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**Entry Barriers and Concentration
in Chemicals Shipping**

by

Trygve Stene

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“Strategisk atferd i noen utvalgte shippingsegmenter”
(Strategic behaviour in some selected shipping segments)

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PREFACE

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NHH Bergen, July 1999.

Trygve Stene

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NON-TECHNICAL SUMMARY

Deep-sea chemicals shipping has for the last decade been dominated by four major players, Stolt-Nielsen, Odfjell, JOTankers and Seachem. During the same period, the risk-adjusted return of these operators has seemingly been higher than for other operators in comparable shipping markets. This report seeks to gain insight into the underlying mechanisms that have sustained the high-return oligopoly in the chemicals shipping market.

The first question the report seeks answered, is whether the oligopolists have exercised market power to deter entry from new competitors and, if yes, in what way. Secondly the report investigates the potential role of price collusion in the market. The purpose of the report is to shed light on both the question of entry deterrence and the question of collusion through theory of industrial organisation. The research strategy is to derive theoretical predictions of optimal behaviour in the chemicals market and then confront these predictions with factual behaviour from chemicals shipping.

The report has two main findings. First, it is proposed that the leading incumbents follow a top dog strategy towards potential competition. This means that the established operators in chemicals shipping act tough to restrain small players and prevent potential new entrants. Toughness to deter competition can for instance be seen in the high level of investment in new chemical tankers in recent years, and in the high investments in "state of the art" maintenance of current vessels. Second, on the question of price collusion, it is proposed that the multimarket contact that is prevalent in chemicals shipping can sustain a situation with price collusion. However, this issue needs to be further explored in more data-intensive studies.

The deep-sea segment in chemicals shipping is dominated by four companies. Stolt-Nielsen is the largest operator with a market share above 25%. The second largest operator is Odfjell, who has a market share of approximately 20%. The other two major operators are JO Tankers (appr. 8%) and Seachem (appr. 9%). The four leading incumbents have had a steady total market share, approximately 60%-65%, since the beginning of the 1990s. In addition to being the largest players in the market, Stolt-Nielsen and Odfjell are also strong in related distribution services. Such distribution services include regional feeder service, tank container management and the operation of tank terminals.

Stolt-Nielsen and Odfjell operate liner services between all continents, while other operators offer services on fewer routes and continents. The way operators compete on several distinct routes leads to what we label a multimarket situation, where the same players meet each other in tightly related, but distinct, geographical markets. Chemicals shipping is also

distinguished by high entry barriers, such as the high cost of new tonnage. For instance, a new 38,000 Dwt chemical tanker costs approximately the same as a new 300,000 Dwt oil tanker. In addition, limited newbuilding capacity of yards, operational skills and close client relations are additional factors making entry difficult in chemicals shipping.

Considering the question of pre-empting entry, an established firm knows that his pre-entry decision can influence the prospective entrant's view of what will happen if he enters. The incumbent will naturally want to exploit this to his own advantage, and a taxonomy of four optimal business strategies regarding entry deterrence and accommodation is derived. The different investment strategies give the optimal action for the incumbent, taking into account the presumed behaviour of the potential entrant. The report elaborates that when there is competition on capacity, entry can be deterred by overinvestment in capital.

On the second question, it is well known that price collusion can occur if firms in one market compete against each other over an indefinite period of time. More recently, however, new models have been developed where multimarket contact can enhance the incentive for price collusion. The report gives an introduction to tacit price collusion and shows how such collusion can affect market competition between established players. Especially it is shown how multimarket contact increases the incentives for tacit collusion when there are several firms operating in two distinct markets. It is shown that multimarket competition can lead to sustained higher profits for the incumbents through tacit collusion.

The conclusion of the report is that the incumbents seem to follow a "top dog" strategy by overinvestment in capital. This strategy is an active force to deter potential competition. In addition, multimarket contact has enhanced the incentives for tacit collusion, thereby increasing the rate of return of the leading incumbents.

