot D_M(P_1)$. For simplicity, let us assume that the incumbent's marginal costs equal zero. Defining π_i^{jk} as firm i's profit when its response to rival k is j, the monopolist's profit of accepting direct imports by the consumer is:

$$\pi_M^{AG} = \max_{P_M} P_M D_M(P_M)[1 - \xi] \ . \tag{5.1}$$

The monopolist's second alternative is to bribe all the foreign producers, i.e., compensate them for not delivering to the consumer. Let us for simplicity assume there are N foreign producers (N > 1), all with marginal costs equal to C_H. The foreign producers will accept being bribed only if that is more profitable than delivering to the consumer, i.e., a self-enforcing outcome. The monopolist's profit from bribing is then the initial monopoly profit (π_M) minus the cost of bribing the N foreign producers:

$$\pi_M^{BG} = \pi_M - N(P_1 - C_H)D_G(P_1) \ . \tag{5.2}$$

π_M^{BG} is decreasing in P_1 (see Appendix B). The intuition is that the foreign producer's profit from delivering to the consumer is low when the input price is low, and the side payment, the bribe, needed to compensate foreign producers for not delivering to the consumer is low as well.

The monopolist's third alternative is to fight by setting the price announced by the consumer throughout the market. We assume that the consumer will choose him rather than foreign producers that offers to deliver at an identical price[2]. The monopolist's profit from fighting is defined as:

$$\pi_M^{FG} = P_1 D_M(P_1) \ . \tag{5.3}$$

π_M^{FG} is increasing in P_1 (see Appendix B), because the consumer's input price determines how large the monopolist's price cut will be if he decides to fight.

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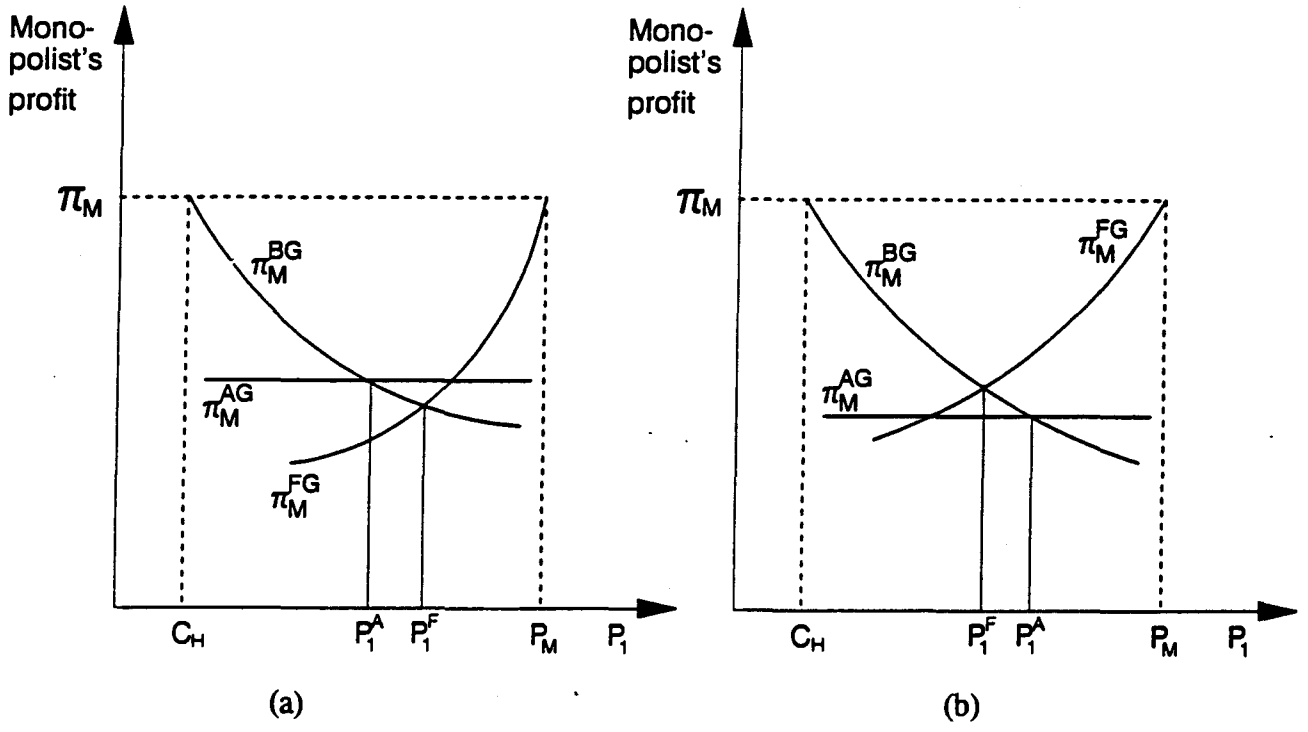
[2]When consumers lexiographically prefer the incumbent's brand at equal prices, it is a limiting case of differentiated products (see Gelman and Salop 1983). See Schmalensee (1982) for an alternative specification of a pioneering brand advantage.

At stage 2, after the sunk investment, the consumer will maximize his profit subject to the constraint that bribing is not the most profitable option for the monopolist:

$$\pi_M^{BG} \leq \max \{\pi_M^{AG}, \pi_M^{FG}\} . \tag{5.4}$$

Figure 5.1 The consumer's input price



This constraint can be illustrated in Figure 5.1. Note that if $P_1 = C_H$ the monopolist's profit from bribing equals his initial monopoly profit, and if $P_1 = P_M$ the monopolist's profit from fighting equals his initial monopoly profit. If $N \to + \infty$, it is straight forward to see that the incumbent's cost of bribing will be prohibitively high (see equation 5.2). In such a case the bribing curve will be vertical at the price C_H.

In the case reported in Figure 5.1 (a), we see that the consumer will never announce a price lower than P_1^A, because that would make bribing the monopolist's best response. If the consumer announces P_1^A, none of the foreign producers will be bribed and they will thus offer to deliver at that price. In the case reported in Figure 5.1 (b), the consumer will not

announce a price below P_1^F, because the monopolist's best response would be to bribe. If the consumer announces P_1^F, the monopolist will prefer to fight, i.e., match the announced input price, rather than accept that a foreign producer delivers at that price.

Proposition 5.1: *To ensure that bribing is not the incumbent's best response, the consumer announces* $P_1^* \geq min\ \{P_1^F, P_1^A\}$ *where* $P_1^A = \{P_1 | \pi_M^{AG} = \pi_M^{BG}\}$ *and* $P_1^F = \{P_1 | \pi_M^{FG} = \pi_M^{BG}\}$.

$P_1^* = C_H$ only if there exists an infinite number of foreign producers. If the monopolist bribes some foreign producers and this invites additional foreign producers to enter the industry, this can be interpreted as though $N = + \infty$. Consequently, bribing is a viable strategy for the monopolist only if there exists barriers to entry that prevents new producers to enter the industry and collect bribes.

2. An entrant that is a rival to the incumbent

Let us here investigate the case where the entrant is a firm that penetrates a market which is dominated by the domestic monopolist (here called incumbent). In the case of the Norwegian cement market, this implies that we will focus on an entrant that sells cement in Norway and thus is a rival to the incumbent. Such an entrant, called a 'dealer', is to be contrasted with the 'consumer', which was interpreted as a construction firm where cement is input to its production.

Consider a dealer that buys from a foreign producer. Let us assume that at stage 1 the dealer, denoted E, undertakes a sunk investment committing him to a certain capacity Q. At stage 2 he announces an input price (P_1), i.e., import price, and an output price (P_2). The incumbent observes these prices. At stage 3, he either bribes, fights or accepts. In accordance with Gelman and Salop (1983), we assume that the incumbent meets the whole demand if he matches the dealer's output price, not input price. Otherwise we assume a

random rationing rule, also called a proportional rationing rule[3]. The incumbent's profit in each of the three alternatives is then as follows:

$$\pi_M^{BE} = \pi_M - N(P_1 - C_H)Q \ , \tag{5.5}$$

$$\pi_M^{AE} = \max_{P_M} P_M D_M(P_M)[1 - \frac{Q}{D_M(P_2)}] \ , \tag{5.6}$$

$$\pi_M^{FE} = P_2 D_M(P_2) \ . \tag{5.7}$$

Analogous to the consumer model, π_M^{BE} is decreasing in P_1 (see Appendix B). π_M^{FE} is increasing in P_2 instead of P_1, because it is now P_2 that determines the price cut if the incumbent fights. π_M^{AE} is decreasing in P_2 (see Appendix B). The intuition is that a low output price by the dealer will enlarge the market, and the dealer's sale will only partly replace the incumbent's sale. While the consumer must avoid bribing as the incumbent's response to entry, the dealer must avoid both fighting and bribing as responses to entry. The dealer will thus face the following constraint:

$$\pi_M^{AE} \geq \max \{\pi_M^{BE}, \pi_M^{FE}\}$$

It follows directly from Proposition 5.1 that the dealer must announce an input price above a minimum input price to ensure that $\pi_M^{AE} \geq \pi_M^{BE}$. This minimum input price might deter the dealer from entering, even if his entry cost is zero. A low N and a high C_H, i.e., C_H close to P_M, will imply that the bribe paid to each foreign producer is low and the number of foreign producers receiving bribes are low as well. In such a situation an input price equal to the incumbent's monopoly price might not be sufficient to prevent the incumbent from bribing, i.e., ensure that $\pi_M^{AE} \geq \pi_M^{BE}$.

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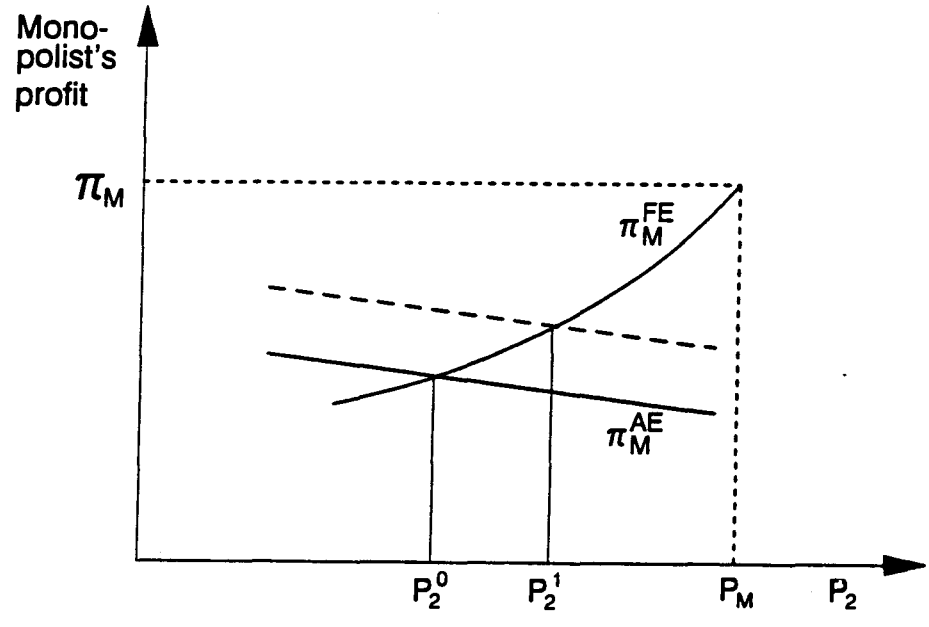
[3]An alternative specification is an efficient rationing rule, also called parallell or intensity rationing rule. It can easily be shown that the results are robust to such a re-specification of the model. Note that if we apply a random rationing rule, the incumbent's loss of sale when accommodating entry is less than the entrant's sale. The reason is that some of the entrant's consumers have a willingness to pay which is lower than the monopoly price. Put differently, the entrant's low price enlarges the market and this limits the incumbent's loss of sale when accommodating the entrant. For a description of various rationing rules, see Rasmusen (1989), chapter 12.2, or Tirole (1988), chapter 5.3.1.

To ensure that $\pi_M^{AE} \geq \pi_M^{FE}$, the dealer must announce an output price that is below a maximum output price. Figure 5.2 illustrates this, where the solid lines show the incumbent's profit from accepting and fighting, respectively. We see that only if $P_2 \leq P_2^0$, $\pi_M^{AE} \geq \pi_M^{FE}$. The intuition is that a low output price will make it costly for the incumbent to match such a price, and thus induce him to accept entry rather than fight.

Figure 5.2 The dealer's output price



A necessary condition for entry is that $P_2 \geq P_1$. One way the dealer can ensure $P_2 \geq P_1$, is by limiting capacity. A limited capacity will make it more profitable for the incumbent to accept entry, because the loss of sales when accepting entry is reduced. On the other hand, the incumbent's profit from fighting is unchanged. If the incumbent decides to fight, he has to cut price throughout the market regardless of the dealer's capacity. The effect of a capacity reduction is illustrated in Figure 5.2 by the shift from the solid to the dotted line for π_M^{AE}. A capacity limitation will thus induce the incumbent's to respond by accepting instead of fighting. It enables the entrant to announce a higher output price without triggering off fighting (P_2^1 instead of P_2^0).

Proposition 5.2: *If the dealer announces*

$$P_1 \geq P_1^{min} \equiv \frac{P_M}{N}\frac{D_M(P_M)}{D_M(P_2)} + C_H \quad \textit{and}$$

$$P_2 \leq P_2^{max} \equiv P_M\frac{D_M(P_M)}{D_M(P_2)}[1 - \frac{Q}{D_M(P_2)}] ,$$

the incumbent's best response is to accept entry. If

$$D_M(P_2)[1 - \frac{1}{N} - \frac{C_H}{P_M}\frac{D_M(P_2)}{D_M(P_M)}] > 0,$$

there exists a $Q > 0$ *for which* $P_2^{max} > P_1^{min}$.

Proof: See Appendix C.

We see that except for the case where N is low and C_H is high, there exists a positive capacity ($Q > 0$) for which the output-input price margin is positive. The entry strategy of a 'limited' capacity and a 'low' output price is similar to the result in Gelman and Salop (1983), where bribing was ruled out as an option for the incumbent.

When bribery is a possible response for the incumbent, the dealer must in addition set a 'high' input price to make bribing costly. If bribing is ruled out, or the number of foreign producers are infinitely large, the minimum input price equals the foreign producers' marginal costs (C_H).

Comparing Propositions 5.1 and 5.2, we see that the 'consumer' has an advantage relative to the 'dealer'. He will face no capacity constraint, and he will be in a better position than the 'dealer' regardless of whether bribing is an option for the incumbent.

3. The Norwegian cement market

In this section, we contrast the results from our analysis with some observations in the Norwegian cement market. In addition, we analyse the consequences of a ban on regional price cuts, a public policy measure that was implemented in the Norwegian cement market in the mid '80s.

3.1 Two Hypotheses

The domestic producer of cement, Norcem, has a market share of 97 per cent, and the price-cost margin is high (see chapter 2). There are sunk costs in this industry. The investment in a kiln, the major part of a cement plant where the conversion from limestone to clinker takes place, is site-specific and has no alternative use[4]. The investment in silo terminals for distribution are site- and industry-specific as well.

The intra-European trade of cement is very limited. According to Norcem, the reason is "balance of deterrence between the producers, as well as ownership in the cement industry across the borders" [m.t.] (see Guthus 1984, p. 25). The term 'balance of deterrence' refers to the risk of retaliation in the domestic market if one producer starts exporting. In addition, a secret market sharing agreement between 11 German producers has been disclosed. The firms had to accept fines which in all amounted to 224 million DM. This suggests that implicit, as well as explicit, collusion limits the number of foreign producers that are willing to deliver cement to Norway.

Although threats of retaliation limit the number of potential exporters to Norway, some foreign firms were willing to export to Norway during the '80s. Examples are East Germany, Poland, and a small West German producer. In the mid eighties Norcem bought

[4]The annual costs of a plant investment is more than half the total annual costs of producing cement (see Norwegian Ministry of Industrial Affairs 1983, p. 38).

the exclusive rights to import from East Germany and Poland[5]. This was a response to entry attempts from these two countries. Although these agreements are well known to the Norwegian Price Directorate, it did not intervene (see Guthus 1984, p. 16). On the other hand, in the '80s the Norwegian authorities had a restrictive attitude towards price discrimination and other anticompetitive actions by Norcem in the domestic market (see section 3.2). Given that bribing foreign producers (but not any domestic actors) is an option for the incumbent, we can use the predictions from the theoretical model to construct two hypotheses.

Hypothesis 5.1: *A dealer will choose a 'low' output price, a 'high' input price and a 'limited' capacity.*

Viking Cement is an independent Norwegian company that in the autumn of 1983 started importing cement from a small West German producer. The firm rented a silo terminal in Stavanger in the Western part of Norway to receive shipped cement. In the contract with the West German firm the annual quantity of imports was set very low, amounting to less than 3 per cent of the total Norwegian cement market. The firm explained that this was done 'for fear of Norcem' (see Guthus, 1984, p. 17). In addition to restricting its supply, Viking Cement set its output price 15-20 per cent below Norcem's price[6]. Finally, Viking Cement's import price was well above the foreign producers' marginal costs[7]. If we

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[5]Norcem agreed upon importing a minimum amount of cement annually from each of these two countries at a price more than 50 per cent above the lowest alternative import price (see Sørgard 1989, p. 49).

[6]Apparently there was only a 2 per cent price difference between the price of Norcem and the price of Viking Cement; 500 and 490 NOK per ton, respectively. However, a certain quantity of this cement from Norcem, Modified Portland Cement (MP 30), has by some customers been replaced with a 10 per cent lower quantity of Viking Cement's type of cement (Standard Cement (PZ 30)). Other customers have replaced PZ 30 with an equal amount of another cement type from Norcem, Rapid Portland Cement (RP 38) (see Guthus 1984, p. 18). The price difference is then 12 - 17 per cent. In addition, the price of cement from Viking Cement includes freight from the silo to the consumer. This freight cost is not included in the price of cement from Norcem.

[7]Viking Cement's cif import price was about NOK 420 per ton in 1984 (see Guthus 1984, p. 18). According to figures from official trade statistics this is slightly below the Viking Cement cif import price for 1986 and 1987, and somewhat above their cif import price for 1985 (see the Central Bureau

interpret the contract for deliveries as its capacity decision, we see that Viking Cement's behaviour is consistent with Hypothesis 5.1. A half year before imports started, Norcem stated that 'it will not be possible to avoid a minimum imports of 50.000 tons annually' (Norwegian Ministry of Industrial Affairs 1983, p. 88). Except for 10 per cent discounts to two of its larger customers, a discount policy the government subsequently forced them to stop (see section 3.2), Norcem accommodated Viking Cement's entry. Viking Cement suffered an accumulated loss equal to its equity during the period 1983-89. This illustrates that a dealer's profit in such a situation will be squeezed due to a low output price, a high input price and a limited capacity.

Hypothesis 5.2: A consumer will choose a 'high' input price, and has no incentives to avoid price cutting as the incumbent's response.

Some of the largest consumers of cement in Norway are subsidiaries in the same corporation where Norcem is a subsidiary (see Figure 2.6 in chapter 2). As a result, there are few independent consumers of cement in Norway that are large enough to cover the sunk costs from investing in a silo terminal. One consumer, Concord Vige Cement Trading in Kristiansand in Southern Norway, actually built a silo terminal in 1990. The largest shareholder in Concord is Hübert-gruppen, which is a construction firm using cement as an input in its own production. Concord's capacity is the same as Viking Cement's sale, and its input price is in line with the input price of Viking Cement[8]. Concord has thus set a 'high' input price, which is consistent with our Hypothesis. The firm planned to sell cement to other consumers as well, and thus be a rival to Norcem, i.e., a combination of a 'dealer'

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of Statistics: "Utenrikshandel 1987 hefte I", table 2, CCCN 2523). In the years 1985-87 Norcem imported cement from Belgium at a price of NOK 215-230 to meet an extraordinary domestic boom (see the Central Bureau of Statistics, ibid.). Even if we correct for the quality difference and the possibility that Norcem's imported clinker rather than cement, the cif import price from Belgium would be well below NOK 300 per ton. As a consequence, the cif import price of Viking Cement was more than 30 per cent above the adjusted cif import price of Norcem in the same time period.

[8]According to the Central Bureau of Statistics, Norway, the cif import price in 1990 (the year Concord was established) is NOK 500 per ton. In comparison, Viking Cement's cif import price that year was NOK 510.

and a 'consumer'. As it turned out, Concord never sold cement to other users and their imported quantities were very limited. One important reason was that Norcem cut prices to some of the other consumers of cement in that region. According to Concord, it ran into financial difficulties and was forced to close down in early 1992.

The consumer's investment had apparently failed. However, Hübert-gruppen signed in late 1991 a long term contract with Norcem for deliveries of cement. We have no exact information about the content of the contract, but the fact that Norcem cut prices to other buyers in the same region suggests that Hübert-gruppen were offered discounts as well. If the price in the long term contract is set 20 per cent below the initial monopoly price, the investment in the silo terminal has in fact been profitable for the consumer[9]. In addition to signing a long term contract for deliveries, Leif Hübert (majority shareholder in Hübert-gruppen) purchased the silo terminal from Concord. He has rented the silo terminal to Norcem for a ten year period. The Norwegian price authorities did not intervene, which is surprising in light of their active policy in this market in the '80s. It illustrates that the Norwegian Price Directorate in the last few years has become less restrictive towards bargaining between the incumbent and consumers in this particular market. This suggests that in the future it is less likely that a consumer will install a silo terminal, as done by Concord, because the consumer and Norcem can bargain in advance of the investment.

3.2 A ban on regional price cuts

Despite the soft behaviour of the dealer Viking Cement, the Norwegian Price Directorate was afraid that Norcem would force the dealer to leave the market. In 1984 the Price Directorate informed Norcem that if the firm reduced its price in this region, the maximum price for the whole of Norway could be lowered to that price level (see Guthus 1984, p. 31). This can be interpreted as a ban on regional price cuts. Let us reformulate the model slightly to allow

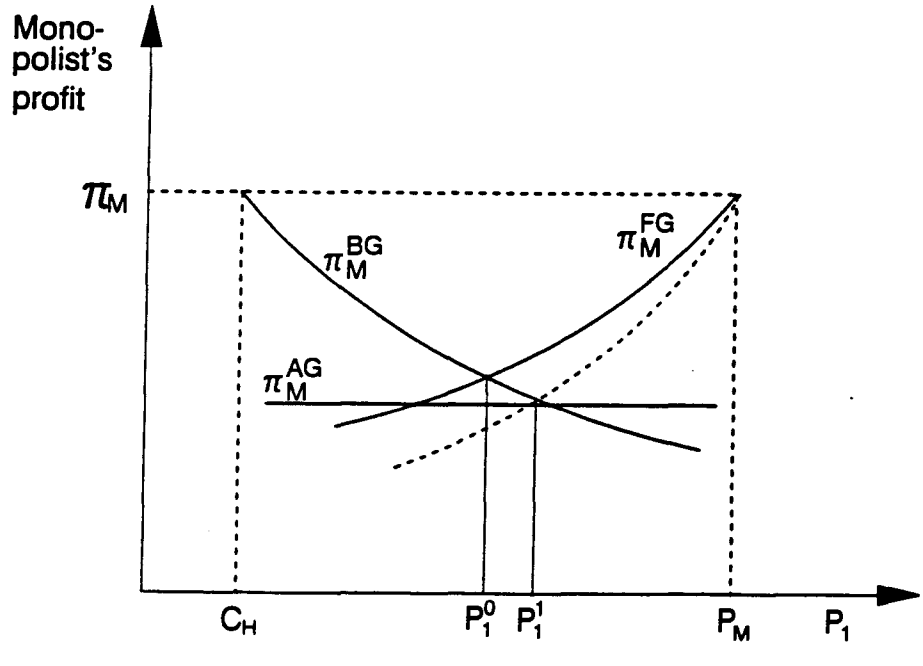
[9]We assume the investment cost is NOK 15-20 millions, Hübert-gruppen's annual consumption of cement is 25.000 tons, the annual discount rate is 10-15 per cent, the initial monopoly price is NOK 600 per ton, and an infinite time horizon. The investment is then profitable if price of cement in the contract with Norcem is 10-20 per cent below the initial monopoly price of cement.

for differences in regional prices. Let ρ denote the segment of the market where the incumbent lowers his price, assuming $\xi \leq \rho \leq 1$. If $\rho = 1$, the incumbent must charge the same price throughout the market. If $\rho = \xi$, the incumbent can cut his price to only one consumer, for example, to the large consumer which we denote 'consumer'. Assuming the entrant is an established consumer, the incumbent's profit from fighting (equation 5.3) is now reformulated to:

$$\pi_M^{FG} = [1 - \rho]\pi_M + \rho P_1 D_M(P_1) \ . \tag{5.8}$$

A ban on regional price cuts can now be interpreted as an increase in the parameter ρ. In Figure 5.3 we illustrate the effect for the 'consumer' for the case where $\pi_M^{BG} = \pi_M^{FG}$ is the binding constraint initially (see Figure 5.1 b).