It is hard to derive any clear-cut conclusions from chemicals shipping, since data from this market are scarce. One specific notion about chemicals shipping is that approximately 50% of all cargo is covered by contracts of affreightment. This high coverage makes the chemical freight market quite secretive and details of actual contract rates are rarely divulged. One proposal to further research is to focus on multimarket contact and investigate how such contact can affect competition in chemicals shipping.

CHAPTER ONE

INTRODUCTION

Chemicals shipping is characterised by entry barriers, multimarket contact and relative strong concentration. This freight market is highly specialised and the major operators compete in several markets as trading takes place on distinct geographical routes. Together the four leading operators have had a steady market share since the beginning of the 1990s, which has remained approximately 60%-65% up until today. Correspondingly the market share for each of these companies has been remarkably steady during the same period. The total market has grown notably the last decade without any new players being able to obtain a position among the leading incumbents. The newcomers that have survived have all remained small operators, implying that the four majors have managed to sustain their market share while meeting growing demand. There are also some indications that this market is

characterised by high profits¹, which ought to send an attractive signal to potential entrants.

This thesis seeks to gain insight into the underlying mechanisms that are active in chemicals shipping. Can the observed concentration and high profits result from the leading incumbents exercising market power? This question will be analysed through established theory of industrial organisation, as I derive theoretical predictions of optimal behaviour and confront these predictions with factual behaviour from chemicals shipping. I will try to establish that the leading incumbents have sustained their position by exercising market power in two ways. The first is to deter entry from potential newcomers, leading to the observed concentration. The second is to increase their profits through tacit collusion, helped by multimarket contact. This makes an interesting case, as we will be able to combine traditional analyses of industrial behaviour (entry barriers) with more recent theories (multimarket contact), and use them to analyse one single industry. Below I will briefly present the theoretical framework and outline the further progress of this thesis.

1.1 THEORETICAL FRAMEWORK

Traditional analyses of industrial behaviour typically link the exercise of market power in an industry to features such as demand conditions, concentration, and barriers to entry. But more recently, some economists have developed models to show that other factors, like multimarket contact between firms, also can play a significant role in determining the level of

¹ Birkeland et al (1999) show that the average returns of the major operators have been higher than companies in other comparable shipping markets. However, caution should be taken, as the data material in this research is limited.

competitiveness in a particular industry. As mentioned, both angles will be presented in this thesis.

A barrier to entry can create a situation where one or several incumbent firms successfully deter entry from potential entrants. Using Salop's (1979) words they can be classified as either innocent entry barriers or strategic entry barriers. An innocent entry barrier is unintentionally erected as a side effect of profit maximisation. A strategic barrier is in contrast intentionally erected to reduce the possibility of entry.

Two formal models will be presented in this thesis to show how an incumbent can deter entry from a newcomer. The models are Dixit (1980) and Eaton and Lipsey (1980). In addition the taxonomy of entry-detering and accommodating strategies of Fudenberg and Tirole (1984) will be reviewed.

Dixit (1980) pointed out the game theoretical aspects that distinguish an incumbent when he faces a potential entrant. Even when we have the simplest situation where there exist only one established firm and one potential entrant, there are some subtle strategic interactions. Dixit (1980) sums up the situation clearly when he writes that "*[t]he established firm's pre-entry decisions can influence the prospective entrant's view of what will happen if he enters, and the established firm will try to exploit this possibility to his own advantage*". In sharp contrast to a perfect competitive market, the firms in the setting described by Dixit (1980) do not take market competition as given. The incumbent can take strategic actions to alter the entrant's behaviour and beliefs. It will be shown that an incumbent successfully can deter entry from a newcomer by overinvesting in capital, as the commitment in capital is made before the potential entrant makes his decision to enter or stay out. The incumbent thus has an opportunity to act strategically and prevent entry.

Eaton and Lipsey (1980) developed the second model that will be presented. This model shows how an incumbent can deter entry by

overinvesting in maintenance. This results in the incumbent having “too much” maintenance for strategic purposes compared to a cost minimising solution.

The exercise of market power is also linked to the possibility that established firms can try to co-ordinate their activities. Many industries are dominated by a small number of firms, which can have an affect on market competition. Tacit collusion, where firms are able to “soften” competition without explicit co-operation, can increase their profits. I will first elaborate the problems of tacit collusion by looking at the Nash equilibrium in a one shot game. I will then change the setting and look at tacit collusion in an infinitely repeated game. This changes the result, and proof will be given for an equilibrium where tacit collusion can be sustained. Bernheim and Whinston’s (1990) model will extend this analysis, as I elaborate their model of multimarket contact. This model shows that the sustainability of tacit collusion could be enhanced, if firms meet in several distinct geographical markets. Multimarket contact can make it profitable to sustain tacit collusion in several markets, even if one of the markets is characterised by tough competition.

1.2 THESIS OVERVIEW

We head out in the next chapter with a more detailed description of the market for sea-borne trade of chemicals and associated products. I shall concentrate on deep-sea trading with sophisticated chemical carriers operated by the four majors. This shipping segment is fairly new, so a brief cover of the historical development will be given. Further, a closer presentation of the four major shipping operators will add background to the historical review. The end of chapter two will be devoted to a description of

market competition in chemicals shipping and an elaboration of the entry barriers in this industry.

Chapter three will be the first of two chapters providing a theoretical background. This chapter focuses on entry barriers and on how an incumbent can deter a potential entrant. The first sections will describe the concept of entry barriers more closely and present the game between the incumbent and the entrant more formally. Furthermore the taxonomy of entry and accommodation strategies by Fudenberg and Tirole (1984) is derived, before reviewing shortly different theoretical determinants of barriers to entry. Finally two formal models will be presented to show how an incumbent can deter entry. The models are Dixit (1980) and Eaton and Lipsey (1980).

In chapter four I examine how a group of firms can increase their profits without any direct communication. This is achieved through tacit collusion as I assume that a formal agreement is not possible. Sustainability of tacit collusion is analysed through game theory, more precisely infinitely repeated games or supergames. The last section of chapter four extends this by exploring how multimarket contact can help sustain a tacit cartel.

Chapter five will be devoted to concluding comments and short discussion. This chapter will view the chemicals shipping market in light of the theoretical models provided. I will try to answer the questions set out in this thesis and see if the models put forward can explain the situation in chemicals shipping. It is hard to derive any clear-cut conclusions from chemicals shipping since data from this market are scarce. Nevertheless the different perspectives from the previous chapters will be brought together to get a broader picture of chemicals shipping, including a proposal to further research of this market.

CHAPTER TWO

CHEMICALS SHIPPING

A chemical tanker is a technically advanced ship able to carry a range of petrochemicals and non-petroleum liquid cargoes². This chapter will give a short survey of chemicals shipping where the market for seaborne trade of chemicals will be introduced and an overview of the most important aspects of this specialised freight market given. Although the whole market will be presented, the main focus is on deep-sea³ trading with sophisticated parcel carriers above 10,000 dwt. These vessels are able to carry the most hazardous trades and a few companies dominate this market. The main players within this segment are often referred to as "the major (chemical) four".

2.1 HISTORICAL DEVELOPMENT

The world's chemical industry is fairly new, but has developed rapidly the last fifty years. This has led to an increase in the demand for seaborne

² I use the same definition as Østensjø (1992).

³ The deep-sea market includes seaborne trade of chemicals on intercontinental routes.

transportation of chemicals. Until the mid 1950s liquid chemicals were not carried in bulk at sea, but were shipped in drums. In this early phase there existed no strict international requirements to the safe handling of chemical cargo and the knowledge of problems and consequences of such freight was scarce. The first ships to carry chemicals in bulk were initially designed for handling other cargoes, and were usually rebuilt product tankers. Due to low cost of converting these vessels, many shipowners were willing to invest in this conversion work. More knowledge of the hazards linked to transportation of chemicals led to strict international regulation on the treatment of these products. The new regulations gave way to an era where specialised tankers purely designed for handling chemicals were developed. In the 1960s the first tankers designed for operation as parcel tankers came into service. These ships had a greater number of tanks, and compared to the rebuilt vessels they were treated with more sophisticated coatings⁴. This enabled the tankers to carry a wider range of cargoes at the same time, thus becoming more competitive towards the traditional liner (Østensjø, 1992).