Figure 5.3 The effect for the consumer of a ban on regional price cuts



A ban on regional price cuts will have no effect on the incumbent's profit from bribing or accepting, but reduce the incumbent's profit from fighting. The latter is because an increase in ρ will increase the number of consumers who will be offered lower prices when the incumbent fights. This is illustrated in Figure 5.3 with the shift from the solid to the dotted line in the curve π_M^{FG}. We see that the consumer's optimal input price increases, from P_1^0 to

P_1^1. The reason is that when fighting becomes less profitable, the incumbent would shift from fighting to bribing if the input price is not increased. It can easily be shown that in the other regime, where fighting is not a binding constraint initially (see Figure 5.1 a), a ban on regional price cuts will have no effects on the consumer's input price.

Proposition 5.3: *A ban on regional price cuts will increase the dealer's profit, while it will increase the consumer's input price or have no effect on it.*

Proof: See Appendix D.

The intuition for the dealer's increased profit is straight forward. Fighting is made less profitable for the incumbent and thus becomes a less severe threat towards the dealer. The dealer can exploit this fact by increasing his capacity and/or increasing his output-input price margin and still ensure that accept is the incumbent's best response.

It is doubtful whether a ban on regional price cuts will increase domestic welfare. First, let us assume that the public policy measure will have no effect on the entry decision. The increased input price for the consumer implies a dead weight loss, and a profit shift from the domestic producer to the foreign producer if the consumer switches from buying from the domestic producer to direct imports. Simulations reported in Sørgard and Vagstad (1989) suggests that a dealer will respond to a ban on regional price cuts, i.e., an increased relevant market size, by expanding his capacity and maintaining his output price. Because entry of a dealer causes a welfare loss per unit of sale, as we will show later (see chapter 7), the welfare loss will increase if the dealer expands his capacity. Consequently, the ban on regional price cuts will reduce the domestic welfare if such a ban have no effect on the consumer and the dealer's entry decision.

Second, let us assume that the ban on regional price cuts will deter the consumer from investing and induce the dealer to enter. The cancellation of the consumer's investment will be a welfare gain, and the same is true when the incumbent is allowed to serve the consumer at a lower price than the import price. On the other hand, there is a dead weight loss when

the consumer faces the incumbent's monopoly price rather than the import price. As we will show in chapter 7, the entry of a dealer will probably cause a welfare loss. The welfare gains from price reductions for plausible demand and cost parameters will be wiped out by the profit shift to the foreign producer when a dealer enters the Norwegian cement market.

Let us now compare with the argument put forward by the government for introducing a ban on regional price cuts. Although it is not stated explicitly, it is clear that the Norwegian Price Directorate had in mind what we call a dealer (see Guthus 1984, p. 31-32). They wanted to stop Norcem from forcing the dealer to leave the market. We have shown that the public policy measure that were implemented could be consistent with such a goal. However, the welfare effect could be negative (see above paragraph). A main reason is that the welfare gain for ordinary consumers from lower prices can be wiped out by welfare loss from importing at a high price instead of producing domestically at a low marginal cost. How can the government make sure that the cement is produced domestically, i.e., at lower costs than importing cement, and sold at a low output price? If the government cannot sign contracts with the incumbent, it can be beneficial to allow the incumbent to price discriminate[10]. If the incumbent has the option to bargain directly with the consumers, they can sign an agreement prior to the consumer's planned investment and thereby stop the consumer from undertaking such a sunk investment. The large consumers, who credibly can threat to start direct import, will be offered a lower price. The amount of import will be limited, and at the same time some consumers will be offered a lower price.

[10]If the government can sign a contract with the incumbent, specifying a menu of maximum prices and transfer payment according to the quantity produced, it can achieve a first best optimum if there exists no private information. If the incumbent has private information about his own costs, the optimal contract will be such that the incumbent earns some profit and produces at an inefficient scale (see Laffont and Tirole 1986).

4. Summary and conclusions

In this chapter we have focused on the distinction between an entrant that is in fact an established consumer of the incumbent's product (called a 'consumer'), and an entrant that sells to the same customers as the incumbent (called a 'dealer'). The consumer will, in contrast to the dealer, welcome price cutting as a response to entry, because his only concern is to ensure a low input price. The consumer has therefore no reason to limit his capacity and set a low output price, as Gelman and Salop (1983) have shown that the dealer must do to avoid triggering off price cutting as a response to entry. The 'low' output price makes it costly for the incumbent to match the dealer's output price, while the 'limited' capacity limits the incumbent's loss from accommodating the entrant. The predictions from the theoretical model is consistent with observations in the Norwegian cement market. A 'dealer' that entered in the early '80s restricted his supply and set a low output price. A 'consumer' that entered in 1990 triggered off price cuts. It closed down its imports less than two years later, and signed a long term contract with the domestic monopolist for cement deliveries.

Another feature in the Norwegian cement market is the fact that the incumbent has purchased the exclusive right to import from foreign producers and has thus cut off some of the entrants' potential sources for input supplies. The theoretical model predicts that an entrant that imports from a foreign producer will accept a 'high' input price. This will make a purchase of the exclusive right to import from foreign producers unprofitable for the incumbent, and thus ensure that the entrants' input supplies is not cut off. Both types of entrants that were observed in the Norwegian cement market in fact accepted a high import price compared to the international price of cement.

In addition, we have shown that if regional price cuts are banned, which was the case in the Norwegian cement market in the mid eighties, this might increase the consumer's input price. Price cutting will become less profitable for the incumbent, because he will lose profit nationwide. The consumer has to accept a high input price in order to prevent the incumbent from bribing foreign producers to stop deliveries. The dealer, on the other hand, will be

better off. Fighting is made less profitable for the incumbent, and the dealer can exploit this by, for example, increasing his capacity.

Our model is simplified, and there are reasons to ask how sensitive the results are to alternative model specifications. In particular, what if prices are set simultaneously rather than sequentially and can differ from period to period rather than be set once and for all? It can be shown that the capacity limitation result is robust to such a re-specification of the model if we assume trigger strategies, but that the low output price result is no longer valid (see chapter 8). The latter result is because there is no longer any price commitment, so the entrant has the option to set a high output price initially and to cut prices later on if that is needed. Empirical studies have shown that there exists price rigidities in many markets, in particular in markets with a high seller concentration (see Carlton 1986; Carlton 1989). This suggests that although our price commitment assumption is unrealistic and must not be interpreted literally, it reflects some of the price rigidities that are observed in real markets such as the cement market.

Another question is what happens if the incumbent and the consumer are allowed to bargain prior to the consumer's investment. The Norwegian Price Directorate was in the '80s restrictive towards bargaining between specific consumers and Norcem, but in the last few years it has gradually changed its policy by welcoming signing of contracts between Norcem and some of its consumers. This suggests that in the future it is less likely that a consumer will install a silo terminal, as done by Concord in the past. The consumer and Norcem can now bargain in advance of the investment, an option that was ruled out during the '80s. As stated in an internal Norcem report we referred to in chapter 3, which analyses the prospects for the '90s: 'Consumers will use the threat of imports as an argument in bargaining'. By allowing the incumbent to price discriminate the large consumers can face a lower price from the incumbent, the consumers' sunk investment can be prevented and so also the import of cement at a higher cost than the domestic incumbent's marginal costs. Consequently, price discrimination by the incumbent can improve the domestic welfare.

Appendix B: Some technical properties

From (5.1) we see that π_M^{AG} is insensitive to P_1. Differentiating π_M^{FG} and π_M^{BG} with respect to P_1 we get:

$$\frac{\partial \pi_M^{FG}}{\partial P_1} = D_M + P_1 \frac{\partial D_M}{\partial P_1} > 0 \qquad \text{(B.1)}$$

$$\frac{\partial \pi_M^{BG}}{\partial P_1} = -\left[ND_G + (P_1 - C_H)\frac{\partial D_G}{\partial P_1}\right] < 0 \qquad \text{(B.2)}$$

The first and the second term in both (B.1) and (B.2) work in opposite directions. If the second order condition for profit maximum is met, i.e., $[(P - C_M)\cdot D''(P) + 2\cdot D'(P)] < 0$, we know that π_M^{FG} is increasing in P_1 as long as $P_1 < P_M$. Assuming random rationing rule, as we do, we know that $P_M = P_M^A$ (see Gelman and Salop, Appendix), and thus that the incumbent's optimal price to the consumer is P_M as well. This implies that as long as $C_H > C_M$, which is met by assumption, we have that $[(P - C_H)\cdot D''(P) + 2\cdot D'(P)] < 0$ as long as $[(P - C_M)\cdot D''(P) + 2\cdot D'(P)] < 0$. This ensures that π_M^{BG} is always decreasing in P_1 when π_M^{FG} is increasing in P_1.

From (5.5) we see that π_M^{BE} is insensitive to P_2. Differentiating π_M^{AE} (from 5.6) with respect to P_2 we have that:

$$\frac{\partial \pi_M^{AE}}{\partial P_2} = P_M D_M(P_M)\frac{\partial D_M}{\partial P_2}\frac{Q}{[D_M(P_2)]^2} < 0 \qquad \text{(B.3)}$$

It is easily seen from (B.1) (replacing P_1 with P_2) that π_M^{FE} is increasing in P_2. From (5.6) and (5.7) we see that both π_M^{AE} and π_M^{FE} are not influenced by P_1. Differentiating π_M^{BE} with respect to P_1 we have that:

$$\frac{\partial \pi_M^{BE}}{\partial P_2} = -NQ < 0 \qquad \text{(B.4)}$$

Appendix C: Proof of Proposition 5.2

From (5.6) and (5.7) we have that $\pi_M^{AE} \geq \pi_M^{FE}$ if:

$$P_2 \leq P_M \frac{D_M(P_M)}{D_M(P_2)}[1 - \frac{Q}{D_M(P_2)}] \tag{C.1}$$

From (C.1) we see that as $Q \rightarrow 0$, then $P_2 \rightarrow P_M$. From (5.5) and (5.6) we have that $\pi_M^{AE} \geq \pi_M^{BE}$ if:

$$P_1 \geq \frac{P_M}{N}\frac{D_M(P_M)}{D_M(P_2)} + C_H \tag{C.2}$$

We see that $P_1 > P_M$ for a combination of low N and high C_H. If we set $P_1 = P_2$ and substitute (C.1) into (C.2), we can solve for Q:

$$Q^{max} \equiv Q = D_M(P_2)[1 - \frac{1}{N} - \frac{C_H D_M(P_2)}{P_M D_M(P_M)}] \tag{C.3}$$

If the entrant sets Q^{max}, he will ensure that $P_1 = P_2$. We see that Q^{max} is positive unless we have a combination of low N and high C_H. Q.E.D.

Appendix D: Proof of Proposition 5.3

Let us first check for the dealer. ρ has no effect on π_m^{AE} and π_m^{BE}. Formulating π_m^{FE} in an analogous way as π_m^{FG}, and differentiating with respect to ρ we have:

$$\frac{\partial \pi_M^{FE}}{\partial \rho} = P_2 D_M(P_2) - \pi_M < 0 \tag{D.1}$$

Rewriting (5.5) and (5.6), we see that π_m^{AE} and π_m^{BE} will be reduced equal-proportionally when Q increases:

$$\pi_M - N(P_1 - C_H)Q = \pi_M - P_M Q \ . \tag{D.2}$$

One option for the dealer when ρ increases is thus to maintain his input-output price margin and increase Q until all the incumbent's three profit alternatives again are equalized.

Let us check for the consumer. It follows straight forwardly from (D.1) that π_m^{FG} is decreasing in ρ. Let us assume that initially either $\pi_m^{AG} = \pi_m^{BG}$ and $\pi_m^{FG} > \pi_m^{BG}$, or $\pi_m^{AG} > \pi_m^{BG}$ and $\pi_m^{FG} = \pi_m^{BG}$. In the former case π_m^{FG} is not binding initially, and thus a marginal increase in ρ has no effect on P_1. In the latter case a reduction in π_m^{FG} as a result of increased ρ implies that the consumer must change P_1 in such a way that π_m^{BG} is reduced as well. From (B.2) we see that P_1 then increases. Q.E.D.

Chapter 6:

Lars Sørgard and Steinar Vagstad:

THE INCUMBENT'S CHOICE OF TECHNOLOGY

When building or modernizing a production plant, a firm can sometimes choose between different technologies, i.e, different combinations of fixed and variable costs. The purpose of this chapter is to analyse how threat of entry will influence an incumbent's choice of technology. The main elements of our entry game model is:

i) The incumbent, who holds idle capacity, chooses technology from a menu of known technologies before the entry. His choice is observed by the entrant.

ii) The entrant has a cost disadvantage, and his technology is exogenously determined. His product is identical with the incumbent's, and he chooses capacity and price before the incumbent sets his price.

In the basic version of our model we assume that both firms are profit maximizing entities who act in line with a rational choice model, and assuming no conflicts of interest inside the firms nor between the owner and the manager. This model, which constitutes the major part of this chapter, is at the end extended to take into account conflicts of interest in the incumbent firm between the owner and the manager. In particular, the owner of the incumbent firm is by assumption boundedly rational and he sets a profit target. The incumbent firm's manager is by assumption behaving in line with a rational choice model, and his received payment is high if the firm achieves the profit target and low otherwise.

The chapter is organized as follows. In the next section, we describe some characteristics of the Norwegian cement market. This motivates the construction of our particular entry game. In section 2, we relate our work to the literature on strategic investments in technology. The basic model is presented in section 3. We examine the two kinds of possible outcomes in the model; deterrence and accommodation. In section 4, we present an extended version of the model from section 3. The owner is by assumption boundedly rational, and he sets a profit target the manager must achieve to receive a high payment (low payment otherwise). Our results are summarized in section 5.

1. The Norwegian cement market

The incumbent firm in the Norwegian cement market, Norcem, held idle capacity throughout the '80s (except 1985-88), and any potential entrant had a cost disadvantage due to higher transportation costs (see chapter 2). As shown in chapter 5, an entrant's behaviour in the Norwegian cement market in the early '80s was consistent with the predictions from the model in Gelman and Salop (1983). In that particular model the entrant sets price and capacity before the incumbent sets his price. However, the incumbent was not allowed to preempt the entrant. One kind of preemption would be to invest in cost reductions before the entrant's decision to penetrate the market. Let us discuss whether this is a plausible preemption strategy in this particular market.

First, is investment in cost reduction a viable alternative in the Norwegian cement market? The technology in the cement industry allows for different combinations of fixed and variable costs (Stewart 1985; Rosenbaum 1989; Anderson and Tushman 1990). The referred studies concern investment in new plants. However, there will also be a choice of technology when modernizing old plants. For example, the firm could invest in computer-based systems that smooths the mixing of materials and thus lowers the amount of inputs. The entrant, on the other hand, will typically not be able to choose between different combinations of fixed and variable costs. He is an importer of cement, i.e., no own production of cement, and he will therefore have no choice of technology concerning production.

Second, will Norcem deliberately invest in cost reductions to preempt potential entrants? Or could the main motive for such investments simply be to maintain the incumbent's profitability, i.e., to achieve a profit target? To answer, let us start by reviewing Norcem's performance in the past. In the early '80s Norcem had three production plants in Norway, and the marginal costs of production were distinctly different in these three plant: NOK 297 per ton in Kjøpsvik; NOK 242 in Slemmestad; NOK 215 in Dalen[1]. The plant in Kjøpsvik

[1]These are data for 1982, and they are provided by Norcem (see Norwegian Ministry of Industrial Affairs, 1983, p. 81). The fact that there are differences in marginal costs between the three plants is in line with the findings in Førsund et.al. (1985), see Figure 6.2c.

is in a special position, because it is located in an area in Northern Norway where the employment opportunities are very limited. The Norwegian government is strongly in favour of continued production in Kjøpsvik and thus maintaining the existing employment opportunities in this area. In order to bargain with the government, for example, the introduction of anti dumping measures, Norcem might find it profitable to continue production at this plant even if it is a cost inefficient plant[2]. There are no such reasons that can explain why Norcem had two plants in Southern Norway. A close down of one of them would apparently reduce the total costs. The stop in export from the late '70s made it possible to transfer production from Slemmestad to Dalen and thus to exploit the lower marginal costs in Slemmestad. In addition, one would expect a reduction in fixed costs from the close down of one plant. The structure of production in the early '80s thus seems to be in conflict with a profit maximizing goal, i.e., a cost minimizing goal.

In the annual report 1982 the firm refers to environmental changes, arguing that these changes will reduce Norcem's profitability:

> 'The market development, the technological development with mixing of substitutes into cement, and the increasing imports of concrete products will substantially reduce domestic demand for cement. .. [I]f the present structure [of Norwegian cement industry] is maintained, Norwegian cement industry will soon be unprofitable' (Norcem Annual Report 1982, p. 6) [my translation]

To avoid such a scenario, it was proposed to close down production in Slemmestad. In the annual report 1983 it was also proposed to invest in cost reduction in Dalen. This investment, amounting to about NOK 500 millions, were undertaken in the period 1985-90 (see chapter 2). According to the annual report, the effect of the investment in cost reduction would be the following:

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[2]In 1984 Norcem threatened to close down Kjøpsvik if the government did not impose an anti dumping duty on import from East Germany. An anti dumping duty was put into effect (see White Paper no. 12 (1984-85)).

> 'This, combined with a close down of production at Slemmestad, will improve our competitive position substantially, and Norcem can react efficiently towards imports based on business criteria. .. As a result of this we can maintain the profitability, but the scale of operation and number of employees will go down'. (Norcem Annual report 1983, p. 9). [m.t.]

Given profit maximizing behaviour, it is difficult to explain why the firm did not implement such cost reducing measures earlier and thus increased its profit earlier. Furthermore, the term 'maintain the profitability' indicates that there exists a profit goal rather than a decision rule to maximize profit. It also indicates that the firm's profit goal in duopoly is identical with its profit goal in monopoly. Again, this is inconsistent with a profit maximization goal.

The annual report is an official document, so we have to be careful about the interpretation of it. As shown in chapter 3, the information can be biased due to strategic considerations. However, in a non-published document it is argued that the investment is an adjustment to a stagnating and falling demand[3]. Again, why were no such cost reducing measures implemented earlier? The findings we reported in chapter 3 are also of interest. We concluded that Norcem's decision rule concerning investment in cost reduction in the '90s was governed by a profit goal rather than a goal to minimize costs.

In contrast to the rather 'naive' decision rule to achieve a profit target, some of the information we have suggest that the incumbent behaves in a more sophisticated way. Note that in the internal report we referred to in chapter 3, the firm was well aware of rival's response and thus their way of thinking was influenced by strategic considerations. The statement in the annual report 1983, that it 'can react efficiently towards imports', suggests that the investment decisions might be influenced by some strategic considerations.

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[3]The non-published document is Norwegian Ministry of Industrial Affairs (1983). In 1983 Norcem provided the committee that wrote the report with information concerning future structural changes in the Norwegian cement industry. In the report the structural changes are explained as an adjustment to environmental changes, in particular increased imports, substitutes mixed into cement, and a recession in the construction industry (see Norwegian Ministry of Industrial Affairs, 1983, p. 84).

All in all, we have a mixed picture of the incumbent's behaviour in this particular market. On the one hand, the incumbent sets a profit target. On the other hand, the incumbent is well aware of the rival's responses. In the model we construct both elements are included. In the basic model the incumbent is well aware rival's responses and he maximizes profit (see section 3). In an extended version of the model we introduce a boundedly rational owner that sets a profit target. The incumbent firm's manager is by assumption maximizing his own utility, and his received payment is high if he achieves the profit target and low otherwise (see section 4).

2. Related literature

The incumbent's choice of technology is a long-standing issue in the theory of industrial organization. The technological choice concerns both the creation of new products, called product innovation, and producing the existing products at lower costs, called process innovation. In the early '40s Joseph A. Schumpeter argued that the exercise of monopoly power is a key source to raise funds to support costly and risky innovation. The only way one can induce firms to undertake research and development (R&D) is to allow them to have a monopoly position (see Schumpeter 1943). This conclusion was challenged 20 years later by Kenneth Arrow, who found that the incentive to invest in R&D is less under monopoly than under competitive conditions (see Arrow 1962). He argued that the monopolist cannot fully appropriate the social surplus of a new product, unless he can price-discriminate perfectly. In addition, he argued that a competitive firm can become a monopolist if he innovates while a firm that has a secure monopoly position has no such incentives. The secure monopolist will only replace himself if he innovates, and he will therefore tend to 'rest on his laurels'. This result is in line with Barzel (1968) and Dasgupta, Gilbert and Stiglitz (1982), who found that the optimal date for a monopolist's adoption of a patented technology will be later than the date determined by competition (the preemption date). Gilbert and Newbery (1982) demonstrated that allowing for entry would increase the incumbent's incentive to invest in R&D, because such investments could deter potential entrants. This will not necessarily imply that the incumbent adopts the new technology, because he could deter entry simply by innovating and withholding it from use (called

"sleeping patents" by Gilbert and Newbery (1982))[4].

Inspired by Scherer (1967) and Reinganum (1981a, 1981b), Fudenberg and Tirole (1985, 1987) analysed an adoption race between two firms. The adoption by one firm can be imitated by its competitor. One possible outcome is the preemption case, where one firm adopts early and its competitor never adopts. Another extreme outcome is the case where adoption triggers immediate imitation. In such a case, there is little incentive to adopt, and therefore no adoption takes place.

In some cases there exists an asymmetry because only one firm can adopt the new technology, or only one firm has a first mover advantage. The former is analysed in Kamien and Schwartz (1982), who assume that a firm's environment is exogenously determined, i.e., no rival response to the firm's adoption. The consequences of a first mover advantage has been extensively analysed during the last decade. If we define the adoption of new technology as an investment to reduce marginal costs, this has been analysed in, for example, Dixit (1986) and Schwartz (1989). They analyse the case of a duopoly where one firm can invest in cost reductions, and the rival responds after observing this (sunk) investment. The investment decision will crucially depend on the kind of equilibrium of the output game (see Bulow et.al. 1985b).