The demand for chemicals and thus the need for seaborne transportation have increased steadily since the late 1950s. We can sum up the historical development of chemicals shipping in four phases. The first phase was the initial growth period from 1959 to 1973. This period was characterised by strong growth in the chemical industry and a corresponding growth in the trade of chemicals. There was also an increase in the number of chemical products, which meant an increasing demand for more sophisticated ships to handle the new and more hazardous chemicals. The shipbuilding prices were still low, encouraging more investment in chemical tankers.

The next phase ran from 1973 to 1982. Within this period the chemical carrier market became more segmented. There was a further expansion of the fleet, especially by the major operators. In addition, the fleet was updated to

⁴ Paint protecting the inside of a vessel's tanks. Usually epoxy or zinc based paints.

meet the increasing international regulation of seaborne trade of chemicals, meaning bigger ships and more stainless steel capacity. When the freight rates peaked in 1980, this optimistic outlook gave way for even more newbuilding. More ships above 30,000 dwt, with higher emphasis on stainless steel capacity, were built and entered the freight market for chemicals. By investing in stainless steel capacity an operator became able to handle the most sophisticated chemicals traded. The decision to use stainless steel tanks entails using stainless steel in all other parts of the cargo system which are in contact with the cargo⁵. This increases the cost of a vessel, but owners quickly appreciated the advantages of stainless steel construction. They considered that the extra cost of construction could be recouped by offering charterers the benefits of stainless steel tanks for products other than acids and thereby obtain a premium in the freight rate (Drewry, 1999).

The years from 1982 to 1990 describe the third phase, where a concentration in the chemical carrier market occurred. In the beginning of this period there was a continued growth in the size of the fleet, which outstripped the growth in trade, pushing the market into recession. Revival of the market led to a slow recovery of the freight rates, followed by the main players strengthening their positions by taking over several of the smaller operators.

The last phase runs from 1991 until the present time and is characterised by the growth of independent shipping operators. The main operators have maintained their strong positions but the spread of ownership has changed. In the early 1990s the four major operators and Tokyo Marine controlled 70% of the market. This has changed according to Richardson Lawrie Associates, as the number of organisations operating in excess of 5% had increased to six. They estimate that these organisations control nearly

65%⁶ of the total fleet, with a further 22% controlled by a wide range of other shipping companies. Since mid-1995, the chemical carrier market has suffered from strong growth in the overall fleet and a subsequent weakening demand base, hastened by the Asian crisis in mid-1997. The chemical carrier orderbook is in excess of some 20% of the present fleet in terms of tonnage, rising to more than 30% in some of the fleet segments (Drewry, 1999). This and other structural observations, such as some of the smaller operators growing bigger, will most likely affect the next phase of chemical shipping emerging in the forthcoming decade.

2.2 THE MARKET

The freight market for chemicals is highly differentiated, as several hundred different chemicals are traded by sea. Today the total volume of organic and inorganic chemicals traded is estimated at approximately 60 million metric tonnes per year. In addition the transportation of vegetable oils, alcohol's, molasses and lubricating oils amounts to 40 - 45 million tonnes per year (Odfjell Annual report, 1998). The product range has developed a lot since the early days bringing new and more hazardous chemicals into seaborne trade. This has led to an increase in the technical level a vessel has to meet, which will be further revealed in section 2.4.

Chemicals are traded all around the world, and freight by sea is an important way to get the chemicals from supplier to buyer. The chemicals moved by the chemical fleet are according to Richardson Lawrie Associates usually divided into five main groups. These are organic chemicals, which is

⁵ Cargo pumps, valves, pipelines, tank vent lines, heating coils, tank washing machines and tank access ladders are all required to be made from stainless steel of the same quality as the cargo tanks.