Romano (1987) assumes that an entrant has a first mover advantage concerning choice of technology, while Seabright (1990) assumes that the incumbent can choose technology, i.e., the level of marginal costs, before the entrant's entry decision. The entrant is not allowed to invest in cost reductions in Seabright's model, and the entrant's marginal costs are therefore exogeneously determined. This has some similarities with our model. However, in contrast to Seabright, we assume that the entrant can make a strategic commitment by undertaking sunk investment in capacity. In addition, we assume that prices are set

[4]For a discussion of the results in Gilbert and Newbery (1982), see Reinganum (1983, 1984), Gilbert and Newbery (1984a, 1984b), Salant (1984), Gallini (1984) and Cave (1985). See also Grossman and Shapiro (1986), where the monopolist's optimal time path for R&D expenditures is analysed.

sequentially, and not simultaneously as in Seabright's Bertrand output game. Finally, in order to capture some aspects of the U.S. airline market during deregulation, Seabright assumes that the incumbent has a cost disadvantage.

3. A model of strategic behaviour

First, we present the classical framework for a monopolist's choice between technologies with different combinations of fixed and variable costs. Then we present a model where the monopolist faces an entry threat of the kind described by Gelman and Salop (1983), and where he can choose either to deter or accommodate the entrant.

Assuming constant marginal costs, let C denote the technology with marginal costs C_M and fixed costs $I(C_M)$, where subscript M denotes the monopolist. The investment cost function is decreasing in C and convex, i.e., $I' < 0$ and $I'' > 0$. Let D(P) denote the demand for the firm's product as a function of its price P, and superscript M the monopoly equilibrium. Given technology C, the monopoly profit is given by

$$\pi_M^M(C_M) = \max_{P_M} \{(P_M - C_M)D(P_M) - I(C_M)\} . \tag{6.1}$$

The first- and second-order conditions for profit maximum for a fixed technology is given by (6.2) and (6.3):

$$D(P_M) + (P_M - C_M)D'(P_M) = 0, \tag{6.2}$$

$$(P_M - C_M)D''(P_M) + 2D'(P_M) < 0. \tag{6.3}$$

To find the optimal technology the firm maximizes $\pi_M^M(C_M)$ with respect to C_M:

$$\Pi_M^M = \max_{C_M} \pi_M^M(C_M) = \max_{C_M} \{ \max_{P_M} \{ (P_M - C_M)D(P_M) - I(C_M)\}\} \tag{6.4}$$

The relevant first- and second-order conditions for optimal technology then are

$$- D(P_M) - I'(C_M) = 0, \tag{6.5}$$

$$I''(C_M) > - [D'(P_M)]^2/[(P_M - C_M)D''(P_M) + 2D(P_M)]. \tag{6.6}$$

Let C_M^M denote the optimal monopoly technology, and let P_M^M denote the monopoly price, given technology C_M^M. Our game is presented in Table 6.1.

Table 6.1 Structure of the entry game

Players

Two firms: the entrant and the incumbent

Information

Perfect

Actions and Events

(1) The incumbent chooses technology C_M by undertaking investment $I(C_M)$.
(2) The entrant decides to enter or not. Fixed entry cost equals F, and marginal cost is C_E. If entry, the entrant sets capacity $Q > 0$, price P_2.
(3) The incumbent sets price P_M.

Payoffs

If no entry:

Incumbent: $\pi_M = (P_M - C_M)D(P_M) - I(C_M)$
Entrant: $\pi_E = 0$

If entry and $P_M > P_2$:

Incumbent: $\pi_M = (P_M - C_M)D(P_M)[1 - Q/D(P_2)] - I(C_M)$
Entrant: $\pi_E = (P_2 - C_E)Q - F$

If entry and $P_M \leq P_2$:

Incumbent: $\pi_M = (P_M - C_M)D(P_M) - I(C_M)$
Entrant: $\pi_E = - F$

Depending on the demand and cost conditions, this game will result in a deterrence equilibrium where no entry occurs, or in an accommodation equilibrium where entry occurs.

3.1 Characterizing the equilibria

The following two assumptions will ensure the existence of equilibrium:

A1: *If the firms set identical prices, the incumbent serves the total demand.*
A2: *If one firm is indifferent between two alternatives, he will choose the alternative which is preferred by the other.*

If the entrant has decided not to enter, the incumbent is just an ordinary monopolist and chooses the monopoly price defined by (6.1). After entry, the incumbent has two alternative actions: He can accommodate (superscript A) by letting the entrant sell the desired quantity Q, or fight (superscript F) by matching the entrant's output price P_2. Setting price $P_M = P_2$ is sufficient to cut off the entrant's sale (from A1). If $P_M > P_2$, we know that all consumers would prefer to buy from the entrant. We assume that all the consumers have the same probability of being served by the entrant, i.e., random rationing rule[5]. Let

$$\pi_M^A(C_M,Q,P_2) = \max_{P_M} (P_M - C_M)D(P_M)[1 - Q/D(P_2)] - I(C_M) \tag{6.7}$$

$$\pi_M^F(C_M,P_2) = (P_2 - C_M)D(P_2) - I(C_M) \tag{6.8}$$

The incumbent will choose accommodation strategy if and only if $\pi_M^A \geq \pi_M^F$ (the weak inequality follows from A2). The first order condition for the maximization problem (6.7) is

$$D(P_M) + (P_M - C_M)D'(P_M) = 0 \tag{6.9}$$

The second-order condition is given by (6.3).

From Table 6.1 we see that the entrant will earn negative profit if the incumbent responds by fighting. Therefore, if he enters he will set P_2 and Q to ensure accommodation. The entrant's profit when entry is deterred equals zero by assumption, and the maximum profit if he enters is given by

$$\pi_E(C_M) = \max_{P_2,Q} [(P_2 - C_E)Q - F] \text{ subject to } \pi_M^A(C_M,Q,P_2) \geq \pi_M^F(C_M,P_2) \tag{6.10}$$

Let $P_2(C_M)$ and $Q(C_M)$ denote the entrant's optimal price and capacity, i.e., the price and capacity that maximizes (6.10). Clearly, the entrant will choose to enter if and only if entry yields positive profit, that is, $\pi_E(C_M) > 0$. The strong inequality follows from A2.

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[5]In some of the earlier versions of the chapter we have assumed efficient rationing rule. It turned out, however, that we were not able to derive an expression for condition no. 2) in Proposition 6.2 that we could interpret. We are indebted to Geir B. Asheim, who suggested that we should use random rationing rule.

At the first stage of the game, the incumbent's choice between accommodation and deterrence is determined by comparing the maximum profit from deterrence with the maximum profit from accommodation:

$$\Pi_M^*(C_M) = \left\{ \begin{array}{lll} \pi_M^A(C_M, Q(C_M), P_2(C_M)) & \text{if} & \pi_E(C_M) > 0 \\ \pi_M^M(C_M) & \text{if} & \pi_E(C_M) \leq 0 \end{array} \right\} \qquad (6.11)$$

The entrant is deterred if $F \geq (P_2 - C_E) \cdot Q$, i.e., if his entry costs wipes out his operating profit. In such a case the incumbent will act as a monopolist for the given technology C_M. If he decides to deter the entrant, he must choose technology among all C_M for which $\pi_E \leq 0$. For all C_M for which $\pi_E > 0$, the incumbent accommodates the entrant. The incumbent's choice between deterrence and accommodation is determined by comparing the C_M that maximizes profit given that $\pi_E \leq 0$ with the C_M that maximizes profit given that $\pi_E > 0$.

3.2 Optimal technology in the case of deterrence

According to Bain (1956), entry is blockaded if it is unprofitable to enter even if the incumbent has not taken any precautions to prevent entry. In our terms, entry is blockaded if $\pi_E(C_M^M) \leq 0$. Clearly, C_M^M is the optimal deterrence technology in this case. When entry is not blockaded, the following result will be useful:

Lemma 6.1: $\dfrac{d\pi_E(C_M)}{dC_M} > 0.$

Proof: See Appendix E.

Entry is deterred if and only if the entrant's maximum profit is non-positive. Hence, if entry is not blockaded, lemma 6.1 says that the incumbent has to choose a technology with lower marginal costs than C_M^M to deter entry. Once entry is deterred, the incumbent is an ordinary monopolist, and there is no reason to reduce marginal costs further. This follows from condition (6.3). These results can be summarized in the following proposition, where C_M^D denotes the optimal deterrence technology:

Proposition 6.1: $C_M^D = min\ \{[max\ C_M | \pi_E(C_M) \leq 0], C_M^M\}$.

3.3 Optimal technology in the case of accommodation

In the case of accommodation, the incumbent's optimal investment is determined by C_M's influence on his own profit. It is of interest to reveal how a reduction in the incumbent's marginal costs affects the entrant's capacity and price. To reveal this effect, called strategic effect in the literature, we can define a hypothetical benchmark called the open loop equilibrium. It is the outcome of the following game:

Stage 1: Incumbent sets C_M, and entrant sets P_2 and Q
Stage 2: Incumbent sets P_M

Comparing with the sequence of moves we defined in Table 6.1, we see that the incumbent in the open loop equilibrium no longer has any first mover advantage concerning investment in marginal costs reduction. Put differently, the entrant cannot observe C_M before entry. By comparing the open loop equilibrium with the case of accommodation, i.e., the equilibrium of the three-stage game specified in Table 6.1 if the entrant in fact enters the market, we reveal how strategic considerations influence the incumbent's investment decision. The open loop equilibrium can thus be regarded as a hypotethical benchmark against which to compare the effect of an observable change in C_M. Unfortunately, the open loop equilibrium has no equilibrium in pure strategies. We can use Table 6.2 to explain this.

If the incumbent decides to fight, he will have a large sale after entry. A reduction in marginal costs will in such a case affect many units, and this will induce him to set a 'low' C_M. The incumbent will thus choose a 'high' C_M if he decides to accommodate, and a 'low' C_M if he decides to fight. If the entrant believes that the incumbent will accommodate and thus set a 'high' C_M, the entrant's best response will be to set a combination of a 'high' P_2 and a 'high' Q. This is the situation depicted in the upper lefthand cell in Table 6.2. However, this is not a subgame-perfect equilibrium. If the incumbent believes that the entrant sets a combination of 'high' P_2 and 'high' Q, the incumbent's best response would

be to set a 'low' C_M and thus to fight. This is the situation depicted in the upper righthand cell in Table 6.2. However, this is not a subgame perfect equilibrium either. The entrant's best response to 'low' C_M is a combination of 'low' P_2 and 'low' Q in order to prevent the incumbent form fighting. However, if the incumbent is not going to fight, he set a 'high' C_M. Arguing this way, we see that there are no equilibrium in pure strategies.

Table 6.2 No equilibrium in pure strategies in open loop equilibrium

		INCUMBENT	
	'High' C_M		'Low' C_M
'High' (P_2, Q)	(1 , 0)	→	(0 , 1)
ENTRANT	↑		↓
'Low' (P_2, Q)	(0 , 1)	←	(1 , 0)
			(Entrant, Incumbent)

Although we have not shown it, there will exist an open loop equilibrium in mixed strategies (see Kreps 1990, p. 409). The non-existence of an open loop equilibrium in pure strategies, however, reveals that the three stage game we have specified is sensitive to changes in the sequence of moves.

There will exist an equilibrium in pure strategies in the case of accommodation. Let us therefore compare the incumbent's optimal investment in the case of accommodation with the optimal investment in the monopoly equilibrium. Whether the incumbent should invest in cost reductions or not when facing entry, will depend on two effects that might work in opposite direction. First, if there are no strategic considerations, i.e., no intertemporal linkage, the incumbent should choose the investment level that minimizes his total costs in the post entry equilibrium. This is called the cost effect. Second, if there is intertemporal linkage, the incumbent should take into account how a reduction in his own marginal costs

affects the entrant's capacity and price and thereby the incumbent's own profit. This is called the strategic effect[6].

The incumbent's profit when accommodating entry is defined as:

$$\Pi_M^A = \max_{C_M} \pi_M^A(C_M, Q(C_M), P_2(C_M)) \tag{6.12}$$

Solving (6.12), we find the optimal marginal costs in the case of accommodation, and we denote this C_M^A. For a given technology, we know from the incumbent's first order condition in (6.9) that the incumbent's optimal post entry price is influenced neither by the entrant's capacity nor by his price. Consequently, given the monopoly technology C_M^M the entrant's optimal post entry price, P_M^A, equals his optimal monopoly price at that technology, i.e., $P_M^M = P_M^A$.

Proposition 6.2: *We have that*

1) $C_M^M > C_M^A$ *if and only if*

$$[P_M - C_M]\frac{D(P_M)}{D(P_2)}[\frac{dQ}{dC_M} - \frac{QD'(P_2)}{D(P_2)}\frac{dP_2}{dC_M}] > D(P_M) - D(P_M)[1 - \frac{Q}{D(P_2)}]$$

2) $C_M^M > C_M^A$ *if*

$$C_E \leq C_M^M \quad \text{and} \quad D''(P_2) \leq \frac{2D'(P_2)^2}{D(P_2)}$$

Proof: See Appendix F.

At the technology C_M^M we have that $P_M^M = P_M^A$, and entry will always reduce the incumbent's sale. In such a case the incumbent should invest less in marginal costs reduction compared to the monopoly equilibrium to ensure cost minimization, all else equal. The reason is that

[6]The strategic effect is extensively studied in the literature, for surveys see Shapiro (1989) or Tirole (1988), chapter 8. The term strategic effect is from Fudenberg and Tirole (1984). Dixit (1986) defines the strategic effect as the indirect effect, and defines what we call cost effect as the direct effect.

a reduction in the incumbent's sale will reduce the number of units an investment in marginal costs reduction will affect. The righthand side of condition no. 1) in Proposition 6.2 is the incumbent's change in sale from entry, and can be interpreted as the cost effect. Hence, according to the cost effect the incumbent should not invest in cost reductions.

The lefthand side of condition no. 1) in Proposition 6.2 can be interpreted as the strategic effect, i.e., how a reduction in the incumbent's marginal costs affects the entrant's capacity and price and thereby the incumbent's own profit. Intuitively, we would expect that strategic considerations instruct the incumbent to invest in marginal costs reduction. A reduction in incumbent's marginal costs would favor the incumbent's response fighting relative to accommodating the entrant. To compensate for this, the entrant must reduce his capacity or reduce his price or both at the same time. A reduction in the entrant's capacity, as well as a reduction in the entrant's price, will increase the incumbent's profit from accommodating entry. Put differently, we would expect that the incumbent's investment at stage 1 will force the entrant to respond at stage 2 by reducing his capacity or reducing his price and thereby induce the incumbent to accommodate entry at stage 3. If so, the incumbent should follow a Top Dog strategy: overinvest to make himself aggressive and thereby soften the entrant (see chapter 4). Sufficient conditions for a Top Dog strategy which are reported in 2) in Proposition 6.2 are, however, rather restrictive. The entrant's marginal costs must not exceed the incumbent's marginal costs, and the demand condition is more restrictive than the one we have from the incumbent's second order condition (see equation 6.3).

Consequently, for $C_E > C_M$ we cannot rule out that investing in cost reductions will reduce the incumbent's profit when accommodating the entrant. To understand such a counter-intuitive result, note that the entrant's response to a reduction in the incumbent's marginal costs can be to lower his price and increase his capacity. The entrant's price reduction will increase the incumbent's cost from fighting and thereby ensure that the incumbent prefers to accommodate entry even though he has lowered his own marginal costs. Because the entrant's response to a reduction in the incumbent's marginal costs is to increase his own capacity, it might not be profitable for the incumbent to invest in a reduction in marginal costs in such a case.

We see from Proposition 6.2 that the cost effect and the strategic effect can work in opposite directions. Assuming the demand is independent of the price at prices below P and equals zero above P, we can reveal the effect analytically.

Proposition 6.3: *Assume* $D(P) = 0$ *for* $P > P_M^M$ *and* $D(P) = D$ *for* $P \leq P_M^M$. *Then we have that* $C_M^A = C_M^M$.

Proof: See Appendix G.

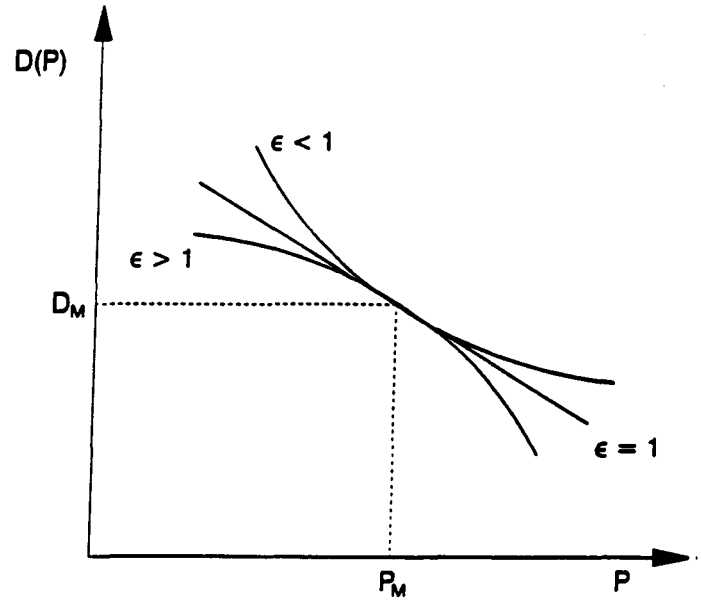
We see that in this extreme case the incumbent's optimal technology in the case of accommodation equals his optimal technology in the monopoly equilibrium. The cost effect will thus exactly wipe out the strategic effect.

3.4 Some simulation results

We have argued that an entrant in the Norwegian cement market will have to import cement from abroad, and thus have higher costs than the domestic incumbent (see chapter 2). Because of the ambiguity for exactly such a case, i.e., $C_E > C_M$, we have used a numerical model to simulate the strategic effect and the total effect. The class of demand functions is defined by $D(P) = a + bP^{\epsilon}$, and satisfies the first and second order conditions for the monopoly pricing problem in (6.1). Note that if $\epsilon > 0$, then $a > 0$ and $b < 0$, and if $\epsilon < 0$, then $b > 0$. As shown in Figure 6.1, ϵ determines the curvature of the demand function (concave demand function if $\epsilon > 1$, linear if $\epsilon = 1$, and convex otherwise).

All demand functions are calibrated at a monopoly equilibrium point: $(P_M^M, D(P_M^M))$, and they have the same slope at this point. We calibrate the demand function by choosing ϵ, and then solving for the parameters a and b. The difference between different demand functions occurs when there is substantial deviation from the initial point. Entry induces such a deviation.

Figure 6.1 The curvature of the demand function



Data for the Norwegian cement market are used to construct a numerical model. We have information about the price, the size of the region (demand), and the marginal costs[7]. If we assume that Norcem behaves as a monopolist initially, we can calibrate a demand function[8]. We simulate how a marginal reduction in C_M, evaluated at the monopoly technology where $C_M = C_M^M$, will affect the equilibrium outcome, i.e., will affect P_M, Q and P_2.

In Table 6.3 we report some results from simulations with the numerical model, assuming random rationing rule[9]. First, we see that in all reported simulations the entrant responds

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[7]The initial price is set to NOK 620 per ton, the initial quantity 400.000 tons, marginal costs NOK 200 per ton for both producers, transportation costs NOK 40 and NOK 100 for the incumbent and the entrant, respectively.

[8]Assuming monopoly behaviour and a linear demand function ($\epsilon = 1$), the calibrated demand function is

$$D = 105.26 - 10.53P.$$

D is 10.000 tons of cement, and P price per ton in NOK 100. For more details about the calibration procedure, see chapter 7.

[9]The numerical model we have used is the one presented in Chapter 7. A sufficient condition for a global (not local) optimum is that the entrant's second order condition is negative. The denominator on the lefthand side of (F.12) is the entrant's second order condition. Unfortunately,

to a reduction in the incumbent's marginal costs by reducing his capacity. The intuition is that a reduction in the incumbent's marginal costs will favor the incumbent's response alternative fighting relative to accommodation, all else equal. To avoid fighting, the entrant must either reduce his price or reduce his capacity, or both at the same time. In the reported simulations the entrant's optimal response is to reduce his capacity, and thus not to reduce his price and increase his capacity. In other simulations, which we have not reported in Table 6.3, the qualitative results are the same as the one reported in Table 6.3.

Table 6.3 Some simulation results[10]

	Shape of the demand function:		
Entrant's Marginal costs:	Convex $\epsilon = -1$	Linear $\epsilon = 1$	Concave $\epsilon = 3$
$C_E = 2.4$	$dP_2/dC_M = 0.0$ $dQ/dC_M = +64$ $d\pi_M^A/dC_M = -93$	$dP_2/dC_M = +0.0$ $dQ/dC_M = +26$ $d\pi_M^A/dC_M = -57$	$dP_2/dC_M = 0.0$ $dQ/dC_M = +16$ $d\pi_M^A/dC_M = -42$
$C_E = 2.7$	$dP_2/dC_M = 0.0$ $dQ/dC_M = +50$ $d\pi_M^A/dC_M = -80$	$dP_2/dC_M = +0.0$ $dQ/dC_M = +24$ $d\pi_M^A/dC_M = -55$	$dP_2/dC_M = 0.0$ $dQ/dC_M = +14$ $d\pi_M^A/dC_M = -37$
$C_E = 3.0$	$dP_2/dC_M = 0.0$ $dQ/dC_M = +39$ $d\pi_M^A/dC_M = -70$	$dP_2/dC_M = 0.0$ $dQ/dC_M = +22$ $d\pi_M^A/dC_M = -52$	$dP_2/dC_M = 0.0$ $dQ/dC_M = +14$ $d\pi_M^A/dC_M = -38$

Second, we see that incumbent's investment has no effect on the entrant's price. According to our simulations, the entrant will respond to incumbent's investment by reducing his capacity and maintaining his initial price. If so, the strategic effect instructs the incumbent

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$\partial^2\pi_E/\partial^2 P_2$ is not negative for all values of P_2. We therefore had to check that Q and P_2 found by the iteration process is a global optimum by plotting the entrant's profit function for different values of P_2 and Q. We substituted the formula for Q from (F.3) into (6.10). By plotting π_E from (6.10) for different values of P_2 we found that the iteration process has picked the global maximum.

[10]Assuming random rationing rule, we have simulated dQ/dC_M and dP_2/dC_M when the incumbent's marginal cost is reduced from 2.4 to 2.39. We have used the formula in Proposition 6.2.1 to calculate $d\pi_M^A/dC_M$.

to invest in cost reductions, because that will soften the entrant.

Third, we see that in all simulations we have reported the incumbent's optimal policy should be to invest in cost reductions so that $C_M^A < C_M^M$. This implies that the strategic effect wipes out the cost effect. In section 3.3 we could only prove analytically that this was the case if $C_E \leq C_M^M$ and the demand function was not too convex.

Sørgard and Vagstad (1990) demonstrated that the entrant's operating profit drops only modestly when the incumbent's marginal costs are reduced[11]. The potential for deterrence is thus limited. Only in cases where the entrant's profit from entry is close to zero when the incumbent has a monopoly technology, will there be scope for reducing the incumbent's marginal costs until entry is unprofitable. In addition, Sørgard and Vagstad (1990) found that the choice between deterrence and accommodation depends critically on the convexity of the demand function as well as the convexity of the investment cost function. Even the incumbent may lack information about these parameters, especially concerning the demand function. The entrant will probably face even larger problems when deducing his optimal behaviour, because he is probably less informed than the incumbent about the demand conditions. It is thus reasonable to ask whether the firms in reality are able to pick the alternative that maximizes profit.

4. An extension: a boundedly rational owner

In this section we will construct a model with behavioral assumptions that differ from the assumptions in the model we analysed in section 3. In line with the theory of bounded rationality, let us assume that there are boundaries set by humans' cognitive limitations. This implies, among other things, that it is not possible for the decision maker to always choose the alternative that maximizes profit, but that there are some specific goals that the decision

[11]Note that in the simulations reported in Sørgard and Vagstad (1990) we assumed an efficient rationing rule.

maker wishes to satisfy[12]. Let us make a distinction between the owner of the firm and the firm's manager. The owner will typically have less time to spend on this particular firm than the manager, and therefore the manager will be in a better position than the owner to choose the alternative that maximizes profit. To focus on this point, let us make the unrealistic assumption that the owner has cognitive limitations and thus is boundedly rational while the manager is behaving in line with the assumptions in the rational choice model[13]. Apart from this, the model is identical with the one we constructed in the previous section.

4.1 The case of monopoly

We assume that the owner has a 'naive' decision rule. He delegates all the decisions, for example, pricing, investments, etc., to the manager. The owner sets a profit target for the firm. If the profit target is met, the manager receives a fixed payment W_0, i.e., independent of the firm's profit. Otherwise the manager is paid W_1, where $W_1 < W_0$. This can be interpreted as though the manager is fired if the profit target is not achieved, assuming no golden parachute. The manager's utility U is increasing in his received payment W and decreasing in the investment I, as in the following utility function:

$$U = W - \psi[I(C^1) - I(C^0)] , \quad \psi > 0 , \quad \psi(0) = 0 . \tag{6.13}$$

---

[12]Search for better production technologies, rather than choosing the optimal technology, is the crucial element in models of bounded rationality. The decision maker searches for cost reductions (or income increases) until he finds an alternative that satisfies the firm's goal (say, profit goal). When the goal and the performance are equalized, the decision maker stops searching for cost reducing (or income increasing) measures. Such ideas was first introduced in Simon (1955,1956) and elaborated further in Cyert and March (1963) and Nelson and Winter (1980,1982).

[13]Alternatively, we could assume that both the manager and the owner act in accordance with a rational choice model and that the owner cannot observe manager's action directly (asymmetric information). This brings us to the principal-agent literature. These models study ways to design an incentive scheme for the manager that induces him to act in line with the owner's goal rather than his own goal. This issue, called moral hazard in the literature, has been studied extensively. For instance, some of the early contributions are Spence and Zeckhauser (1971), Stiglitz (1975), Mirrlees (1976), Harris and Raviv (1979) and Shavell (1979). For surveys of later contributions, see Holmstrøm and Tirole (1989) and Milgrom and Roberts (1992).

C^0 denotes the marginal costs at the start of the period, C^1 the marginal costs at the end of the period. If no investment, $C^0 = C^1$. $\partial U/\partial I < 0$ because it is effort involved in planning and implementing investments, and the manager has disutility from effort. It is obvious that the manager will never invest more than what is needed to achieve the profit target. The reason is that an investment level above the one that is needed to achive the profit target will have no effect on the manager's received payment, but it will imply increased effort and thus increased disutility. The incumbent's technology is the one described in equations (6.4)-(6.6), and the manager has by assumption perfect information about this technology.

Let us first investigate the manager's decision if the firm is a monopolist, and let us formulate it as a three stage game between the owner and the manager. The owner sets the profit target π_M^T (stage 1). The manager observes π_M^T and then decides whether to invest in cost reductions or not (stage 2). The owner observes the profit achieved, and pays the manager W_0 if the profit target is achieved and W_1 otherwise (stage 3). Let superscrift T denote that there exists a profit target rather than a goal to maximize profit. If the manager decides to achieve the profit target, he has the following decision problem:

$$\begin{aligned} C_M^{MT} &\equiv Max\ C_M \\ s.t. \quad &\max_{P_M} (P_M - C_M)D(P_M) - I(C_M) \geq \pi_M^T . \end{aligned} \tag{6.14}$$

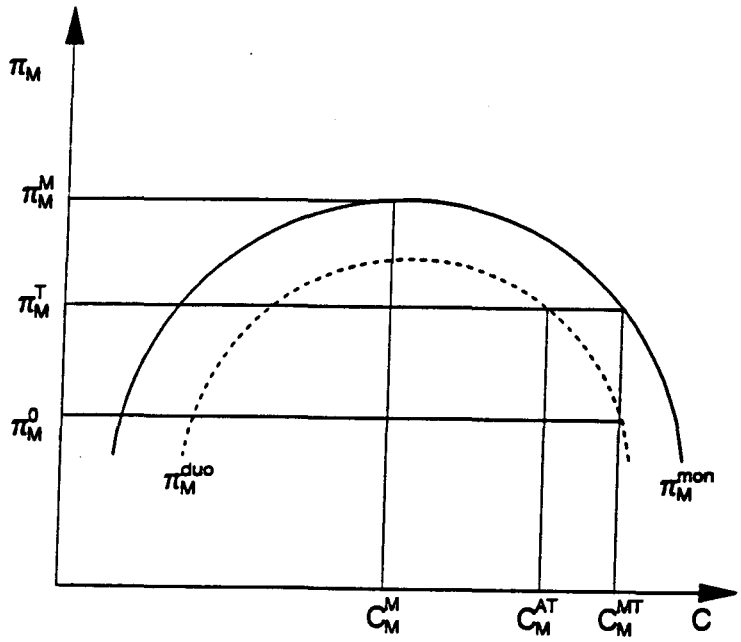
The manager chooses the lowest investment level, i.e., the highest marginal costs, consistent with the profit target the owner has set. Such a behaviour minimizes the disutility of effort to generate the income W_0. Alternatively, he can do nothing, that is, undertake no investment, and receive W_1. Denote the marginal costs if no investment as C_M^0. The manager will invest, i.e., choose marginal costs C_M^{MT}, if:

$$W_0 - \psi[I(C_M^{MT}) - I(C_M^0)] \geq W_1 . \tag{6.15}$$

The relationship between the technology and the incumbent's profit if he is a monopolist is shown in Figure 6.2 with the solid curve denoted π_M^M. C_M^M denotes the optimal monopoly technology, i.e., the marginal costs that maximize monopoly profit. Assuming the profit

goal is π_M^T and the manager decides to achieve the profit goal, he will choose marginal costs C_M^{MT} as shown in Figure 6.2.

Figure 6.2 The relationship between incumbent's investment and profit



4.2 The case of accommodation

The incumbent, who initially is a monopolist, becomes aware of a potential entrant. For the moment, let us assume that he decides to accommodate the entrant. The sequence of moves is identical with the three stage entry game we formulated in section 3, except that we add a stage 0 and a stage 4. At stage 0, the owner of the incumbent firm sets a certain profit target. At stage 4, the owner of the incumbent firm observes the profit achieved, and pays the manager W_0 if the profit target is achieved and W_1 otherwise.

Let us assume that:

$$\pi_M^M > \pi_M^A \; \forall \; C_M. \tag{6.16}$$

For a given investment level, the incumbent thus earns less in duopoly than in monopoly.

The dotted curve in Figure 6.2 shows π_M^{duo}, the incumbent's profit in duopoly. At the initial C_M^{MT}, the incumbent's profit decreases as a result of entry (from 6.16). In Figure 6.2 this is illustrated with the decrease in the incumbent's profit from π_M^T to π_M^0. The profit target can be achieved in duopoly only if the incumbent's maximum profit in accommodation equilibrium (π_M^A) exceeds the profit target:

$$\pi_M^T \leq \pi_M^A \tag{6.17}$$

In Figure 6.2 the profit target is achieved in duopoly if $C = C_M^{AT}$. Assuming the profit target is attainable in duopoly and $C = C_M^{MT}$ initially, the manager will find it profitable to invest only if:

$$W_0 - \psi(I(C_M^{AT}) - I(C_M^{MT})] \geq W_1 \ . \tag{6.18}$$

In line with the prediction from the previous model (section 3), prospects of entry can thus trigger off investment in marginal costs reduction. However, one of the underlying mechanisms in this model is distinctly different from the one in the previous section. According to the model in this section, the manager invests to achieve the profit target. In the model in the previous section the motive for having lower marginal costs in duopoly than in monopoly is to soften the entrant, or to adjust total costs to the increase in own sale. In this particular model, one can observe 'overinvestment' even if the entrant is not softened by incumbent's investment and the incumbent's sale has dropped because of entry. The reason is that entry will always reduce the incumbent's profit below the initial profit target (from equation 6.16). As a consequence, the incumbent must invest in marginal costs reduction to maintain the profitability. Alternatively, the manager can do nothing and receive a lower payment (W_1 instead of W_0).

Proposition 6.4: *Let marginal costs initially be* C_M^{MT}. *Assume that the incumbent accommodates entry, and the owner sets a profit target* π_M^T. *The manager then sets* $C < C_M^{MT}$ *if and only if*

$$W_0 - \psi[I(C_M^{AT}) - I(C_M^{MT})] \geq W_1 \ , \quad \textit{and}$$

$$\pi_M^T \leq \pi_M^A \ .$$

4.3 The case of deterrence

Let us assume that entry is not blockaded ($C_M^M > C_M^D$, see section 3.2). As long as $\pi_M^T \leq \pi_M^A$, the manager will not find it profitable to deter entry. The reason is that deterrence compared to accommodation will have no effect on the manager's received payment, but will increase his disutility because of lower marginal costs and thus higher effort. If $\pi_M^T > \pi_M^A$ and $\pi_M^T > \pi_M^D$, the profit target is not attainable, and the manager invests nothing and receives the payment W_1. If $\pi_M^T > \pi_M^A$ and $\pi_M^T \leq \pi_M^D$, the manager can achieve the profit target only if he chooses the technology that deters entry (C_M^D). He will do so as long the disutility from investing is not wiping out the increase in received payment from W_1 to W_0. We can summarize the results in the following proposition:

Proposition 6.5: *Let marginal costs initially be* $C = C_M^{MT}$. *The manager sets* $C = C_M^D$ *and deters entry if and only if*

$$W_0 - \psi[I(C_M^D) - I(C_M^{MT})] \geq W_1 \ , \quad \textit{and}$$

$$\pi_M^T > \pi_M^A \quad \textit{and} \quad \pi_M^T \leq \pi_M^D \ .$$

5. Some final remarks

We have constructed a theoretical model where the incumbent chooses technology, i.e., the combination of fixed and variable costs, before an entrant behaving in line with the assumptions in Gelman and Salop (1983) decides to enter or not. Will the prospects of such an entrant trigger off changes in the monopolist's technology? Let us first summarize the

results from our basic model, and then see how the results change when we introduce a boundedly rational owner that sets a profit target.

We have shown that if the entrant cannot observe the incumbent's marginal costs before entry, there are no equilibrium in pure strategies. This illustrates that the three-stage entry game we have specified is sensitive to the sequence of moves. Moreover, it illustrates that the model of Gelman and Salop (1983) is sensitive to the extension of letting the incumbent choose marginal costs simultaneous with the entry decision.

We have compared the case of accommodation with the monopoly equilibrium, and distinguished between the cost effect and the strategic effect. Without any strategic considerations, how should the incumbent invest to minimize costs in the post entry equilibrium (cost effect), and how should he invest to soften the entrant (strategic effect)? We have shown analytically that an increase in marginal costs will reduce total costs when entry has taken place. Put differently, cost considerations instruct the incumbent not to invest in lower marginal costs when accommodating entry.

Intuitively, we expected that a lower marginal cost would soften the entrant. We could, however, only prove analytically that this was the case if the entrant's marginal cost was lower than the incumbent's marginal costs. The reason for a possible counter-intuitive sign of the strategic effect is that the entrant can respond by reducing his price and increasing his capacity, or the reverse. Such a response to the incumbent's investment will reduce the incumbent's profit from accommodating entry, and the incumbent will thus be better off if he does not invest in a reduction in marginal costs. Results from numerical simulations suggest that even if the entrant has a cost disadvantage, a reduction in marginal costs will soften the entrant.

Results from the simulations suggest that the strategic effect wipes out the cost effect. If so, the optimal accommodation technology has higher fixed costs and lower variable costs than the optimal monopoly technology. If entry is not blockaded when the incumbent has the monopoly technology, we have shown analytically that the incumbent has to choose a

technology with lower marginal costs to deter entry.

The model referred to above predicts that the incumbent should typically invest in cost reduction when facing a threat of entry of the kind described in Gelman and Salop (1983), because this will soften or deter the entrant. However, in an extended version of our model we have shown that there can be another rationale for the incumbent's investment in cost reduction when facing an entry threat. If the owner sets a certain profit goal the manager must achieve to receive a high payment (low payment otherwise), the manager will invest in cost reduction when facing entry simply to maintain the firm's profitability and thereby maintain his own high payment.

Our specific entry game was motivated by some characteristics of the Norwegian cement market. It is reasonable to ask what was the main driving force behind Norcem's investment in cost reductions during the '80s. Was the driving force strategic considerations as highlighted in the basic version of our model, or was the driving force to maintain profitability as highlighted in the extended version of our model? The information we reported in section 1, which was a combination of official statements, internal reports etc., suggests that both motives had importance.

Although we lack more precise information that enable us to reveal which one of these two motives was the most important for the decision, it is reasonable to ask whether it is fruitful to search for one single motive. Other factors than those two mentioned here might have influenced the decision as well. The investment could be the result of old plants that were ready for modernization at that particular point of time. During the '80s Norcem and the Swedish cement producer established close relations. Especially through its jointly owned trading firm Scancem Group Ltd., and this has been mentioned as one factor that might influenced the investment decisions during the '80s[14]. This suggests that the timing, for

[14]When Jørn Lindstad, the marketing director of Norcem a.s., was asked to comment on the rationale for investment decisions during the '80s, he replied that several factors in addition to those that were directly related to the cement market influenced the decisions: Norcem had other options for investments, for example in construction industry; the three plants competed, because investment

example the simultaneity between old plants ready for modernization and the cooperation between Norcem and the Swedish cement producer, has influenced the decision making process. The explanation stated in the annual report might thus be an ex post rationalization of a decision that was in fact partly a garbage can decision, i.e., affected by timing rather than the consequential connections between different factors.

The complexity surrounding this specific investment decision emphasizes the warning in chapter 3. It was pointed out that the predictions from a specific model must not be interpreted as an ultimate explanation of past action. Our model has focused on some factors and neglected others, excluding, among others, the driving forces in a garbage can model. The predictions from the specific model can thus do no more than help us to understand what decisions would have been made if the decision maker was governed by some pure economic incentives, and not influenced by the rest of the complexity in the real world.

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decisions were decisive for which would survive; the cooperation with the Swedish cement producer was started; the labour union preferred a high investment level, partly to secure employment opportunities; uncertainty about the future development in the Norwegian market.

Appendix E: Proof of Lemma 6.1

To find the maximum value of the entrant's accommodation profit we form the Lagrangian for problem (6.10):

$$L(P_2,Q,\lambda) = (P_2 - C_E)Q - F + \lambda[\pi_M^A(C_M,Q,P_2) - (P_2 - C_M)D(P_2) + I(C_M)] \qquad (E.1)$$

which gives the following set of first order conditions (using the envelope theorem to differentiate the maximum value function $\pi_M^A(C_M,Q,P_2)$ defined by equation (6.7)):

$$\partial L/\partial P_2 = Q - \lambda[(P_2 - C_M)D'(P_2) + D(P_2) + (P_M - C_M)QD'(P_2))/D(P_2)^2] = 0 \qquad (E.2)$$

$$\partial L/\partial Q = P_2 - C_E - \lambda(P_M - C_M)D(P_M)/D(P_2) = 0 \qquad (E.3)$$

$$\partial L/\partial \lambda = \pi_M^A(C_M,Q) - (P_2 - C_M)D(P_2) + I(C_M) = 0 \qquad (E.4)$$

The envelope theorem yields $\partial \pi_E/\partial C_M = \partial L/\partial C_M$. Hence, using (E.3) to eliminate the Lagrange multiplier,

$$\frac{d\pi_E(C_M)}{dC_M} = \lambda[\frac{\partial \pi_M^A}{\partial C_M} + D(P_2)] = \frac{(P_2 - C_E)D(P_2)}{P_M - C_M}[D(P_2) - D(P_M)(1 - \frac{Q}{D(P_2)})] \qquad (E.5)$$

As $P_2 > C_E$, $P_M > C_M$ and $P_2 < P_M$, the righthand side of equation (E.5) is positive. Q.E.D.

Appendix F: Proof of Proposition 6.2

Differentiating (6.12) with respect to C_M we have that:

$$\begin{aligned}\frac{d\Pi_M^A}{dC_M} &= D(P_M)[1 - Q/D(P_2)][\frac{\partial P_M}{\partial C_M} + \frac{\partial P_M}{\partial Q}\frac{dQ}{dC_M} + \frac{\partial P_M}{\partial P_2}\frac{dP_2}{dC_M} - 1] \\ &+ [P_M - C_M][1 - Q/D(P_2)]D'(P_M)[\frac{\partial P_M}{\partial C_M} + \frac{\partial P_M}{\partial Q}\frac{dQ}{dC_M} + \frac{\partial P_M}{\partial P_2}\frac{dP_2}{dC_M}] \\ &- [P_M - C_M]D(P_M)(\frac{dQ/dC_M}{D(P_2)} - \frac{Q\,D'(P_2)(dP_2/dC_M)}{[D(P_2)]^2}) - I'(C_M) \qquad (F.1)\end{aligned}$$

Using the envelope theorem, we can reveal the effect of a marginal change in marginal costs, evaluated at the incumbent's optimal post entry price:

$$\frac{d\pi_M^A(C_M)}{dC_M} = -[P_M - C_M]D(P_M)\left[\frac{dQ/dC_M}{D(P_2)} - \frac{QD'(P_2)dP_2/dC_M)}{[D(P_2)]^2}\right]$$

$$- I' - D(P_M)[1 - Q/D(P_2)] \qquad \text{(F.2)}$$

Assuming monopoly technology, we have that - I' = $D(P_M^M)$. Substituting this into (F.2), we have condition no. 1 in Proposition 6.2.

To derive condition no. 2 in Proposition 6.2, we start by rearranging the constraint in the entrant's profit maximization problem in (6.10)[14]:

$$Q = [1 - \frac{(P_2 - C_M)D(P_2)}{(P_M - C_M)D(P_M)}]D(P_2) \qquad \text{(F.3)}$$

Substituting (F.3) into the entrant's profit maximization problem and multiplying with the incumbent's profit, we have:

$$\max_{P_2} (P_2 - C_E)D(P_2)[(P_M - C_M)D(P_M) - (P_2 - C_M)D(P_2)] \qquad \text{(F.4)}$$

We see that Q is eliminated, so that the entrant's problem is to choose P_2 so that (F.4) is maximized. Let us denote the profit functions as follows:

$$\pi(P_i,C_j) = (P_i - C_j)D(P_i) \qquad i = 2,M \quad and \quad j = E,M \qquad \text{(F.5)}$$

and π_i the derivate of the profit function with respect to i. The entrant's first order condition is as follows:

$$\pi_P(P_2,C_E)[\pi(P_M,C_M) - \pi(P_2,C_M)] - \pi_P(P_2,C_M)\pi(P_2,C_E) = 0 \qquad \text{(F.6)}$$

The incumbent's maximization problem is as follows:

$$\pi_M = \max_{C_M} \pi(P_2(C_M),C_M) - I(C_M) \qquad \text{(F.7)}$$

We know from the monopolist's maximization problem that:

$$\pi_C(P_M^M,C_M^M) = I'(C_M^M) \qquad \text{(F.8)}$$

The solution to this problem is C_M^A, the optimal technology in accommodation equilibrium. We then have that

$$C_M^A < C_M^M$$

if

[14]We are indebted to Geir B. Asheim for extremely helpful suggestions concerning the remaining part of this proof.

$$\pi_C(P_M^M, C_M^M) > \frac{d}{dC_M}[\pi(P_2(C_M^M), C_M^M)] \tag{F.9}$$

Writing the righthand side explicitly and rearranging, we have that $C_M^A < C_M^M$ if and only if

$$\frac{dP_2}{dC_M} < \frac{\pi_C(P_M^M, C_M^M) - \pi_C(P_2(C_M^M), C_M^M)}{\pi_p(P_2(C_M^M), C_M^M)} \tag{F.10}$$

To derive dP_2/dC_M, we differentiate the entrant's first order condition, i.e. (F.6), with respect to C_M:

$$\begin{aligned}
&[\pi_{PP}(P_2, C_E)[\pi(P_M, C_M) - \pi(P_2, C_M)] - 2\pi_P(P_2, C_E)\pi_P(P_2, C_M) \\
&\quad - \pi(P_2, C_E)\pi_{PP}(P_2, C_M)]dP_2 \\
&+ [\pi_P(P_2, C_E)[\pi_C(P_M, C_M) - \pi_C(P_2, C_M)] \\
&\quad - \pi(P_2, C_E)\pi_{PC}(P_2, C_M)]dC_M = 0
\end{aligned} \tag{F.11}$$

Rearranging (F.11), substituting dP_2/dC_M into (F.10) and rearranging, we have that:

$$\begin{aligned}
&\frac{\pi_P(P_2, C_E)[\pi_C(P_M^M, C_M^M) - \pi_C(P_2, C_M^M)] - \pi(P_2, C_E)\pi_{PC}(P_2, C_M^M)}{\pi_{PP}(P_2, C_E)[\pi(P_M^M, C_M^M) - \pi(P_2, C_M^M)] - \pi_{PP}(P_2, C_M^M)\pi(P_2, C_E) - 2\pi_P(P_2, C_E)\pi_P(P_2, C_M^M)} \\
&> \frac{\pi_C(P_2(C_M^M), C_M^M) - \pi_C(P_M^M, C_M^M)}{\pi_P(P_2(C_M^M), C_M^M)}
\end{aligned} \tag{F.12}$$

Multiplying with the denominators on both sides, we have that:

$$\begin{aligned}
&\pi_P(P_2, C_E)\pi_P(P_2, C_M^M)[\pi_C(P_M^M, C_M^M) - \pi_C(P_2, C_M^M)] - \pi(P_2, C_E)\pi_P(P_2, C_M^M)\pi_{PC}(P_2, C_M^M) \\
&< [\pi_C(P_2, C_M^M) - \pi_C(P_M^M, C_M^M)][\pi_{PP}(P_2, C_E)[\pi(P_M^M, C_M^M) - \pi(P_2, C_M^M)] \\
&- \pi_{PP}(P_2, C_M^M)\pi(P_2, C_E)] - 2\pi_P(P_2, C_E)\pi_P(P_2, C_M^M)[\pi_C(P_2, C_M^M) - \pi_C(P_M^M, C_M^M)]
\end{aligned} \tag{F.13}$$

Moving the last term on the righthand side to the lefthand side, we have that:

$$\begin{aligned}
&\pi_P(P_2, C_E)\pi_P(P_2, C_M^M)[\pi_C(P_2, C_M^M) - \pi_C(P_M^M, C_M^M)] \\
&\quad - \pi(P_2, C_E)\pi_P(P_2, C_M^M)\pi_{PC}(P_2, C_M^M) \\
&< [\pi_C(P_2, C_M^M) - \pi_C(P_M^M, C_M^M)][\pi_{PP}(P_2, C_E)[\pi(P_M^M, C_M^M) \\
&\quad - \pi(P_2, C_M^M)] - \pi_{PP}(P_2, C_M^M)\pi(P_2, C_E)]
\end{aligned} \tag{F.14}$$

From the monopolist's first order condition we know that $\pi_P(P_2, C_M^M) > 0$ as long as $P_2 < C_M^M$, which is the case. As a result, we can see from (F.6) that $\pi_P(P_2, C_E) > 0$. From (F.5) we have that $\pi_{PC}(P_2, C_M^M) = -D'(P_2) > 0$. Consequently, the last term on the lefthand side is positive. From (F.5)

we have that $\pi_C(P_i,C_M^M) = - D(P_i)$. The fact that $P_2 < P_M^M$ and $D'(P) < 0$ implies that the expression in the parenthesis in the first term on the lefthand side is negative. Consequently, the first term on the lefthand side is negative, and the sum of the first and second term on the lefthand side is negative. A sufficient condition for $C_M^A < C_M^M$ is then that the righthand side is positive. This implies that $C_M^A < C_M^M$ if:

$$\pi_{PP}(P_2,C_E)[\pi(P_M^M,C_M^M) - \pi(P_2,C_M^M)] - \pi_{PP}(P_2,C_M^M)\pi(P_2,C_E)] \leq 0 \qquad \text{(F.15)}$$

From the entrant's first order condition, we know that:

$$[\pi(P_M,C_M) - \pi(P_2,C_M)] = \frac{\pi_P(P_2,C_M^M)}{\pi_P(P_2,C_E)}\pi(P_2,C_E) \qquad \text{(F.16)}$$

Substituting (F.16) into (F.15) and deleting $\pi(P_2,C_E)$, we have:

$$\pi_{PP}(P_2,C_E)\frac{\pi_P(P_2,C_M^M)}{\pi_P(P_2,C_E)} - \pi_{PP}(P_2,C_M^M) \leq 0 \qquad \text{(F.17)}$$

Rearranging:

$$\frac{\pi_P(P_2,C_M^M)}{\pi_P(P_2,C_E)} \geq \frac{-\pi_{PP}(P_2,C_M^M)}{-\pi_{PP}(P_2,C_E)} \qquad \text{(F.18)}$$

Assuming $D''(P) = 0$, we see from (6.3) that the righthand side equals 1. By substituting the incumbent's first order condition from (6.2) into the lefthand side of (F.18) and rearranging, we have that (F.18) is met if $C_M^M \geq C_E$.