⁶ Different sources seem to disagree of this estimate, see section 2.5.

the most important and accounts for around 63% of all trade by sea. Organic chemicals can be divided in two subgroups, commodity chemicals (45.5%) and speciality chemicals (17.5%). The groups differ in parcel size and the proportion in which they are traded on specific routes. The other groups are inorganic acids (12%), vegetable oils/animal fats (19%) and caustic soda solution (6%). The products mentioned above all have in common that they are carried on front haul routes although some of the trade flows may be backhaul as well. Chemical carriers also carry CPP and molasses, but these are backhaul products and vary enormously year on year. It depends on the precise patterns of trade whether operators decide to carry these backhaul products or move other product ranges that are both front haul and backhaul. Operators can also have trade patterns where they schedule vessels without moving these products to any large extent.

The market for seaborne trade of chemicals has grown from 49 million tonnes in 1982 to an estimated 100 million tonnes today. Thus in less than 15 years the market has doubled with an average annual growth rate of 4.9% (Drewry 1999). This is quite different from the trading pattern of crude oil, which declined dramatically in the early 1980s as a result of radical energy saving measures initiated by the world's leading economies after the OPEC price hikes of the oil crisis of 1979/80 (Ibid.). Although there were enormous chemical tanker surpluses in the early to mid 1980s, the growth in chemical trade has led to a considerable increase in the chemical carrier fleet. Statistics from Drewry (1991,1999) show that the total chemical fleet⁷ had increased by more than 30% to nearly 21,000,000 dwt from 1991 to the end of 1998. Seaborne trade in chemicals is more closely related to changes in world GDP, as demand for chemicals is associated to levels of industry production rather than energy consumption. It thus seems that as world GDP expands, so will the markets for chemicals shipping. Drewry (1999) notes that chemical

trade on average for the last 25 years has grown 1.5 times the growth in world GDP.

2.3 DEEP-SEA TRADING

There are several different types of vessels habitually trading the deep-sea parcel service. The carriers are classified by the different degrees of complexity, in particular their cargo containment characteristics. This thesis will divide the different chemical carriers in the following way; parcel carriers, product/chemical carriers and specialised carriers⁸. The major operators such as Stolt-Nielsen and Odfjell have vessels in all of these categories except for the specialised carriers, which are owned/operated by acid producers/receivers.

This thesis examines strategic aspects of deep-sea trading in the most sophisticated segment of chemicals shipping, and will thus focus on parcel carriers above 10,000 dwt. The major operators have a strong position in this segment and have invested increasingly in these vessels. (Odfjell Annual report, 1998). Before presenting this segment, a brief description will be made of the other groups in chemicals shipping.

Product/Chemical tankers are built in accordance with the regulations of Marpol⁹ Annex I¹⁰ to carry crude oil and/or clean and dirty refined products (Drewry, 1996). The ships are permitted to carry chemicals classified as “oil-

⁷ This number includes all vessels above 1,000 dwt, and thus also vessels involved in regional trade.

⁸ According to Richardson Lawrie Associates the tankers are analysed in four sections; parcel carriers, chemical carriers, product/chemical carriers and dedicated acid carriers. I will use the classification from Drewry (1999), which seems to analyse parcel carriers and chemical carriers as one group.

⁹ The International Conventions governing Marine Pollution Prevention.

¹⁰ This was the first international pollution convention, which contained standards for the control of both intentional and accidental pollution from ships transporting hazardous materials.

like substances". If the ships are equipped to meet Annex II regulations, they can carry more "easy" chemicals and vegetable/animal oils. Ownership in this category is very distributed, with the largest fleet made up of twelve vessels (Drewry, 1999). According to Drewry (1996) this indicates a shipping segment with a fleet of marginal status, as owners in this market tend to operate as a spill over from either the chemical or the product markets. The most important differences between parcel carriers and product tankers are that the latter do not have any stainless steel capacity nor are they able to carry as many types of cargo.