Assuming $D''(P) < 0$ and $C_M^M \geq C_E$, we have that (F.18) is met if the righthand side equal to or less than 1, i.e.:

$$-(P - C_M^M)D''(P) \leq -(P - C_E)D''(P) \qquad \text{(F.19)}$$

We see that (F.19) is met if $C_M^M \geq C_E$.

Let us assume that $C_M^M \geq C_E$. If:

$$\frac{\pi_{PC}(P_2,C)}{\pi_P(P_2,C_E)} \geq \frac{-\pi_{PPC}(P_2,C)}{-\pi_{PP}(P_2,C_E)} \quad \textit{for all} \quad C \in [C_E,C_M] \qquad \text{(F.20)}$$

we know that (F.18) is met. By substituting the first, second and third order derivatives into (F.20), we have that:

$$\frac{-D'(P_2)}{D(P_2) + (P_2 - C_E)D'(P_2)} \geq \frac{-D''(P_2)}{2D''(P_2) + (P_2 - C_E)D''(P_2)} \qquad \text{(F.21)}$$

We see that if $D''(P) \leq 0$, (F.21) is met. This is consistent with what we found in the two preceding paragraphs. Rearranging (F.21), we have that:

$$D''(P_2) \leq \frac{2D'(P_2)^2}{D(P_2)} \tag{F.22}$$

(F.22), in addition to $C_E \leq C_M^M$, is condition no. 2 in Proposition 6.2. We know from (6.2) that for $P < P_M$ and $C = C_M$, $D(P) > -(P - C)D'(P)$. From (F.4) we see that $\pi_P(P_2, C_E) > 0$, that is, for $P < P_M$ and $C = C_E$, $D(P) > -(P - C)D'(P)$. Consequently, the incumbent's second order condition, i.e.,

$$D''(P_2) < -\frac{2D'(P_2)}{P_2 - C} \tag{F.23}$$

is less strict than (F.22). Q.E.D.

Appendix G: Proof of Proposition 6.3

Totally inelastic demand implies that $D'(P) = 0$, and $D(P) = D$. By rewriting equations (E.2) - (E.4), eliminating the Lagrange multiplier and solving for Q and P_2 we get

$$P_2 = (P_M^M + C_E)/2 \tag{G.1}$$

$$Q = D\,(P_M^M - C_E)/[2(P_M^M - C_M)] \tag{G.2}$$

We see that P_2 is no longer influenced by changes in C_M ($dP_2/dC_M = 0$). Consequently, dQ/dC_M is found by differentiation of (G.2). From (F.2), assuming $dP_2/dC_M = 0$, we have the strategic effect:

$$-(P_M^M - C_M)\frac{dQ}{dC_M} = -(P_M^M - C_M)\frac{(P_M^M - C_E)D}{2(P_M^M - C_M)^2} = -Q \tag{G.3}$$

We see that the strategic effect equals - Q. From equation (F.2) we then see that the cost effect (the sum of the second and third term of F.2) equals Q, since the demand is invariant to price changes for prices below P_M^M. Hence the sum of these two effects equal zero. Q.E.D.

Chapter 7:

A MULTIPRODUCT INCUMBENT[1]

Intra-European trade barriers will probably be reduced during the 1990s. This is due to the establishment of the internal market in the European Community and a European Economic Space consisting of EC and EFTA countries, as well as the closer integration of the Eastern and Western European economies. The purpose of this chapter is to assess how reduced trade barriers might affect the Norwegian cement market. This is done by 'tailoring' the theory to the characteristics of this specific market. We use inside information from the incumbent firm in this market to model a plausible future entry game. In particular, we assume that there is a common, international standard for cement, and this standard is less restrictive than the one in Norway at present. Because of this, the Norwegian cement market is segmented into a high and a low quality part. We assume that the entrant has a cost disadvantage, specifically higher transportation costs, and that he can only enter in the low quality segment. The incumbent holds idle capacity and is prepared to cut prices if that is a profitable strategy. We analyse what might happen if the entrant pursues a Puppy Dog strategy by limiting his capacity and setting a low price, the strategy Viking Cement followed when it succeeded in entering this market in the early '80s (see chapter 5).

This chapter is organized as follows. In Section 1, we briefly present a plausible future entry game in the Norwegian cement market. In section 2, we describe the model. We simulate the entry game in section 3, and analyse the net welfare gains. In Section 4, we present a summary of the results.

1. The Norwegian cement market in the '90s

As we reported in chapter 2, the cement industry is a typical oligopolistic industry in many European countries. In Norway the domestic producer has a market share of 97 per cent, despite the fact that price-cost margin far outweighs transportation costs from Europe to Norway. It is reasonable to ask whether this will change during the '90s. An internal

[1]This is a revised version of Sørgard (1992).

report, written jointly by Norcem and the Swedish cement company Cementa, outlines four scenarios for the '90s (see chapter 3). We can do no better than accepting the main features in their scenarios, which we report in the following.

A common, international standard for cement (CEN-standard) will probably come into effect by the end of 1992, and will replace the existing national standards in all EC and EFTA countries. Such a common standard is expected to be less restrictive than some of the existing national standards, e.g. the Norwegian standard for cement (see Skjelle 1989). This might result in a high quality segment and a low quality segment (see summary of scenario IV, p. 1).

In the low quality segment, e.g. cement used for indoor construction and housing, the CEN-standard requirements are sufficient and will define a minimum quality. Norcem expects that the importers will try to mimic their quality choice:

> 'The importer offers cement which as far as possible is identical with the quality of Norcem/Cementa'. (scenario II, p. 4) [my translation]

In other parts of the market, e.g. cement used in the construction of large buildings and offshore platforms, necessary strength requirements will exceed the specifications set by the CEN-standard. In such cases, each buyer will demand a specific quality, and the producer must 'tailor' his quality to each customer's need. This will probably favour the domestic producer, who is closer to the market and has the distributional capacity to offer a large variety of qualities. According to this scenario, importation is more likely in the low quality than the high quality segment (scenario IV, p.8).

Norcem may block some of the potential imports for the low quality segment. This will be the case if Norcem holds the exclusive right to import from some Eastern European countries, through, for example, an agreement similar to those arranged with Poland and East Germany in the 1980s (see scenario II, p. 4 and scenario III, p. 4). In addition, Norcem

may further integrate downstream to 'protect the market by strategic positioning' (scenario II, p. 6).

Finally, Norcem may undertake sales promotion in the high quality segment, putting effort into 'tailoring the product quality to the customers' need' (scenario II, p. 4). This will increase customers' loyalty in this segment. A price war in the low quality segment following entry will then have only a minor or no price effect in the high quality segment.

The low quality segment is expected to constitute at most half of the total domestic demand for cement. This suggests that even if Norcem succeeds in its strategy of preventing some low quality imports and increases its downstream integration, there might be room for new entrants in some parts of the low quality segment. One option for Norcem would then be to trigger off price competition to secure its dominant position:

> 'Cementa and Norcem have adjusted to the new competitive situation .. locally by price competition to keep away guerilla competition from EC suppliers' (scenario II, p. 1) [m.t.]

Price cutting is a viable strategy, because Norcem's capacity will exceed the domestic demand when its new plant comes into operation in 1992 (see chapter 2). However, it will not always be a profitable strategy:

> '..[O]ne must/should allow [establishment of] suppliers in time-specific project deliveries where .. the price/quality requirements are not well suited for the Scandinavian producers'. (scenario I, p. 7) [m.t.]

Has a high cost entrant any chance to succeed when Norcem holds idle capacity and is prepared to cut prices as a response to entry if that is a profitable strategy? It is of interest to take a look at the strategy chosen by the only existing importer of cement, Viking Cement in Stavanger. It restricted its supply and set a low price (see chapter 5). The restriction on its supply, which according to Viking Cement was done 'for fear of Norcem', limits the

incumbent's loss by accommodating this entry. The low price makes it costly for the incumbent to match the entrant's price.

2. A theoretical model

The following model depicts the main features of a future entry game consistent with the foregoing. We assume that the market is segmented into a low quality and a high quality part. All entrants are excluded from the high quality segment. An entrant that decides to establish in the low quality segment will offer a good which is identical to the existing one, but due to higher transportation costs it will have a cost disadvantage. Furthermore, we assume that the incumbent will cut its price as a response to entry if that is a profitable strategy.

The entrant sets the capacity Q and the price P_2 in the low quality segment (stage one). The incumbent has excess capacity and sets price P_L in the low quality segment and P_H in the high quality segment after observing Q and P_2 (stage two). If the incumbent matches the entrant's price, we assume that the incumbent meets the whole demand. If the incumbent accommodates entry, he will set $P_L > P_2$ in order to maximize profit from the residual demand.

For the moment, let us assume that the entrant's customers are randomly chosen from among all those who demand the low quality product at price P_2. Let D_i ($i = L,H$) denote the demand in segment i. We assume that low quality and high quality products are substitutes ($\partial D_j/\partial P_i > 0$, $i,j = L,H$ for all i different from j). The incumbent's initial customers who switch to buying from the entrant are the following for the low quality and the high quality segments, respectively:

$$D_L(P_L,P_H)\frac{Q}{D_L(P_2,P_H)}\ , \tag{7.1}$$

$$[D_H(P_L,P_H) - D_H(P_2,P_H)]\frac{Q}{D_L(P_2,P_H)}\ . \tag{7.2}$$

In particular, (7.1) and (7.2) show the customers in each of the two segments who prefer to be served by the entrant rather than by the incumbent, multiplied by the share of the customers demanding the entrant's quantity that actually are served by the entrant. Assuming that the incumbent's marginal costs for both the low and the high quality segment (C_L and C_H, respectively) are constant, the incumbent's per-period profit if it accommodates entry is:

$$\pi_M^A = \max_{P_L,P_H} \{(P_L - C_L)[D_L^L - \frac{QD_L^L}{D_L^2}] + (P_H - C_H)[D_H^L - \frac{Q(D_H^L - D_H^2)}{D_L^2}]\} \tag{7.3}$$

D_i^L and D_i^2 denote the demand in segment i (i = L,H) at the incumbent's and the entrant's prices in the low quality segment, respectively. Let us define $\eta_{ij}|_{Pk}$ as the elasticity of demand in market i with respect to prices in market j, evaluated at price P_k.

Proposition 7.1: *Assuming a random rationing rule, the incumbent's best response to entry is to raise his price in both the high quality and the low quality segment if:*

$$\eta_{HH}|_{P_L}(1 - D_L^2/Q) - \eta_{LH}|_{P_2} \geq 0\ , \tag{7.4}$$

$$\eta_{HH}|_{P_L}D_H^L - \eta_{HH}|_{P_2}D_H^2 \leq 0\ , \tag{7.5}$$

$$(P_L - C_L)[\eta_{LH}|_{P_2} - D_L^L\eta_{LH}|_{P_L}] \geq \frac{P_H(D_H^L - D_H^2)}{D_L^2}\ . \tag{7.6}$$

Proof: See Appendix H.

The intuition is that the entrant captures a representative portion of the total demand for the low quality product. As a result, both the own price elasticity (η_{LL}) and cross price

elasticities (η_{HL}) are unaffected by entry. The incumbent will, therefore, maintain his pre-entry price for the low quality product. In the high quality segment, entry may change both the own price elasticity and the cross price elasticity. A reduced own price elasticity ($-\eta_{HH}|_{P2} < -\eta_{HH}|_{PL}$), as well as an increased cross price elasticity ($\eta_{LH}|_{P2} > \eta_{LH}|_{PL}$), will induce the incumbent to increase his price in the high quality market. On the other hand, a reduced market share in the low quality segment will induce the incumbent to reduce his price in the high quality segment towards the single product monopoly price. The final outcome depends on the size of the low quality segment and the entrant's capacity, as well as the price elasticities in the high quality segment. If the price in the high quality segment increases, the incumbent will have an incentive to raise his low quality price as well. The reason is that the incumbent earns a higher price-cost margin on those consumers who switch from the low quality to the high quality product. This result is different from the single product case, where the incumbent will maintain his pre-entry price in the post entry period if the entrant's quantity is rationed randomly (see Gelman and Salop 1983).

Proposition 7.2: *Assuming an efficient rationing rule, the incumbent's best response to entry is to reduce his price in both the high quality and the low quality segment.*

Proof: See Appendix I.

The intuition for this result is that the incumbent's demand becomes more price sensitive when the consumers with the highest willingness to pay are served by the entrant rather than the incumbent. This induces the incumbent to reduce his price in the low quality segment. As a consequence, the incumbent will have an incentive to reduce his price in the high quality segment towards the single product monopoly price. This result is in line with the results in Gelman and Salop (1983).

If the incumbent matches the entrant's price P_2 in the low quality segment, his per-period profit is defined as:

$$\pi_M^F = \max_{P_H} \{(P_2 - C_L)D_L(P_2,P_H) + (P_H - C_H)D_H(P_2,P_H)\} \tag{7.7}$$

The price-cost margin in the high quality segment will then be:

$$\frac{P_H - C_H}{P_H} = -\frac{1}{\eta_{HH}} - \frac{(P_2 - C_L)D_L^2\eta_{LH}}{P_H D_H^2 \eta_{HH}} \tag{7.8}$$

Clearly, a price cut in the low quality segment will reduce the optimal price in the high quality segment.

If the incumbent cuts prices, it will be difficult for him to return to the initial monopoly price immediately afterwards. The reason is that the producer may sign contracts with the buyers, contracts that will last a certain number of periods (denoted f). This is typically the case in the cement industry, where buyers are involved in long term projects such as the building of dams. Let us assume that the entrant decides to leave immediately if he observes that the incumbent matches his price. This seems natural because he knows that the incumbent has lower marginal costs and thus can undercut him[2]. Furthermore, let us assume that if the incumbent decides to cut prices, he will continue to do so until the entrant has left the market. Given such strategies, the matching period equals f, i.e., the length of the contract between the incumbent and buyer. If we assume an infinite time horizon, the entrant will have the following maximization problem (assuming entry):

[2]Alternatively, the entrant leaves after a certain number of periods with price cutting. See Seabright (1990) where such an entry game is modelled.

$$\pi_E = \max_{P_2,Q} \frac{(P_2 - C_E)Q}{1 - \delta} \tag{7.9}$$

subject to:

$$\frac{\pi_M^A}{1 - \delta} \geq \sum_{t=1}^{f} \frac{\pi_M^F}{(1/\delta)^{t-1}} + \frac{\pi_M \delta}{(1 - \delta)(1/\delta)^{f-1}}$$

where δ is the discount factor and π_M denotes monopoly profit in both markets. The term on the left hand side of the constraint is the incumbent's present value if he accommodates entry, while the term on the righthand side is the incumbent's present value of matching the entrant's price. In the particular case where the duration of matching and accepting are equal and the cross price elasticities equal zero, the model is identical to Gelman and Salop (1983). They have shown that the optimal strategy for such an entrant is to limit his capacity and set a rather low price. Low capacity will imply that the incumbent's profit loss from accommodating entry is rather small, while a low price set by the entrant implies that the incumbent's profit loss in the matching period will be rather large. This is an example of what Fudenberg and Tirole (1984) call a Puppy Dog strategy, where the entrant underinvests to ensure a friendly behaviour of the incumbent.

The net welfare gain of such an entry is ambiguous in theory. Consumers served by the entrant will gain, while the incumbent's remaining customers will gain only if the incumbent's response to entry is to reduce his price. If entry occurs through imports, the incumbent, i.e., the domestic producer, will lose profit, while the foreign high cost entrant will gain. If the profit shift from the domestic to the foreign producer outweighs the consumers gain, if any, the host country will experience a net welfare loss from entry.

3. A numerical model

The theoretical ambiguity concerning net welfare justifies a simulation model. Here we will construct such a model (see section 3.1), simulate the entry game (see section 3.2) and compute the net welfare gain (see section 3.3).

3.1 Model specification and calibration

To allow for various alternatives concerning the demand curvatures, we have chosen the following demand system:

$$D_L = A_L + B_L P_L^{\epsilon_{LL}} + G P_H^{\epsilon_{LH}} \tag{7.10}$$

$$D_H = A_H + G P_L^{\epsilon_{HL}} + B_H P_H^{\epsilon_{HH}} \tag{7.11}$$

For linear demand functions ($\epsilon_{ii} = 1$ where i = L,H), the system is identical with the one applied by Dixit (1988) and Laussel et.al. (1988) in their analyses of the automobile industry.

Several studies provide evidence of economies of scale in cement production (see, for example, McBride 1981). These are mainly the result of kiln investment costs, but can also arise from the supervisory role of some of the labour input. Other inputs such as raw materials and energy are found to exhibit constant returns to scale. We therefore assume that the cost function (K) has the following form:

$$K = C_i X_i + S \quad for \quad i = L,H \tag{7.12}$$

where X_i denotes quantity produced for segment i, and S denotes the fixed costs from investment and supervisory labour.

According to Norcem's internal report, the low quality segment will not exceed half the Norwegian cement market of 1.6 million tons annually. However, price competition is expected to be local, i.e., an entrant will not penetrate the whole market. We have therefore rather arbitrarely set the relevant market size to be 400,000 tons in our base case. The c.i.f price of cement exclusive taxes was in 1990 NOK 620 in Oslo for the most common quality, which we will set as the initial price in the low quality segment. In line with the information in chapter 2, we set marginal costs of this quality to NOK 200. The transportation costs per ton exclusive of capital costs, i.e., investment in silo terminal, have been set at NOK 40 for Norcem and NOK 100 for the entrant who ships cement from Europe to Norway (see chapter

2). We have set the length of the matching period to one year, a typical contract length according to our information. Finally, the annual discount rate is set at 15 per cent.

Norcem is facing a maximum price regulation. As a consequence, we assume that the firm is unable to raise its price to the monopoly equilibrium where the demand for cement is price elastic. In line with the estimates referred to in Smith and Venables (1988), we have chosen to set the own price elasticities at - 0.6. From technological reasons, namely, strength requirements, it seems reasonable to assume that the possibility of switching from the high to the low quality segment is very limited. We therefore set the cross price elasticities equal to zero. As a result, data for the high quality segment is only needed for the sensitivity analysis. Because of price regulation, we assume that the price-cost margin is set to be the same in both segments. In line with the information from Norcem, the initial quantity is set to be the same in the two segments. The marginal costs (and hence the price) is arbitrarely set to be 50 per cent higher in the high quality segment.

If we now choose a specific demand curvature (choose ϵ) and choose cross price elasticities in the initial monopoly situation so that

$$\eta_{ji} D_j / P_i = \eta_{ij} D_i / P_j \quad \text{for} \quad i, j = L,H \ (i \neq j), \tag{7.13}$$

we are able to calibrate the parameters B_L, B_H and G in the demand functions:

$$B_i = \frac{D_i \eta_{ii}}{\epsilon_{ii} P_i^{\epsilon_{ii}}} \quad \text{for} \quad i = L,H \tag{7.14}$$

$$G = \frac{D_i \eta_{ij}}{\epsilon_{ij} P_j^{\epsilon_{ij}}} \quad \text{for} \quad i, j = L,H \ (i \neq j) \tag{7.15}$$

The remaining parameters A_L and A_H are calibrated by substituting (7.14) and (7.15) into (7.10) and (7.11):

$$A_i = (1 - \eta_{ii})D_i - GP_j^{\epsilon_{ij}} \quad for \quad i, j = L,H \ (i \neq j) \tag{7.16}$$

The data and the calibrated demand functions, assuming linear demand, are shown in Table 7.1.

Table 7.1. Stylized data and calibrated demand function; the base case.

		Low quality	High quality
Price per ton (NOK)	=	620	930
Quantity (1000 tons)	=	400	400
Marginal costs (NOK)	=	200	300
Transportation costs (NOK)			
Norcem	=	40	60
Entrant	=	100	
Length of matching (years)	=	1	
Norcem's disc. rate (ann.)	=	15%	
Own price elasticity	=	-0.6	-0.6
Cross price elasticity	=	0	0

Calibration of the demand functions (assuming $\epsilon_{ii} = 1$):

$$\text{---->} \quad D_L = 64 - 3.87 \cdot P_L$$
$$D_H = 64 - 2.58 \cdot P_H$$

3.2 Some simulation results

For a particular P_2 and assuming that the maximum price regulation is a binding constraint, we can solve for Q. Let π_{Mi}^A denote the incumbent's profit in segment i (i = L,H) if he accommodates entry, and note that $\pi_M^A \equiv \pi_{MH}^A + \pi_{ML}^A$.

$$Q = \left[\frac{\pi_M^A}{1 - \delta} - \sum_{t=1}^{f} \frac{\pi_M^F}{(1/\delta)^{t-1}} - \frac{\pi_M}{(1/\delta)^{f-1}}\right] \frac{D_L(P_2)}{\pi_{ML}^A}(1 - \delta) \tag{7.17}$$

Using an iterative process, we can pick the combination of Q and P_2 that maximizes the entrant's profit. Assuming the base case data listed in Table 7.1 and a random rationing rule, the main results of the simulations are reported in Table 7.2. We see that the entrant's capacity is rather limited compared to the total market size, and its price is substantially lower than Norcem's price. The market is only modestly enlarged. The reason is that

Norcem acts as a monopolist on the residual demand. About 95 per cent of the initial consumers will face no price reduction. The increase in total sales is the result of the entrant attracting new buyers who have a lower willingness to pay than the initial price.

Table 7.2. Base case simulation results

	Norcem	Entrant
Absolute figures:		
Sale (1000 tons)	379	24
Price (NOK pr. ton)	620	435
Relative to initial equilibrium:		
Sale (rel. to init. quantity)	95%	6%
Price (rel. to init. price)	100%	70%

Entry is unprofitable if the entry cost F in the period of entry outweighs the present value of the operating profit:

$$F \geq \frac{(P_2 - C_E)Q}{1 - \delta} . \tag{7.18}$$

According to information from Norcem and Viking Cement, the cost of investing in a silo terminal with an annual capacity of 20-30,000 tons is about 15 million NOK. In the base case simulation the annual operating profit of the entrant is 3.3 million NOK. Given these data, entry is profitable for annual discount rates below 22 per cent.

In Appendix J, we show the results of simulations with alternative assumptions. A sensitivity analysis shows that the entrant's price is rather sensitive to the initial equilibrium, the rationing rule, the entrant's marginal costs and the cross price elasticity. The incumbent's post entry price is equal to his pre entry price in all cases, except when we assume an efficient rationing rule and unrestricted monopoly equilibrium initially. The entrant's capacity is rather sensitive to the same assumptions as the entrant's price, and, in addition, it is sensitive to the length of the matching period, the incumbent's marginal costs and the discount rate. For example, the entrant's capacity is almost quadrupled when the length of the matching period is increased from half a year to two years (see Table J.4). One reason

for a more sensitive capacity, is that there is an optimal price-cost margin for the entrant, while the capacity of the entrant is adjusted to the optimal level according to the length of the matching period and other characteristics concerning the entry game (see Appendix J for more details). The sensitivity of both the entrant's capacity and price implies that in some of the simulations reported in Appendix J where the entrant's capacity is rather small and his price is low, the present value of the entrant's operating profit will be wiped out by the entry cost F (see Appendix J).

As mentioned earlier, Norcem is aware of several ways to preempt the entrant. One option is downstream integration. Let us assume a random rationing rule and that the segmentation is successful. This will imply that the cross price elasticities equal zero, and the incumbent maintains his monopoly price if he accommodates entry. Let τ denote the share of the low quality segment that is foreclosed. When $\tau = 1$, there is no market foreclosure. The entrant's constraint in equilibrium can now be written as:

$$\frac{[1 - \frac{Q}{D_L(P_2)\tau}]\pi^A_{ML}\tau}{1 - \delta} - \sum_{t=1}^{f} \frac{(P_2 - C_L)D_L^2\tau}{(1/\delta)^{t-1}} - \frac{\pi^A_{ML}\tau\delta}{(1 - \delta)(1/\delta)^{f-1}} = 0 . \qquad (7.19)$$

A market foreclosure, i.e., reduced τ, will have the following effect:

$$\frac{\partial}{\partial\tau} = \sum_{t=1}^{f} \frac{\pi^A_{ML} - (P_2 - C_L)D_L^2}{(1/\delta)^{t-1}} > 0 . \qquad (7.20)$$

Matching is made more favourable for the incumbent, which implies that increased market foreclosure makes the incumbent tough (see Fudenberg and Tirole 1984). To satisfy the constraint, we see that the entrant must either choose a lower capacity or set a lower price compared to the optimal strategy if no market foreclosure. The simulations show that market foreclosure will result in an equal-proportional reduction in the entrant's capacity. 'Tailoring' the quality in the high quality segment, for example, by undertaking sales promotion, was mentioned as another strategic option for Norcem. This can be interpreted as reducing the cross price elasticity between the two segments. We see from Appendix J (Table J.5) that such preemption would cause the entrant to choose a more limited capacity and lower price. This implies that the incumbent should follow a Top Dog strategy

concerning market foreclosure and 'tailoring' of quality, regardless of whether it decides to accommodate or deter the entrant.

3.3 Public policy implications

We are concerned about the welfare effects of import penetration for Norcem, Norwegian cement consumers, and the Norwegian importer of cement (if any). The producers can be involved in socially wasteful rent seeking activities in order to obtain the monopoly profit (see Tullock 1967; Posner 1975). To take this into account, the domestic operating profit has been adjusted with the rent seeking parameter θ. $\theta = 0$ if rent seeking takes place, i.e., the domestic producer's operating profit is dissipated. The operating profit of the entrant has been adjusted with the parameter μ to take into account a profit shift to the foreign producer. $\mu = 1$ if all profit goes to the importer, which is a domestic company, rather than to the foreign producer. Assuming that the segmentation is successful and defining P_L^M as the monopoly price in the low quality segment, the net welfare gain of import penetration is defined as in (7.21).

$$\Delta W = [Q\frac{D_L^L}{D_L^2}(P_L^M - P_2) + \frac{Q(1 - \frac{D_L^L}{D_L^2})}{D_L^2 - D_L^L}\int_{D_L^1}^{D_L^1 + Q} D(P)dP \qquad (7.21)$$

$$- \theta[Q\frac{D_L^L}{D_L^2})(P_L^M - C_L) + \mu Q(P_2 - C_2)]]\frac{1}{1 - \delta} - \mu F \ .$$

The first and second terms in the brackets are the increased consumer surplus for the existing and the new consumers of cement, respectively. The third term in the brackets (first term in the second line) is the reduction in Norcem's operating profit, while the fourth term is the entrant's operating profit. The last term is the entry cost, adjusted according to the profit shifting parameter (assuming that the foreign producer finances the entry cost in proportion to its share of profit).

In Table 7.3 we have reported the net welfare gain of the base case simulation in Table 7.2, relative to the sales value in the initial equilibrium. If all the operating profit is dissipated,

the welfare effect of import penetration is the gain to the consumers resulting from the entrant's low price. This explains the net welfare gain reported in cell 2 and 4. However, the net welfare effect is ambiguous if the operating profit is not dissipated. According to the results of the simulations, Norcem's profit loss outweighs the gain for the consumers. The reduction in dead weight loss is very limited, because the market is only modestly enlarged. The entrant's price is about 70 per cent of the incumbent's price in all simulations (see Appendix J). As a consequence, the net welfare gain per unit is rather insensitive to alternative assumptions and the qualitative conclusions are rather robust. This implies, for example, that it will be a net welfare loss if the incumbent's profit is not dissipated regardless of the length of the matching period.

Table 7.3. Net welfare gain - base case simulation

		Socially wasteful rent seeking?	
		NO	YES
Entrant's profit to:			
		1)	2)
	Foreign producer	- 1.5%	+ 1.7%
		3)	4)
	Importer	- 0.6%	+ 1.3%

Despite the fact that the authorities have imposed a maximum price regulation, the price-cost margin is large in this market (see chapter 2). This suggests that this policy can hardly be regarded as successful. It is, therefore, reasonable to ask what other policy options the anti-trust authorities have. In the trade policy literature, it has been shown that the optimal policy towards a domestic firm competing with foreign firm(s) in the domestic market is quite sensitive to the nature of competition, depending upon whether Bertrand or Cournot competition prevails (see for example Cheng 1988, and Eldor and Levin 1990). Our simulations in cell 1 in Table 7.3, with no rent seeking and profit shift to foreign producer, relates to that literature. It follows straightforwardly from Table 7.3 that in such a case,

policy induced entry deterrence will imply a higher domestic welfare than if entry takes place. An optimal policy would be to have a production subsidy. It would shift profit from a foreign entrant to the domestic incumbent, and reduce the incumbent's price if the maximum price is not a binding constraint.

From the sensitivity results we can also conclude that a domestic production subsidy which leaves the entrant with a positive profit will result in a lower domestic welfare than in the initial equilibrium, i.e., no entry. The reason is that the entrant's response to domestic subsidies is to choose a more limited capacity, while his price is almost unaffected (see Appendix J, Table J.3). This implies that the loss per unit of imports will be the same as in the no public policy scenario reported in cell 1 in Table 7.3.

If entry actually takes place, domestic welfare might be improved if the government supports resale of the entrant's quantity. When the entrant's consumers can costlessly resell the good, the entrant's quantity would in reality be rationed efficiently (see Tirole 1988, chapter 5). Assuming monopoly equilibrium initially, the incumbent is induced to lower his price as a response to accepting entry (see Proposition 7.2). In addition, the entrant must set a more limited capacity (see Appendix J, Table J.1). Both a more limited capacity of the entrant and a reduced price of the incumbent would increase the domestic welfare in the no rent seeking scenario. If rent seeking takes place, the reduced size of the entrant would tend to reduce the domestic welfare compared to the no public policy scenario. The net welfare effect of supporting resale is, therefore, ambiguous in that case.

4. Summary and conclusions

Standardisation of cement for all EC and EFTA countries will probably come into effect during the early 1990s. It is likely that such a common standard will increase the importation of low quality cement to Norway, where the domestic producer at present has a market share in excess of 95 per cent. The purpose of this paper has been to analyse what might happen if entry takes place.

We assumed that the incumbent initially was a monopolist in both a high and a low quality segment, and that a foreign producer with a cost disadvantage from transportation penetrated the low quality segment. The entrant set capacity and price in the low quality segment. The incumbent observed this and set his prices in both segments. The optimal strategy for the entrant was to limit his capacity and set a low price, as Viking Cement did when it succeeded in establishing in the early '80s. In contrast to the results for the single-product case reported by Gelman and Salop (1983), we have shown that the incumbent in some cases will have an incentive to raise his prices as a response to such an entry. Some of the customers that the entrant captured, bought the incumbent's high quality product initially. This switch can change the incumbent's own and cross price elasticities in the high quality segment. The price change in the high quality segment because of this will induce the incumbent to change his price in the low quality segment in the same direction.

We constructed a simple numerical model with both data and behavioural assumptions based on information about the Norwegian cement market. Our simulations showed that the entrant's optimal capacity was very sensitive to some of the assumptions, in particular those concerning the length of the matching period and Norcem's discount rate. We found that entry would reduce the domestic welfare, because the profit shift from the domestic to foreign producer wipes out gain to the consumers. The simulations showed that as long as no rent seeking takes place, an optimal public policy would be to use a domestic production subsidy to deter entry. If entry is allowed, domestic welfare might be improved if the government supports resale of the entrant's quantity. The reason is that the entrant's quantity then would be efficiently rationed, and the incumbent would have an incentive to lower his post entry price.

Appendix H: Proof of Proposition 7.1

From the first order conditions of the profit function in (7.3) we can derive the price-cost margins:

$$\frac{P_L - C_L}{P_L} = - \frac{1}{\eta_{LL}|_{P_L}} - \frac{(P_H - C_H)D_H\eta_{HL}|_{P_L}}{P_L D_L^L \eta_{LL}|_{P_L}} \tag{H.1}$$

$$\frac{P_H - C_H}{P_H} = \frac{U - VM - N}{Z + Y} \tag{H.2}$$

where:

$$Y = \frac{QP_H(\eta_{HH}|_{P_L}D_H^L - \eta_{HH}|_{P_2}D_H^2 - (D_H^L - D_H^2)\eta_{LH}|_{P_2})}{D_L^2} \tag{H.3}$$

$$\mathrm{M} = Q(1 - \frac{\eta_{LH}|_{P_2}}{\eta_{LH}|_{P_L}D_L^L}) \tag{H.4}$$

$$\mathrm{N} = \frac{QP_H(D_H^L - D_H^2)}{D_L^2} \tag{H.5}$$

$$U = P_H D_H^L + (P_L - C_L)D_L^L\eta_{LH}|_{P_L} \tag{H.6}$$

$$V = (P_L - C_L)D_L^L\eta_{LH}|_{P_L} \tag{H.7}$$

$$Z = - P_H D_H^L \eta_{HH}|_{P_L} \tag{H.8}$$

(H.1) is identical with the multiproduct monopolist's first order condition (see Tirole 1988, p.70). This implies that the incumbent will, ceteris paribus, maintain his pre entry low quality price. If:

$$\frac{U}{Z} - \frac{U - VM - N}{Z + Y} < 0\,, \tag{H.9}$$

the incumbent's price in the high quality segment will increase as a response to entry. Sufficient conditions for a price increase is that:

$$\begin{aligned} &(i)\ Z + Y < 0 \quad \text{and} \quad \frac{Y}{Z} > \frac{(-VM - N)}{U}, \ \text{or} \\ &(ii)\ Z + Y > 0 \quad \text{and} \quad \frac{Y}{Z} < \frac{(-VM - N)}{U} \end{aligned} \tag{H.10}$$

Rearranging (H.3) and (H.8), we have that Z + Y > 0 if:

$$D_H^L[\eta_{HH}|_{P_L}(1 - D_L^2/Q) - \eta_{LH}|_{P_2}] + D_H^2(\eta_{LH}|_{P_2} - \eta_{HH}|_{P_2}) > 0 \tag{H.11}$$

The last term on the lefthand side is positive. A sufficient condition for (Z + Y) > 0 is therefore that:

$$\eta_{HH}|_{P_L}(1 - D_L^2/Q) - \eta_{LH}|_{P_2} \geq 0 \tag{H.12}$$

From (H.3) - (H.8), we have that Y/Z < (- VM - N)/U if:

$$\begin{aligned} &\frac{P_H Q[\eta_{HH}|_{P_L} D_H^L - \eta_{HH}|_{P_2} D_H^2 - (D_H^L - D_H^2)\eta_{LH}|_{P_2}]/D_L^2}{-P_H D_H^L \eta_{HH}|_{P_L}} \\ < &\frac{-(P_L - C_L)D_L^L \eta_{LH}|_{P_L} Q(1 - \dfrac{\eta_{LH}|_{P_2}}{\eta_{LH}|_{P_L} D_L^L}) - \dfrac{QP_H(D_H^L - D_H^2)}{D_L^2}}{P_H D_H^L + (P_L - C_L)D_L^L \eta_{LH}|_{P_L}} \end{aligned} \tag{H.13}$$

Sufficient conditions are that the lefthand side is negative and the righthand side is positive. The denominator on both sides are positive. The last term in the numerator on the lefthand side is positive, with a negative sign. A sufficient condition for a negative lefthand side of (H.13) is thus:

$$\eta_{HH}|_{P_L} D_H^L - \eta_{HH}|_{P_2} D_H^2 \leq 0 \tag{H.14}$$

The numerator on the righthand side in (H.13) is positive if:

$$[(P_L - C_L)[\eta_{LH}|_{P_2} - D_L^L \eta_{LH}|_{P_L}] - \frac{P_H(D_H^L - D_H^2)}{D_L^2}]D_H^L + [\eta_{LH}|_{P_2} - \eta_{HH}|_{P_2}]D_H^2 > 0 \tag{H.15}$$

The last term on the lefthand side in (H.15) is positive. A sufficient condition for a positive righthand side of (H.13) is therefore:

$$(P_L - C_L)[\eta_{LH}|_{P_2} - D_L^L \eta_{LH}|_{P_L}] \geq \frac{P_H(D_H^L - D_H^2)}{D_L^2} \tag{H.16}$$

We see from (H.1) that a price increase in the high quality segment would result in a price increase in the low quality segment as well. Q.E.D.

Appendix I: Proof of Proposition 7.2

Assuming an efficient rationing rule, the entrant's customers are those in the low quality segment with the highest willingness to pay. The incumbent's per-period profit is defined as:

$$\pi_M^A = \max_{P_L,P_H} \{(P_L - C_L)[D_L(P_L,P_H) - Q] + (P_H - C_H)D_H(P_L,P_H)\} \tag{I.1}$$

From the incumbent's first order conditions, we can derive the price-cost margins:

$$\frac{P_L - C_L}{P_L} = -\frac{1 - Q/D_L^L}{\eta_{LL}|_{P_L}} - \frac{(P_H - C_H)D_H^L\eta_{HL}|_{P_L}}{P_L D_L^L \eta_{LL}|_{P_L}} \tag{I.2}$$

$$\frac{P_H - C_H}{P_H} = -\frac{1}{\eta_{HH}|_{P_L}} - \frac{(P_L - C_L)D_L^L\eta_{LH}|_{P_L}}{P_H D_H^L \eta_{HH}|_{P_L}} \tag{I.3}$$

We know that $1 > Q/D_L^L > 0$. This implies that the incumbent's price in the low quality segment will decrease. The price in the high quality segment will be the same as prior to entry, all else equal. However, we see from (I.3) that a lower P_L will result in a lower P_H as well. Q.E.D.

Appendix J: Results from sensitivity analysis

The results reported in Table 7.2 are valid for the data listed in Table 7.1. Here we will report how sensitive the results are to alternative assumptions. We report the size of the entrant's capacity (Q) and price (P_2) relative to the initial quantity and price, respectively, i.e., the equilibrium before entry.

In Table J.1 we see that both the price and the capacity are sensitive to the assumption concerning initial equilibrium and the rationing rule. In the case of monopoly equilibrium initially, the price elasticity is higher and thus the incumbent's profit loss from fighting is lower than in the case of maximum price restricted equilibrium initially. This forces the entrant to choose both a lower price and a more limited capacity. The same is true if the entrant's quantity is rationed efficiently rather than randomly, because the incumbent then has an incentive to lower his price even if accepting entry. The incumbent's price is in accordance with Proposition 7.2 reduced in the case where we assume efficient rationing rule and monopoly equilibrium initially. However, the price reduction is only modest. This is because of the rather limited capacity of the entrant (see Sørgard 1990, Table 1).

Table J.1 Rationing rule and initial equilibrium

	Initial equilibrium	
	Monopoly	Max price restr.
Rationing rule		
Random	$Q = 7.3\%$ $P_2 = 64\%$ $P_L = 100\%$	$Q = 6.1\%$ $P_2 = 70\%$ $P_L = 100\%$
Efficient	$Q = 4.2\%$ $P_2 = 65\%$ $P_L = 99\%$	$Q = 4.0\%$ $P_2 = 66\%$ $P_L = 100\%$

In Table J.2 we see that the results are rather insensitive to the assumptions concerning the shape of the demand function and the price elasticity.

Table J.2 Demand curvature and own price elasticity

	Shape of the demand function		
	Isoelastic	Linear ($\epsilon_{LL} = 1$)	Concave ($\epsilon_{LL} = 2$)
Own price elasticity			
$\eta_{LL} = -0.9$	$Q = 6.6\%$ $P_2 = 66\%$	$Q = 6.4\%$ $P_2 = 68\%$	$Q = 6.3\%$ $P_2 = 69\%$
$\eta_{LL} = -0.6$	$Q = 6.2\%$ $P_2 = 69\%$	$Q = 6.1\%$ $P_2 = 70\%$	$Q = 5.9\%$ $P_2 = 71\%$
$\eta_{LL} = -0.3$	$Q = 5.8\%$ $P_2 = 72\%$	$Q = 5.8\%$ $P_2 = 72\%$	$Q = 5.7\%$ $P_2 = 72\%$

In Table J.3 we see that the entrant's price is insensitive to alternative assumptions concerning the incumbent's marginal costs. However, it is sensitive to the entrant's marginal costs. The latter shows that there exists an optimal price-cost margin for the entrant, which suggests that the entrant's capacity is more sensitive than his price. This is confirmed in Table J.3, where we see that the entrant's capacity is sensitive to the marginal costs of both Norcem and the entrant.

Table J.3 Marginal costs

	Marginal costs of Norcem		
	190	240	290
Entrant's marginal costs			
350	Q = 3.9% P_2 = 76%	Q = 4.7% P_2 = 76%	Q = 5.7% P_2 = 76%
300	Q = 5.1% P_2 = 70%	Q = 6.1% P_2 = 70%	Q = 7.4% P_2 = 70%
250	Q = 6.4% P_2 = 65%	Q = 7.6% P_2 = 65%	Q = 9.2% P_2 = 65%

Table J.4 shows that the entrant's price is insensitive to the length of the matching period and Norcem's discount rate. This is in line with the results reported in Table J.3 that suggested that there exists an optimal price-cost margin.

Table J.4 Length of matching and discount rate

	Length of Matching		
	Half year	One year	Two years
Norcem's discount rate			
10%	Q = 2.2% P_2 = 70%	Q = 4.2% P_2 = 70%	Q = 8.1% P_2 = 70%
15%	Q = 3.1% P_2 = 70%	Q = 6.1% P_2 = 70%	Q = 11.4% P_2 = 70%
20%	Q = 4.1% P_2 = 70%	Q = 7.8% P_2 = 70%	Q = 14.2% P_2 = 70%

However, the capacity is almost quadrupled when the length of matching is increased from half a year to two years. It is almost doubled when Norcem's discount rate is increased from 10 per cent to 20

per cent. The more patient the incumbent is, the more incentives he has to fight today to ensure a monopoly in the future. Hence, the smaller is the entrant's optimal size.

In Table J.5 we see that an increase in the cross price elasticity increases the entrant's optimal capacity, as well as his price. The higher the cross price elasticity, the larger the incumbent's profit loss from price cutting in the low quality. The reason is that an increase in the cross price elasticity induces more customers in the high quality segment to switch to the low price segment where the price-cost margin is low.

Table J.5 Cross price elasticities

$\eta_{LH} = 0$	$\eta_{LH} = 0.5$	$\eta_{LH} = 2$
Q = 6.1% P_2 = 70%	Q = 7.2% P_2 = 74%	Q = 7.9% P_2 = 76%

In some of the reported simulations where the entrant's optimal capacity is rather limited, the present value of the entrant's operating profit will be outweighted by the entry costs and entry will be unprofitable. If we assume an annual discount rate of 15 per cent and entry cost of 15 million NOK, the entrant will not find it profitable to enter in the simulations reported in the lower cells of Table J.1, the upper left and upper middle cell of Table J.3, and upper left, upper middle and middle left cells of Table J.4.

Chapter 8:

CAPACITY LIMITATION AND COLLUSION

In all the previous chapters we assume that (1) prices are set sequentially and (2) once and for all. In this chapter we will relax these two assumptions by constructing a model where the incumbent and the entrant set prices simultaneously in an infinite number of periods. As in the previous chapters, we assume that the incumbent holds idle capacity and the entrant has a cost disadvantage. At step 1 in our model the entrant sets capacity (not sale) and thereby commits to stay in the market for infinity. At step 2 (which is stage 1 to infinity) the incumbent and the entrant set prices simultaneously. We assume that a deviation will trigger off single-period Nash equilibrium for infinity. The equilibrium of this particular game is compared with the equilibrium of the game where a deviation triggers off optimal punishment paths.

The chapter is organized as follows. In section 1, we briefly refer to related literature. In section 2, we describe the model and characterize a simple strategy profile. The set of collusive outcomes is analysed in section 3. In section 4, we analyse the entrant's capacity decision, asking how a capacity limitation will affect the 'best' and 'worst' equilibrium seen from the entrant's point of view. In section 5, we briefly relate the analysis to the Norwegian cement market and compare it with the results in the preceding chapters. The chapter is summarized in section 6, where we also relate our results to some observations in the U.S. phosphorus industry.

1. Related literature

Strategic aspects concerning choice of capacity was first introduced in the game-theoretic literature in Spence (1977), and further elaborated in Spence (1979), Dixit (1979,1980), Gelman and Salop (1983), Ware (1984), Fudenberg and Tirole (1984), and Bulow et.al. (1985a,1985b). All these models are static in the way that the choice variables are set once and for all. They show that an incumbent must 'overinvest' in capacity, i.e., build a larger capacity than what would have been optimal without any strategic considerations, if the goal is to deter a potential entrant. The reason is that a large capacity credibly commits the

incumbent to act aggressively. Given that the incumbent accommodates the entrant, the capacity choice depends critically on the nature of competition. If the choice variables are strategic substitutes (typically the case if Cournot competition), the incumbent should 'overinvest'. This will make himself more aggressive, and thereby soften the entrant. On the other hand, 'underinvestment' will make himself less aggressive and be the optimal strategy if choice variables are strategic complements (typically the case if Bertrand competition). In such a case a less aggressive incumbent will induce the entrant to behave less aggressively as well. For more details about static games, see chapter 4.