The dedicated specialised chemical carriers are composed of an array of essentially distinct tankers serving a wide range of different chemical trades. Their common factor is that they normally are dedicated to trading a particular commodity, like methanol, phosphoric acid, sulphuric acid or palm oil. The owner structure within this group is more varied than in the other groups. The average specialised fleet comprises just 1.7 vessels compared with 2.1 and 2.3 for the parcel and product/chemical sectors respectively. This reflects the diverse and unconnected ship types labelled as specialised vessels and also accounts for the high concentration of single ship owners, which is nearly 60% (Drewry, 1999).

We can then move on to the parcel carrier segment, sometimes referred to as the sophisticated chemical carriers. These carriers are constructed in accordance to the strongest international regulations, and classified after IMO¹¹ standard. The parcel chemical carriers can be subdivided into IMO Type 3 ships with coated cargo tanks or Type 1 or 2 ships with some or all tanks lined with stainless steel. The parcel carriers will be elaborated further in the next section.

¹¹ This is the International Maritime Organisation, the international UN advisory body on transport by sea. The IMCO Assembly formally adopted the IMO code on 12th October 1971.

2.4 THE SOPHISTICATED CHEMICAL CARRIERS

Sophisticated chemical carriers are, as noted in the last section, carriers with some or full stainless steel capacity as this offers the most flexible operational environment. These parcel tankers are designed to carry a number of chemicals in small lots usually on established routes on a worldwide liner type service. The ships are characterised by a large number of tanks, up to 58, and a separate pump and load/discharge line for almost every tank. The modern parcel tankers are tailored to transport 40–50 different products at the same time and can thereby offer a high degree of flexibility. Stainless steel capacity makes it possible to carry cargoes that need special handling thus offering higher freight rates. Another advantage is that a higher proportion of stainless steel capacity enables the operator to easily interchange vessels from different trades and services.

Looking at the most sophisticated vessels, the major operators have dominated the picture for a long time. According to Drewry (1996), 94% of all stainless steel capacity can be found in the parcel carrier fleet. Accordingly the distribution by size, corresponds with this. Almost 60% of the stainless steel capacity is distributed among carriers between 20,000 dwt to 40,000 dwt. The three biggest operators controlled in 1991 almost 85% of this stainless steel capacity (Drewry, 1991), but this seems to change as some minor operators lately have taken delivery in stainless steel capacity as well.

According to Lazard (1998) most ships in the sophisticated segment meet the strictest IMO regulations. The IMO code applies to bulk chemicals with serious hazards. The purpose of the Code is to minimise the risks of handling chemicals to the ship, its crew and the environment. The Code provides containment for three quite different classes of hazardous chemicals. Type 3 is the least hazardous, while Type 1 is the most hazardous. The Ship

Type classification is based on the ship's ability to survive degree of damage and to prevent or limit cargo release (Grey, 1984). The Type 1 carriers are designed to carry products that require maximum preventative measures to preclude the escape of such cargo. This implies that the ship should be capable of sustaining collision or stranding damage anywhere along the ship's length. The specifications for Type 2 or 3 vessels are less strict, but all of them are required to sustain collision or stranding to some degree. The IMO Code also specifies where the siting of the cargo tanks should be in relations to the ship's side and bottom. IMO also took under consideration the extent to which the ship should be capable of remaining afloat after being damaged and to the extent to which the escape of hazardous cargo should be tolerated.¹²

These environmental restrictions add to the cost of building or rebuilding chemical tankers. Giving a vessel stainless steel capacity is also expensive. This makes newbuildings costly compared to other vessels, for instance crude carriers. We can make a comparison by looking at Frontline¹³, a shipping company operating in the crude carrier market. They have recently engaged in a major newbuilding program, ordering several VLCC¹⁴ ships from Hyundai in Korea. The size of these carriers is around 300,000 dwt, and the price for one of them was approximately \$ 70 million (Frontline Annual Report, 1997). This is the same price the major chemical operators have paid for their new sophisticated chemical carriers. For instance, the new 37,000 dwt chemical parcel tankers Stolt-Nielsen ordered from Danyard in 1993, had a net cost of \$ 70 million each (Lazard, 1998).