Unfortunately, the referred results in the above paragraph are sensitive to the assumption that the game is one-shot (or two-shot). In a dynamic setting there is scope for collusion, and the relationship between price and capacity is ambiguous in theory. A large capacity will make undercutting, i.e., deviation from the collusive outcome, profitable today, because one can capture a large market share. On the other hand, large capacity in the industry will imply that the rival's retaliation can be severe and induce the firm not to undercut. Consequently, the price, i.e., collusive price, need not be a monotonic function of industry capacity. This was first shown in Brock and Scheinkmann (1985), where capacity was exogenously determined. In Benoit and Krishna (1987), where firms set capacity simultaneously before a supergame, it is shown that firms might hold more capacity than they actually need even in the absence of uncertainty or varying demand (see also Davidson and Deneckere 1990). The same result is shown in Maskin and Tirole (1988a), who specified a dynamic game with alternating price setting. In Benoit and Krishna (1991) the incumbent and the entrant set capacity sequentially before entry. It is shown that there exist equilibria where the entrant is deterred only if the incumbent sets a low capacity, even lower than in the monopoly equilibrium. The intuition is that the incumbent's excess capacity will imply a low price in the non-collusive equilibrium, and thus make collusion the incumbent's best response to entry. If the incumbent limits his capacity and thereby increases the equilibrium price in the non-collusive outcome, the threat of deviation from the collusive outcome is credible and deters the entrant.

In the literature of dynamic games the firms typically are symmetric, i.e., exhibits identical

marginal costs. One exception is the model of Maskin and Tirole (1985) with alternating price setting, where the case of two firms with different marginal cost is analysed briefly in one version of their model[1]. It is shown that a collusive outcome can be supported if the high cost producer sets a temporary 'selling constraint'. In the repeated game literature we have some recent studies of asymmetric firms (see Bae 1987; Schmalensee 1987; Harrington 1989, 1991; Bernheim and Whinston 1990), but none of them analyse the capacity setting question, i.e., they all assume idle capacity. Our objective is to analyse an entry game with a low cost incumbent and a high cost entrant within a traditional repeated game model, assuming the incumbent holds idle capacity and the entrant sets capacity before entry. The model we construct has some similarities with Benoit and Krishna (1991). However, in their model the firms have identical marginal costs and the incumbent is allowed to set capacity before the entrant's capacity choice. This restricts the equilibria to cases where the firms set identical capacity. It allows them to analyse entry deterrence, a question which is not raised within our model.

2. The model

Consider an industry with one incumbent firm, i.e., a monopolist. This firm is challenged by one entrant. We make the following assumptions about costs and demand functions:

A 1: The incumbent and the entrant produce identical products, in volumes q_M and q_E.
A 2: The entrant has constant marginal costs, C_E, up to his capacity, Q.
A 3: The incumbent's marginal costs equal zero for all quantities.
A 4: The incumbent has a cost advantage, i.e., $C_E > 0$.
A 5: Market demand: $D(P) = 1$ if $P \leq 1$ and $D(P) = 0$ if $P > 1$.
A 6: C_E is lower than the monopoly price; $C_E < 1$.

A5 implies that there exists a unique monopoly price ($P = 1$). It follows from A3 that the incumbent will face no capacity constraint. Let us restrict the analysis to prices $P \in [0,1]$.

[1]Maskin and Tirole (1985) is an earlier version of Maskin and Tirole (1988a). In that latest version the model with asymmetric firms is is not specified, but only mentioned breifly at the end of the paper.

Let us assume that there exists a grid on prices, so that a price increase (or decrease) is always equal to ϵ or larger[2]. In line with the preceding chapters, let P_M denote the incumbent's price and P_2 the entrant's price.

2.1 The single-period Nash equilibrium

Assuming the entrant's capacity is endogenously determined at step 1, we have to check for different levels of entrant's capacity. Such an analysis is similar to the one in Kreps and Scheinkmann (1983), except for the fact that we assume a more simplified demand function and cost asymmetry between the firms.

Regime 1: $Q \geq 1$

None of the firms will face a capacity constraint, and both of them have constant marginal costs. We know that this will result in a traditional Bertrand equilibrium in pure strategies. The single-period Nash equilibrium will be the one where

$$P_M = C_E - \epsilon \qquad \textit{and} \qquad P_2 = C_E \tag{8.1}$$

The incumbent will serve the whole market, and at a price slightly less than the entrant's marginal costs[3].

Regime 2: $1 > Q \geq 1 - C_E$

When the entrant limits his capacity, the incumbent can earn the following profit by setting $P_M = 1$ and let the entrant set a lower price:

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[2]ϵ can be regarded as the lowest money unit. If there is no such grid, there will not exist a static Nash equilibrium in the asymmetric case where $C_E > C_M = 0$ and both hold idle capacity. The incumbent prefers an ϵ as close as possible to, but lower than, C_E. Such an ϵ does not exist, unless we impose a grid on prices.

[3]In this regime, as well as in regime 2, we assume that none of them play weakly dominated strategies. This ensures that the price is not below $C_E - \epsilon$.

$$\pi_M = 1 - Q \tag{8.2}$$

Alternatively, the incumbent can set the price marginally lower than the entrant's price and serve the whole market. If $C_E > 1 - Q$, the incumbent will earn a larger profit by setting $P_M = C_E - \epsilon$ than by maintaining the monopoly price and serving only a fraction of the market. The Nash equilibrium will be in pure strategies, and identical with the one specified in (8.1) where the incumbent serves the whole market.

Regime 3: $Q < 1 - C_E$

As long as $C_E < (1 - Q)$, the incumbent will never find it profitable to set $P_M = C_E - \epsilon$ and serve the whole market. In such a case there exists an equilibrium in mixed strategies. We know that the incumbent can always set a price equal to the monopoly price and serve the residual demand. The incumbent's expected profit in the mixed strategy equilibrium is thus equal to the one specified in (8.2).

The entrant can always set a price equal to the one that makes the incumbent indifferent between setting monopoly price and serving the residual demand, and setting a low price and serving the total demand. Define the minimum price the incumbent will set as P_L:

$$1P_L = 1 - Q \tag{8.3}$$

The entrant's expected profit in the mixed strategy equilibrium is then the following:

$$\pi_E = (P_L - C_E)Q = (1 - Q - C_E)Q \tag{8.4}$$

Define $F_M(P)$ as the cumulative probability that $P_M \leq P$. The probability that an entrant setting price P undercuts the incumbent is then $\lambda_E = 1 - F_M(P)$. $F_M(P)$ must be set such that the entrant is indifferent between the two pure strategies: either set the price marginally lower than the incumbent's price, or set the price marginally lower than the lowest price the incumbent can set (P_L):

$$\lambda_E(P - C_E)Q = (1 - Q - C_E)Q \tag{8.5}$$

Rearranging:

$$F_M(P) = 1 - \lambda_E = 1 - \frac{1 - Q - C_E}{P - C_E} \tag{8.6}$$

Note that $F_M(P)$ has a mass point for $P = 1$. Define $F_E(P)$ as the cumulative probability that $P_2 \leq P$. If the incumbent sets price P, the probability that he undercuts the entrant is $\lambda_M = 1 - F_E(P)$. $F_E(P)$ must be set such that the incumbent is indifferent between pure strategies:

$$\lambda_M P + (1 - \lambda_M)P(1 - Q) = 1 - Q \tag{8.7}$$

Rearranging:

$$F_E(P) = 1 - \lambda_M = \frac{P - (1 - Q)}{P - P(1 - Q)} \tag{8.8}$$

(8.6) and (8.8) defines a Nash equilibrium in mixed strategies.

2.2 A simple strategy profile

In the preceding section we defined the Nash equilibrium for the static game. To analyse the repeated game, we must define each player's strategy. Let $a_i(t)$ (i = E,M) be player i's action at stage t, and $a(t) = \{a_E(t),a_M(t)\}$ be the action profile at stage t. At the beginning of the first stage (stage 0), we define the history of the game as $h(0) = \varnothing$. At the beginning of the second stage (stage 1), the history of the game is determined by the action profile at stage 0: $h(1) = a(0)$. The history at the beginning of stage k is then defined as the sequence of actions at the previous stages: $h(k) = \{a(0),a(1),\ldots,a(k-1)\}$. We let H(k) denote the set of all stage k histories. A strategy for a player is a plan for which action to choose at each stage contigent on the history of the game. Defining $\sigma_i(2)$ as player i's strategy at stage 2, we have that $\sigma_i(2) = \sigma_i\{a(0),a(1)\}$. A strategy for player i in an infinite horizon game is defined as $\{\sigma_i^t\}_{t=1}^{\infty}$, where each σ_i^t maps H(t) to the set of player i's feasible actions A_i. A strategy profile is the set consisting of one strategy for each player in the game, i.e., $\sigma = (\sigma_1,\sigma_2,\ldots,\sigma_N)$ if there are N players. Each strategy profile generates a path (also called punishment) denoted $A(\sigma) = \{a(\sigma)(t)\}_{t=1}^{\infty}$.

In line with Abreu (1988), we define a simple strategy profile $\sigma(A^0; A^1, A^2)$. It instructs the players 1 and 2 to play according to A^0 until one player deviates singly from A^0, and then play A^i ($i = 1,2$) if player i deviates from A^j ($j = 0,1,2$), where A^j is the ongoing path (see Abreu 1988, definition 1). Put differently, A^i is started to punish player i's deviation from an ongoing path. To verify whether a simple strategy profile is an SPE path, it is sufficient to check that a one-shot deviation by any of the n players from any of the $(n + 1)$ paths at any time will not yield him a higher payoff (see Abreu 1988, Proposition 1).

The most severe punishment path that is an SPE path is called an optimal punishment path. Such a punishment path will induce the player to play in accordance with the ongoing path and not deviate, because the player's profit after the period of deviation is low. Consequently, the optimal punishment paths support the largest set of collusive outcomes that is attainable. It is therefore of interest to specify the optimal punishment paths.

If one player deviates from an ongoing path, how severe can the punishment path that is started then be? We know that after deviation from an ongoing path, the player has the option to sell nothing and thus have zero profit regardless of the rival's behaviour. Consequently, a punishment path where a player earns negative profit is not individually rational and thus not an SPE path. Assuming $Q \geq 1 - C_E$, we know from section 2.1 that the entrant will earn zero profit in the single-period Nash equilibrium. In such a case the most severe punishment triggered off by entrant's deviation can thus be implemented by reverting to the single-period Nash equilibrium for infinity. Assuming $Q < 1 - C_E$, we know from section 2.1 that the entrant will earn positive profit in the single-period Nash equilibrium. As suggested by Abreu (1986) and van Damme (1991, p.190-1), the most severe punishment can in such a case be implemented by using a path with a stick and a carrot structure, e.g., a two-phase structure. For example, in the first phase of the punishment path the entrant sets his price below his own marginal costs, and in the last phase of the punishment path a collusive outcome is attained. There now exists a certain market sharing in the last phase of the punishment path that ensures that the entrant's average profit after the period of deviation equals zero. Let us define A^E as the punishment path with a stick and a carrot structure for which $\pi_E = 0$. It follows from Abreu that for large enough

values of the discount factor, such a path is an SPE path.

The incumbent, on the other hand, can do better than earning zero profit. He can always set the monopoly price and serve the residual demand. Consequently, it is not individually rational for the incumbent to play according to a punishment path where $\pi_M < 1 - Q$. Let us define A^M as the punishment path with a stick and a carrot structure where $\pi_M = 1 - Q$. Again, such a path is an SPE path if the discount factor is large enough. Note that if $Q \leq 1 - C_E$, static Nash equilibrium for infinity is an optimal punishment path following the incumbent's deviation.

To check whether A^i $(i = E,M)$ is an SPE path, we have to check that both will find it profitable to play according to A^i after player i's deviation, and that none of them will find it profitable to deviate from the last phase of A^i. It is straight forward to specify a two-phase punishment path as suggested above and to formulate the four restrictions that have to be met to ensure that A^i is an SPE path[4].

Such a specification of the punishment path raises several question. First, can we be sure that such a two-phase structure is the optimal punishment path? Note that Abreu (1986) and van Damme (1991, p. 190-1) have shown that the optimal punishment can be implemented as a path with a stick and a carrot structure, where the punishment is at least as severe to begin with as later on. A two-phase structure is only one of several ways to specify such a path. For example, we could imagine that a three-phase structure would ensure that A^E is an SPE path for lower discount factors than what is the case for a two-phase structure. We could have that $P_2 = 0$ in the first phase, $1 > P_2 > 0$ in the second phase, and $P_2 = 1$ in the last, collusive phase.

Second, how can we solve such a game analytically? Regardless of whether we end up with

[4]We have done this in an earlier version of the paper. The last phase of the punishment path was specified as a collusive outcome, see the specification in section 3 below. In the first phase, which consists of an endogenous number of periods, $P_M = C_E$ and $P_2 = 0$ with probability ß and $P_2 = C_E + \epsilon$ with probability $(1 - ß)$.

a two-, three-, or n-phase structure, the number of periods in each phase should be endogenously determined. For example, a two-phase structure of A^E should be specified in such a way that the first phase, where the entrant earns a negative per-period profit, consists of the number of periods needed to force the entrant to have a zero profit on average. It will then be analytically intractable to solve for the discount factor. If the first phase of a two phase structure consists of, for example, ten periods, we have to solve a tenth-order equation. Because of this, we have not succeeded in characterizing the optimal punishment path and the lowest discount factor that ensures that A^E and A^M are SPE paths[5].

The analytical intractability of optimal punishment paths forces us to choose punishment paths that are less severe. In the literature trigger strategies are often used as punishment paths. In particular, a deviation from an ongoing path triggers off a reversion to single-period Nash equilibrium for infinity. Let us define this punishment path as follows:

A^N = Play in accordance with single-period Nash equilibrium for infinity. If $Q < 1 - C_E$, $\pi_E = (1 - Q - C_E) \cdot Q$ and $\pi_M = 1 - Q$. If $Q \geq 1 - C_E$, $\pi_E = 0$ and $\pi_M = C_E$.

We know that $\sigma(A^N;A^N,A^N)$ is an SPE path (see section 2.1).

3. The set of collusive outcomes

One possible strategy profile is that they behave collusively in the first period, where the collusive price is 1, i.e., equal to monopoly price. If one of them randomly sets a marginally lower price than its rivals in some periods and not others, it is possible to achieve

[5]An alternative to working directly with the strategy spaces, as we have done here, is to use the concept self-generation. It is the multi-player generalization of dynamic programming's principle of optimality. A supergame profile is decomposed into the induced behaviour today and the value of behaviour in the future, as a function of possible actions today. By using the concept of self-generation, one can find a sufficient condition for a set of payoffs to be supportable by equilibria (see Abreu, Pearce and Stachetti 1986; Pearce 1991).

numerous possible ways to share the market between them[6]. However, the rival must be able to distinguish between an undercutting that in fact is a deviation and an undercutting that is part of the market sharing device in the collusive outcome. This is possible if we assume private randomization that is observable before the next stage (see van Damme 1991, section 8.1). Let us assume that the incumbent randomizes between $P_M = 1$ and $P_M = 1 - 2 \cdot \epsilon$, while $P_2 = 1 - \epsilon$ in all periods. Let us define γ as the probability that $P_M = 1 - 2 \cdot \epsilon$ and $(1 - \gamma)$ as the probability that $P_M = 1$. The higher γ, the larger average market share for the incumbent. The equilibrium in the collusive outcome is thus defined as follows:

A^C = Set $P_2 = 1 - \epsilon$, $P_M = 1$ with probability $(1 - \gamma)$ and $P_M = 1 - 2 \cdot \epsilon$ with probability γ.

We can now define a simple strategy profile:

$$\sigma = \sigma(A^C; A^N, A^N) \tag{8.9}$$

We know that A^N is an SPE path (see section 2.1). There are then two remaining conditions to check. First, whether the incumbent will find it profitable to deviate from the initial collusive outcome. Second, whether the entrant will find it profitable to deviate from the collusive outcome. For each of them we have to check for $Q < 1 - C_E$ and $Q \geq 1 - C_E$. These four restrictions are specified in Appendix K, and the results can be summarized in the following Proposition:

[6]This is one kind of market sharing device. Alternatively, one could assume that prices were distributed between an interval, e.g., $P \in [0.95,1]$. Each player could have a certain probability of winning, and this probability is the same for all the prices in the distribution.

Proposition 8.1: *Assume a simple strategy profile* $\sigma(A^C;A^N,A^N)$. *The set of collusive outcomes is non-empty if and only if*

$$\delta_T \equiv \delta \geq \left\{ \begin{array}{l} \dfrac{1 - C_E}{Q + 1 - C_E} \quad \text{if } Q \geq 1 - C_E \\ \dfrac{Q}{Q + 1 - C_E} \quad \text{if } Q < 1 - C_E \end{array} \right\}$$

Proof: See Appendix K.

If $Q = 1$ and $C_E = 0$, we have a symmetric duopoly where both firms have no capacity constraints and identical marginal costs. In that case both firms have zero profit in the single-period Nash equilibrium, and thus the trigger strategy is an optimal punishment path. We see from Proposition 8.1 that $\delta = 1/2$ will be sufficient to support a collusive outcome in such a case, a result that is well known in the literature (see Tirole 1988, chapter 6). We also see that if the entrant has a cost disadvantage or $Q < 1$, $\delta = 1/2$ will not support a collusive outcome (except for the case where $Q = 1 - C_E$). The intuition is that when cost conditions are asymmetric, either concerning capacity or marginal costs, a reversion to single-period Nash equilibrium will not always be the most severe punishment path. The set of collusive outcomes supported by trigger strategies will in such a case be more limited than what is the case when symmetric cost conditions. Hence, $\delta > 1/2$ to support a collusive outcome.

As reported in section 2.2, we have not managed to check whether $\sigma(A^E;A^E,A^M)$ and $\sigma(A^M;A^E,A^M)$ are SPE paths. To emphasize the distinction between trigger strategies and optimal punishment path, let us report the set of collusive outcomes that is not supported by optimal punishment path.

Proposition 8.2: *Assume a simple strategy profile* $\sigma(A^C;A^E,A^M)$. *The set of collusive outcomes is empty if* $\delta < 1/2$.

Proof: See Appendix K.

Assuming symmetric cost conditions, i.e., identical marginal costs and excess capacity for both, this result is similar to the one valid for trigger strategies. This is obvious, because trigger strategies are the optimal punishment paths in such a case. More interestingly, for asymmetric cost conditions a collusive outcome is supported by optimal punishment paths for $\delta \geq 1/2$ as long as $\sigma(A^E;A^E,A^M)$ and $\sigma(A^M;A^E,A^M)$ are SPE paths. Consequently, for $1/2 < \delta < \delta_T$, a collusive outcome can be supported by an optimal punishment path if they exists, but never by a punishment path defined as a reversion to single-period Nash equilibrium for infinity after deviation. Optimal punishment paths thus may make it possible to implement a more severe punishment toward one who deviates than is the case if using trigger strategies. As a result of this, a player has less to gain from deviation. He will support the collusive outcomes for lower discount factors than is the case if using trigger strategies.

4. The entrant's capacity choice

To analyse the entrant's capacity choice prior to the infinitely repeated price game, we have to take into account his entry costs and costs in installing capacity. Let q_E be the entrant's sale in each period, F his entry costs, and C_F his costs per unit in installing capacity. In line with the preceding section, let π_E denote the entrant's per period gross profit, i.e., profit in each period exclusive of fixed costs and capital costs. Furthermore, let Π_E denote the net present value, i.e., the present value of the per-period net profit:

$$\Pi_E \equiv \frac{\pi_E}{1-\delta} - F - C_F Q = \frac{(1-C_E)q_E}{1-\delta} - F - C_F Q \qquad (8.10)$$

As is well known from theory, there exists numerous equilibria in the post entry infinitely repeated game. The question whether the entrant should enter or not will thus crucially depend on the entrant's expectations about the post entry equilibrium. To simplify, let us assume that they cannot achieve any of the possible equilibrium outcomes that is inefficient, i.e., not on the pareto frontier, and better for the entrant than the best equilibrium for him

among those outcomes that are efficient.

In accordance with the terminology in Benoit and Krishna (1991), the entrant is weakly deterred if $\Pi_E < 0$ in the 'worst' equilibrium. For example, if $\pi_E = 0$ in the 'worst' equilibrium, the entrant is weakly deterred if $F > 0$ or $C_F > 0$. The 'worst' equilibrium, seen from the entrant's point of view, is the one where entry triggers off the punishment path that follows when the entrant deviates from an ongoing path.

If for all the choices of the entrant's capacity there exists no equilibrium where $\Pi_E \geq 0$, the entrant is strongly deterred (see Benoit and Krishna 1991). To check whether the entrant is strongly deterred, we thus have to check the 'best' of all equilibria seen from the entrant's point of view. The 'best' equilibrium would be one where they start out with a collusive outcome (A^C) at the price $P' = 1$ (monopoly price), and the incumbent's average market share is such that he is indifferent between maintaining the collusive outcome and deviating.

The definition of 'worst' and 'best' equilibrium crucially depends on the kind of punishment path which is in force. Let us therefore distinguish between optimal punishment paths and a punishment path with single-period Nash equilibrium for infinity.

4.1 Optimal punishment paths

As a starting point, let us assume that $\sigma(A^E;A^E,A^M)$ and $\sigma(A^M;A^E,A^M)$ are SPE paths, which is the case if δ is sufficiently close to one. The 'worst' equilibrium, seen from the entrant's point of view, is the one where they start out by playing $\sigma(A^E;A^E,A^M)$. $\pi_E = 0$ in such a case, and $\Pi_E < 0$ if $F > 0$ or $C_F > 0$. As first shown in Stenbacka (1990), the entrant is thus weakly deterred if the firms' strategies are based on the most severe punishments, i.e., optimal punishment paths.

The 'best' equilibrium is the one where the strategy profile $\sigma(A^C;A^E,A^M)$ is valid, and the market sharing in collusion is such that the incumbent is indifferent between deviating and maintaining the collusive outcome. This is the case if:

$$\frac{\gamma + (1 - \gamma)(1 - Q)}{1 - \delta} = 1 + \frac{(1 - Q)\delta}{1 - \delta} \qquad (8.11)$$

The lefthand side is the incumbent's gross present value from maintaining the collusive outcome, while the righthand side is the gross present value from deviating. Rearranging (8.11), we have that $\gamma = 1 - \delta \equiv \gamma^{min}$. γ^{min} is the lowest 'market share' the incumbent can have before it is profitable for him to deviate from the collusive outcome[7].

Whether the entrant should enter or not depends on his net present value. $q_E = (1 - \gamma^{min}) \cdot Q$ is the entrant's per-period sale on average in the 'best' equilibrium. From (8.11) we know that $\gamma^{min} = 1 - \delta$. Substituting $q_E = \delta \cdot Q$ into (8.10) and rearranging, we have that the entrant will enter if:

$$\frac{(1 - C_E)\delta Q}{1 - \delta} \geq C_F Q + F \qquad \textit{where} \quad 0 < Q \leq 1 \qquad (8.12)$$

Clearly, for large F or large C_F, the entrant will choose Q = 0 and no entry. To find the entrant's optimal capacity if entry, let us check how a marginal change in the entrant's capacity will influence his net present value:

$$\frac{\partial \Pi_E}{\partial Q} = \left\{ \begin{array}{ll} \dfrac{(1 - C_E)\delta}{1 - \delta} - C_F & \textit{if} \quad 0 > Q \geq 1 \\ - C_F & \textit{if} \quad Q > 1 \end{array} \right\} \qquad (8.13)$$

If Q > 1, the entrant's capacity exceeds the total demand. In such a case $q_E < Q$ even if the entrant undercuts the incumbent's price and serves the whole market. Consequently, it will never be profitable for him to choose Q > 1.