¹² To solve this IMO defined the assumed damages and stated the conditions of survival and cargo containment (Grey, 1984).

¹³ Frontline is a Bermuda based shipping company with one of the world's most modern crude carrier fleet.

¹⁴ Very Large Crude Carrier.

2.5 “THE FOUR (CHEMICAL) MAJORS”

Four major independent operators dominate the worldwide deep-sea chemical trade. This section will present these companies more thoroughly. Despite its image of concentrated ownership, 593 different owners in fact control the total chemical fleet of just over 1,500¹⁵ vessels. This includes 320 single ship companies (Drewry, 1999). The concentration occurs however through time charter or pooling agreements, where the major operators control many of the vessels owned by smaller companies.

Estimations of how much the five largest operators control of the fleet above 10,000 dwt are somewhat disputed. Richardson Lawrie Associates estimate the number to be nearly 60%. Statistics from Odfjell (Annual report, 1998) increase this number to 65%, which coincides with Drewry’s estimate (Drewry, 1999). Drewry (ibid.) states the sophisticated fleet above 10,000 dwt to include 229 vessels. They identify only four owners with more than ten vessels, led by Stolt-Nielsen, Odfjell and Jo Tankers. Drewry (ibid.) further estimates that the four major operators control nearly 63% of the sophisticated parcel tankers and almost 70% if one includes Tokyo Marine, the fifth biggest operator. It also seems that the major operators have managed to maintain their market share despite a large growth in the total fleet as noted in section 2.2. If we use the same statistics (Drewry, 1991, 1999) on the parcel tanker fleet, we find that this fleet has grown by almost 60% from 1991 till 1998. Comparable market shares of the parcel tanker fleet for vessels above 10,000 dwt are given in appendix 1. Inspection of these diagrams tells us that the market shares of the major operators have remained quite steady from 1995 till 1998¹⁶.

¹⁵ This number includes all vessels above 1,000 dwt.

¹⁶ Unfortunately it was not possible to obtain comparable numbers from 1991 but indications from Drewry (1996) suggest that these shares also remained steady from 1990 till 1995.

2.5.1 Stolt-Nielsen S.A.

The Stolt-Nielsen family has been active in international shipping since the turn of the century. Jacob Stolt-Nielsen started in the chemical market from scratch in the 1950s. He was one of the pioneers, and in 1959 his first parcel tanker came into operation. Stolt-Nielsen soon became a global player in the chemical market, establishing a New York office in 1961. Offices in Tokyo and Oslo followed the next year. As mentioned earlier the period from 1973–1982 was characterised by high growth in the chemical trade due to the growth in the chemical industry. Stolt-Nielsen took advantage of this, becoming one of the major operators and continuing their expansion in specialised ships.

This expansive newbuilding programme got Stolt-Nielsen into financial problems in 1976/77. British Petroleum (BP) advanced a finance loan of about US\$ 50 million to ease the short term liquidity problems. As part of the arrangement BP acquired a ten-year option to purchase 50% of the company. The main office was moved from Oslo to the USA in connection with this deal. In 1987 BP decided not to exercise the option, and Stolt-Nielsen regained full control of the company. This proved to be a turning point for Stolt-Nielsen, as it was followed by an aggressive expansionary policy (Drewry, 1996).

The company has been quoted on the NASDAQ Stock Exchange since May 1988, but the Stolt-Nielsen family still controls a 60% stake in Stolt-Nielsen S.A. The company owns a fleet of 49 deep-sea chemical tankers and operates a further number of vessels on a pool or time charter basis (Drewry, 1999). Core business for the Stolt-Nielsen organisation is its chemical parcel business, but they are also strong in related distribution services. This distinguishes Stolt-Nielsen and Odfjell from the other major operators as both offers integrated logistic services. This includes regional feeder service, tank containers and tank terminals.