If Q < 1, an increase in the entrant's capacity will increase his average market share in the collusive outcome. The reason is that the entrant's sale will increase in those periods where $P_M > P_2$, i.e., when $P_M = 1$ and $P_2 = 1 - \epsilon$. Comparing (8.12) and (8.13), we see that as long as $\Pi_E \geq 0$ and F > 0 the entrant's marginal gain from expanding his capacity, i.e., (1

[7]It is not correct to let γ denote the incumbent's market share. More precisely, the incumbent's average market share is $M = (1 - Q)(1 - \gamma) + \gamma$.

$- C_E) \cdot \delta/(1 - \delta)$, wipes out the entrant's loss from expanding his capacity, i.e., C_F. Consequently, if $\Pi_E \geq 0$ the entrant enters and sets $Q = 1$.

Proposition 8.3: *Let us assume optimal punishment paths* $\sigma = \sigma(A^E;A^E,A^M)$ *and* $\sigma = \sigma(A^M;A^E,A^M)$*, and that both are SPE paths. The entrant is weakly deterred if* $F > 0$ *or* $C_F > 0$*. The entrant is strongly deterred if*

$$\frac{(1 - C_E)\delta}{1 - \delta} < C_F + F$$

If not and he expects the 'best' equilibrium to prevail, he enters and sets $Q = 1$*.*

Note that we found that the entrant should not undertake a voluntary capacity limitation, but set capacity equal to total demand if he enters. This result is in contrast to existing literature, for example the results in the static model of Gelman and Salop (1983) and the dynamic model of Maskin and Tirole (1985). The intuition for our result is that a capacity increase by the entrant has two effects on the incumbent's incentive to maintain the collusive outcome, and those two effects work in opposite directions. On the one hand, a capacity increase will reduce the incumbent's average market share in the collusive outcome, and will thus induce him to deviate. On the other hand, a capacity increase will reduce the incumbent's profit in the non-collusive outcome and thus induce him to maintain the collusive outcome. In Gelman and Salop (1983) and Maskin and Tirole (1985) only the first of the two effects was taken into account, and therefore voluntary capacity limitation made sense in such a setting.

4.2 Single-period Nash punishment paths

Let us now assume that the most severe punishment path is the one where they play single-period Nash equilibrium for infinity. The 'worst' equilibrium, seen from the entrant's point of view, is thus the one where $\sigma = \sigma(A^N;A^N,A^N)$. We know that for $Q \geq 1 - C_E$, $\pi_E = 0$ in single-period Nash equilibrium (see section 2.1). In such a case single-period Nash equilibrium for infinity is an optimal punishment path towards the entrant. It thus follows

directly from section 4.1 that for $Q \geq 1 - C_E$ and $\sigma = \sigma(A^N;A^N,A^N)$, the entrant is weakly deterred if $F > 0$ or $C_F > 0$.

For $Q < 1 - C_E$, we have from section 2.1 that $\pi_E = (1 - Q - C_E) \cdot Q$ in the single-period Nash equilibrium. Consequently, if $\sigma = \sigma(A^N;A^N,A^N)$ we have that $\Pi_E \geq 0$ if:

$$\frac{(1 - Q - C_E)Q}{1 - \delta} \geq C_F Q + F \qquad \textit{where} \quad Q < 1 - C_E \tag{8.14}$$

Rearranging the entrant's first order condition, we can define his optimal choice of capacity:

$$Q^N = \frac{1 - C_E - (1 - \delta)C_F}{2} \tag{8.15}$$

We see that for $C_F > 0$, $Q^N < (1 - C_E)/2$. Substituting (8.15) into (8.14) and rearranging, we have that the entrant is weakly deterred if:

$$[\frac{(1 - C_E)}{(1 - \delta)2} + \frac{C_F}{2}][\frac{1 - C_E - (1 - \delta)C_F}{2}] < F \tag{8.16}$$

The 'best' equilibrium is the one where $\sigma = \sigma(A^C;A^N,A^N)$ is valid and the incumbent is indifferent between deviating and maintaining the collusive outcome, i.e., $\gamma = \gamma^{min}$. We know that as long as $Q < 1 - C_E$, a reversion to single-period Nash equilibrium for infinity is an optimal punishment path if the incumbent deviates from an ongoing path. This implies that for $\sigma = \sigma(A^C;A^N,A^N)$ and $Q < 1 - C_E$, $\gamma^{min} = 1 - \delta$ (see section 4.1). Clearly, the entrant's net present value for $0 < Q < 1 - C_E$ will be as defined in (8.12).

Assuming $Q \geq 1 - C_E$ and $\sigma = \sigma(A^C;A^N,A^N)$, the incumbent is indifferent between deviation and maintaining the collusive outcome if:

$$\frac{\gamma + (1 - \gamma)(1 - Q)}{1 - \delta} = 1 + \frac{C_E \delta}{1 - \delta} \tag{8.17}$$

The lefthand side is the incumbent's gross present value from supporting the collusive outcome, while the righthand side is his gross present value from deviating. Comparing with optimal punishment paths, we see that the incumbent earns a larger gross present value after

deviation (C_E instead of (1 - Q) each period). Solving (8.17) with respect to γ, we have that $\gamma = 1 - (1 - C_E) \cdot \delta/Q \equiv \gamma^{min}$ (see K.4 in Appendix K). Π_E in the 'best' equilibrium is thus the following:

$$\Pi_E = \left\{ \begin{array}{ll} \dfrac{\delta(1 - C_E)Q}{1 - \delta} - C_F Q - F & \text{if } Q < 1 - C_E \\ \dfrac{\delta(1 - C_E)^2}{1 - \delta} - C_F Q - F & \text{if } Q \geq 1 - C_E \end{array} \right\} \qquad (8.18)$$

Clearly, for large F or large C_F we have that $\Pi_E < 0$ and the entrant is strongly deterred. If $\Pi_E > 0$, what should be the entrant's optimal choice of capacity? From (8.18) we can derive the effect of a marginal change in the entrant's capacity:

$$\frac{\partial \Pi_E}{\partial Q} = \left\{ \begin{array}{ll} \dfrac{\delta(1 - C_E)}{1 - \delta} - C_F & \text{if } Q < 1 - C_E \\ - C_F & \text{if } Q \geq 1 - C_E \end{array} \right\} \qquad (8.19)$$

Comparing (8.19) and (8.18), it is easily seen that for $Q < 1 - C_E$ an increase in the entrant's capacity will increase his net present value if $\Pi_E \geq 0$ and $F > 0$. For $Q \geq 1 - C_E$, we see that $\partial \Pi_E/\partial Q < 0$. Consequently, his optimal capacity equals $1 - C_E$.

Why will the entrant voluntarily limit his capacity? If $Q > 1 - C_E$, the single-period Nash equilibrium will be in pure strategies and the entrant's sale is zero and his gross profit in each period equals zero (see section 2.1). Consequently, his profit in the non-collusive outcome will not increase in Q. The incumbent must, irrespecive of the entrant's capacity, have a minimum per-period profit in the collusive outcome if he shall find it profitable not to deviate. As a result of that, the entrant must not exceed a maximum per-period profit if he wants the incumbent to support the collusive outcome. This implies that the entrant faces a constraint on his sale, determined by the incumbent's minimum profit for supporting the collusive outcome, and this constraint on his sale is not influenced by his own capacity. The entrant has thus nothing to gain from expanding his capacity beyond $Q = 1 - C_E$, neither in the collusive nor in the non-collusive outcome.

Proposition 8.4: *Let* $\sigma = \sigma(A^N;A^N,A^N)$ *be the punishment path. The entrant is weakly deterred if*

$$[\frac{(1 - C_E)}{(1 - \delta)2} + \frac{C_F}{2}][\frac{1 - C_E - (1 - \delta)C_F}{2}] < F$$

If not and he expects the 'worst' equilibrium to prevail, he enters and sets

$$Q = \frac{1 - C_E - (1 - \delta)C_F}{2}$$

The entrant is strongly deterred if

$$\frac{(1 - C_E)\delta}{1 - \delta} < C_F + \frac{F}{1 - C_E}$$

If not and he expects the 'best' equilibrium to prevail, he enters and sets $Q = 1 - C_E$.

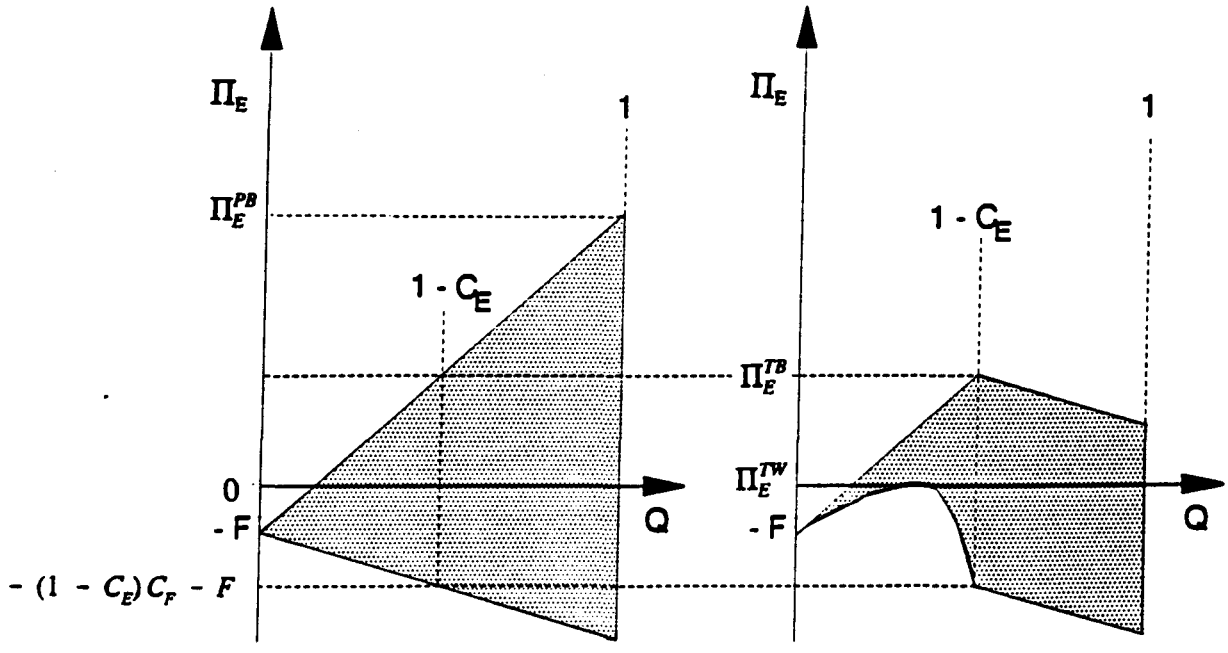
4.3 A comparison of optimal punishment paths and Nash punishment paths

Will the entrant be better off with trigger strategies with reversion to single-period Nash equilibrium than strategies with optimal punishment paths? It depends on whether the 'best' or the 'worst' equilibrium will prevail. If the 'worst' equilbrium prevails, the entrant will be better off with trigger strategies. The reason is that $\pi_E > 0$ in single-period Nash equilibrium, while $\pi_E = 0$ on average in an optimal punishment path. If the 'best' equilibrium prevails, he will be better off with optimal punishment paths. The reason is that such a punishment path will induce the incumbent not to deviate from a collusive outcome, and this can be exploited by the entrant by setting a large capacity and thereby capturing a large market share. Let Π_E^{ij} be the entrant's profit if punishment path i is in force and state j prevails, where i is either trigger strategies (denoted T) or optimal punishment paths (denoted P) and j is either the 'best' equilibrium (denoted B) or the 'worst' equilibrium (denoted W).

Proposition 8.5: $\Pi_E^{PB} > \Pi_E^{TB} > \Pi_E^{TW} > \Pi_E^{PW}$.

Figure 8.1 illustrates our results. We have shown the relationship between entrant's net present value and his capacity in 'best' and 'worst' equilibrium for both optimal punishment paths and punishment path defined as single-period Nash equilibrium for infinity. The upper bound is the set of 'best' equilibria, while the lower bound is the set of 'worst' equilibria. The shaded area between the upper and lower bound is thus the set of outcomes that can be supported by an SPE path if the entrant has entered. We see that the set of outcomes supported by SPE paths is larger with optimal punishment paths than with Nash punishment paths.

Figure 8.1 Entrant's profit in 'best' and 'worst' equilibrium for different choices of capacity



(a) Optimal punishment paths (if they exists)

(b) Nash punishment paths

Clearly, the entrant will not enter if he anticipates that $\Pi_E < 0$. This implies that not all the outcomes in the shaded area in Figure 8.1 are attainable. We see that the entrant's entry decision and capacity choice depends crucially on the strategy profile. If optimal punishment paths, the entrant should set Q = 1 and enter if he expects the 'best' equilibrium to prevail

and $Q = 0$ and not enter if he expects the 'worst' equilibrium to prevail. If the punishment paths are single-period Nash equilibrium for infinity, the entrant can find it profitable to enter even if he expects the 'worst' equilibrium to prevail. This is the case shown in Figure 8.1. Furthermore, if trigger strategies the entrant will never set $Q > 1 - C_E$. Consequently, we see that voluntary capacity limitation makes sense only if there are trigger strategies. In such a case, our results are in line with the results found in the single-period model of Gelman and Salop (1983) and the dynamic model of Maskin and Tirole (1985) with alternating price setting.

5. The Norwegian cement market

Three basic assumptions in our model fit with the characteristics of the Norwegian cement market: the firms are price setters; the entrant has a cost disadvantage; incumbent holds idle capacity. However, the behavioral assumption in our model is apparently in conflict with the actual behaviour in this particular market. Neither the internal report referred in chapter 3 nor other information about the decision makers suggest that they are aware that a mixed strategy would be beneficial in some instances.

However, the mixed strategy assumption might be redundant. It can be viewed as an abstraction and simplification of a complicated process where the actors have private information and act according to pure strategies (see Harsanyi 1973). In particular, there might be other ways to share the market in the collusive outcome than the randomization device we have used. Note also that the at the largest capacity the entrant will find profitable when assuming trigger strategies, i.e., $Q = 1 - C_E$, the punishment path is Nash equilibrium in pure strategies. In all, the behavioral assumptions concerning mixed strategies may not, at least in some instances, have any crucial impact on the results[8]. Let us therefore relate our results to the particular market in question.

[8]For a discussion of the basic assumptions in game-theoretic models, including a discussion of the empirical validity of mixed strategies, see section 3 in chapter 3.

The basic mechanism of a repeated game is that a deviation from an ongoing path will trigger off retaliation, and this might deter a firm from deviating. We have information that suggests that the way of thinking in the cement market is influenced by such stategic considerations. When Norcem was asked to explain the limited intra-European trade, it replied that the reason is 'the balance of deterrence between the producers' (see Guthus 1984, p. 25). This refers to the risk of retaliation if one producer starts exporting. As reported in chapters 2 and 5, the entrant in the Norwegian cement market in the early '80s, Viking Cement, voluntarily restricted its supply and said this was done 'for fear of Norcem [the incumbent]'. In earlier chapters (see chapter 5), we have shown that an entry strategy of voluntary capacity limitation makes sense in a single-period context with sequential price setting. In this chapter we have shown that the capacity limiation result holds when we extend the model to an infinitely repeated game with simultaneous price setting and trigger strategies, but not if a deviation triggers off an optimal punishment path with a stick and a carrot structure. Unfortunately, we do not have inside information about the firms that is detailed enough to answer what particular kind of strategy they deliberately followed, or whether they at all had an explicit strategy.

In contrast to the results from the single-period model, the entrant need not set a low price in the collusive outcome we have specified in our dynamic game. The reason is that price is not a commitment (as it was in previous chapters), and the entrant has the option to cut prices later on if that is needed. In addition, the entrant can share the market with the incumbent if the prices are identical. This is different from the single-period model in earlier chapters, where the incumbent satisfies the total demand if prices are identical.

6. Some concluding remarks

The relationship between collusion and capacity is ambiguous in theory. This was first shown in Brock and Scheinkmann (1985), and more recently shown for a game between an incumbent and an entrant in Benoit and Krishna (1991). They found that an incumbent that sets capacity before entry could make price cutting, i.e., deviation, credible by limiting his own capacity and thereby deter the entrant. They assumed cost symmetry (identical marginal

costs), and showed that this would imply that the two firms set identical capacities even if capacity was set sequentially. In contrast to this, we assumed that the entrant's marginal costs exceed the incumbent's marginal costs and that the incumbent holds idle capacity initially. Despite the fact that we constructed a simple entry game model, we failed to characterize the set of collusive outcomes supported by optimal punishment paths, i.e., the largest set of collusive outcomes that is attainable. Such paths consisted of several phases, and this made it intractable to solve analytically for the discount factor. This forced us to restrict the analysis to the case where deviation triggers off single-period Nash equilibrium for infinity. We admit that this is an ad hoc way to restrict the set of collusive outcomes at the outset of the analysis. To take this into account, we have compared the results from the analysis where the firms have trigger strategies with the results when deviation triggers off a stick and a carrot path which forces the player who deviated to have an average payoff equal to the lowest that is individual rational for him. For a large enough discount factor, such a punishment path is an SPE path and thus an optimal punishment path.

Assuming an initial collusive outcome, how can the entrant facilitate collusion? We have shown that if deviation triggers off optimal punishment paths, a capacity limitation will neither facilitate nor violate the collusive outcome. This result is in contrast to the results in the static model of Gelman and Salop (1983) and the dynamic model with alternating price setting in Maskin and Tirole (1985). The intuition for our result is that a capacity limitation by the entrant has two, opposite effects on the incumbent's incentive to support a collusive outcome. On the one hand, a capacity increase by the entrant will reduce the incumbent's profit in the collusive outcome. On the other hand, a capacity increase will reduce the incumbent's profit in the non-collusive outcome. The latter effect will induce him to maintain the collusive outcome, while the former effect will induce him to deviate. We have shown that the former effect exactly wipes out the latter effect. However, capacity limitation by the entrant makes sense if deviation triggers off single-period Nash equilibrium for infinity. The reason is that a capacity increase by the entrant will have no effect on the non-collusive outcome if his capacity is so large the single-period Nash equilibrium is in pure strategies. The punishment facing the incumbent if he deviates is thus unchanged, and the incumbent will therefore not allow the entrant to increase in his sale in the collusive outcome

either. As a consequence, the entrant has nothing to gain from installing a capacity so large that the single-period Nash equilibrium is in pure strategies, that is, nothing to gain form installing $Q > 1 - C_E$. Our results are thus in line with Gelman and Salop (1983) and Maskin and Tirole (1985) if we assume trigger strategies, but not if we assume an optimal punishment paths with a stick and a carrot structure.

An entrant in the Norwegian cement market, Viking Cement, restricted its supply when it established itself. The firm said this was done for 'fear of Norcem [the incumbent]'. In earlier chapters we have shown that such a strategy makes sense in a static context. We have shown that such a strategy makes sense in a dynamic setting only if the firms have trigger strategies. Unfortunately, we do not have detailed enough inside information to answer whether the firms deliberately behaved according to a trigger strategy.

The results from our model can shed light on the entry that took place in the U.S. phosphorus industry. When a joint venture between Texasgulf and Albright and Wilson (A & W) entered this market in the early 1990, its capacity was set to approximately 10 per cent of the existing capacity in the industry. The incumbent firms did not respond by price cutting. According to Benoit and Krishna (1991), this was because there existed large idle capacity in the industry. They argued that the idle capacity made it possible to increase the quantity supplied substantially if necessary, and hence that the equilibrium price in the non-collusive outcome would be rather low. The incumbent firms realized this, and their best response to entry was to act collusively. The basic mechanism we deduced from our model suggested another, complementary argument for why the incumbent firms did not respond by price cutting[9]. The entrant's limited capacity, only 10 per cent of the market, limited the incumbent firms' loss from accommodation, and thus induced the established firms in the U.S. phosphorus industry to maintain the collusive outcome rather than start price cutting. While Benoit and Krishna (1991) emphasized how idle capacity in the industry made price cutting as a response to entry unattractive for the incumbent firms, our model suggested how

[9]Note that we have to be cautious with the application of our model in this particular case, not interpreting our results from the theoretical model too literally. For example, we are analysing a duopoly while the US phosphorus industry consists of several incumbent firms.

capacity limitation by the entrant made collusion more attractive for the incumbent firms. However, our argument depends on which kind of strategy the firms pursued. To find out whether the mechanism we have described did matter in this particular case, we should investigate more in detail each firm's deliberate strategy.

Appendix K: Proof of Propositions 8.1 and 8.2

Assuming $\sigma = \sigma(A^C;A^N,A^N)$, let us deduce the critical discount factor, i.e, the one specified in Proposition 8.1. We know from section 2.1 that A^N is an SPE path. It then remains to check that neither the incumbent nor the entrant will deviate from the collusive outcome. Assuming $Q < 1 - C_E$, the incumbent will support the collusive outcome if:

$$\frac{\gamma + (1 - \gamma)(1 - Q)}{1 - \delta} \geq 1 + \frac{(1 - Q)\delta}{1 - \delta} \qquad \text{(K.1)}$$

Rearranging, we have that the minimum 'market share' the incumbent can accept without deviating is:

$$\gamma^{min} = 1 - \delta \qquad \text{(K.2)}$$

If $Q \geq 1 - C_E$, the incumbent will not deviate from the collusive outcome as long as:

$$\frac{\gamma + (1 - \gamma)(1 - Q)}{1 - \delta} \geq 1 + \frac{C_E\delta}{1 - \delta} \qquad \text{(K.3)}$$

Rearranging, we have that the minimum 'market share' in the collusive outcome the incumbent can accept without deviating is:

$$\gamma^{min} = 1 - \frac{\delta(1 - C_E)}{Q} \qquad \text{(K.4)}$$

Assuming $Q \geq 1 - C_E$, the entrant will not deviate if:

$$\frac{(1 - \gamma)(1 - C_E)Q}{1 - \delta} \geq (1 - C_E)Q \qquad \text{(K.5)}$$

Rearranging, we have that the maximum 'market share' the incumbent can have before it is profitable for the entrant to deviate from the initial collusive outcome is:

$$\gamma^{max} = \delta \qquad \text{(K.6)}$$

Assuming $Q < 1 - C_E$, the entrant will not deviate if:

$$\frac{(1 - \gamma)(1 - C_E)Q}{1 - \delta} \geq (1 - C_E)Q + \frac{\delta(1 - Q - C_E)Q}{1 - \delta} \qquad \text{(K.7)}$$

Rearranging, we have that the incumbent's largest 'market share' in the collusive outcome the entrant will accept is:

$$\gamma^{max} = \frac{\delta Q}{1 - C_E} \qquad \text{(K.8)}$$

Substituting (K.4) and (K.6) into $\gamma^{max} \geq \gamma^{min}$, we have the upper expression in Proposition 8.1. It ensures that both the incumbent and the entrant support the collusive outcome if $Q \geq 1 - C_E$. Substituting (K.8) and (K.2) into $\gamma^{max} \geq \gamma^{min}$, we have the lower expression in Proposition 8.1. It ensures that both players support the collusive outcome if $Q < 1 - C_E$.

Let us now assume $\sigma = \sigma(A^C;A^E,A^M)$, and deduce the condition in Proposition 8.2. The entrant will earn zero profit in the period after deviation. He will thus support the collusive outcome if (K.6) is met. The incumbent will earn (1 - Q) in each period after his own deviation. He will thus support the collusive outcome if (K.2) is met. Substituting (K.2) and (K.6) into $\gamma^{max} \leq \gamma^{min}$, we have the condition in Proposition 8.2. Q.E.D.

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