The expansive program started in 1987 has been followed by another program in the 1990s to replace older parcel tankers with new more sophisticated ships. This included an order for seven 37,000 dwt advanced IMO Type 1 chemical parcel tankers from Danyard shipyard in Denmark. Stolt-Nielsen ordered a further three sophisticated ships from a French shipyard in March 1995. Six ships were delivered from Danyard in 1996-1998, and a further two sister ships in the series were ordered in 1997. Stolt-Nielsen is the industry leader in the parcel tanker sector, with approximately 26% of the market for sophisticated deep-sea carriers¹⁷ (Drewry, 1999). The company's range of services enables Stolt-Nielsen to offer its customers an extensive and flexible logistics service on a global basis. The company has 25 offices around the world, and a fleet large enough to provide global coverage and compete keenly for contracts of affreightment to give it its strong markets position. The financial performance of Stolt-Nielsen has also been impressive. In the ten years since it became public, the company has given a double-digit return on capital in five years and double-digit return on equity in seven years (Lazard, 1998).

2.5.2 Odfjell ASA

Odfjell¹⁸ was founded in 1914 and became in the 1950s along with Stolt-Nielsen one of the pioneers in the development of the chemical tanker trade. The company went into the sophisticated segment early and expanded heavily by acquiring 15 chemical tankers and a few specialised gas ships between 1960 and 1968 (Østensjø, 1992). All but two of the chemical tankers were smaller than 10,000 dwt, but many of them had stainless steel capacity

¹⁷ This reflects parcel carriers above 10,000 dwt.

¹⁸ The name was changed from Storli ASA to Odfjell ASA in Feb. 1998 to improve and simplify the company's profile and identity as operation already were marketed under the name Odfjell Tankers. To make the presentation less confusing I will only use the name Odfjell throughout this thesis.

and constructed with double skin. This was not common at the time, and paved the way for Odfjell to become a major player in chemicals trading. Stainless steel capacity gave Odfjell greater flexibility compared to other operators regarding transportation of different products consecutively.

Odfjell linked in the early 1970s up with Westfal-Larsen to make a joint venture company. Westfal-Larsen added further stainless steel capacity, and contributed with their experience from owning and operating product tankers. This gave the company an edge to compete with Stolt-Nielsen on the most demanding cargoes, and by 1972 the Odfjell/Westfal-Larsen fleet comprised 24 vessels, 14 of which offered stainless steel capacity. According to Østensjø (1992), 17 of these tankers were larger than 6000 dwt.

In the 1970s, Odfjell/Westfal-Larsen continued their expansion in specialised ships, even though the economic environment of the chemical industry was not so optimistic as in the 1960s. The rate of growth in petrochemical products did not turn out to be as high as expected when orders for new ships were made. This led to an excessive supply of tankers, giving the shipowners poor returns up until 1979. Odfjell remained nevertheless together with Stolt-Nielsen the leaders in the sophisticated chemical carrier niche.

In 1980 Odfjell and Westfal-Larsen established a new joint company to consolidate their activities. At the end of 1989, this joint venture was terminated when Westfal-Larsen went out of the chemicals markets, selling its nine owned chemical tankers, its four part-owned chemical tankers, and its 50% share in the Baytank terminal to Odfjell (Drewry, 1996). Moreover in 1989 Odfjell acquired five more vessels, and the following year they formed a new joint venture company with the National Shipping Company of Saudi Arabia (NSCSA). Odfjell sold the nine vessels bought from Westfal-Larsen to NSCSA, who put them into a new company, National Chemical Carriers

(NCC). The new joint venture was structured so that Odfjell continued to control the operation and marketing of the NCC fleet (Drewry, 1996).

In the beginning of the 1990s, Odfjell set out a policy to first “safeguard their market share” before gradually expanding it. The safeguarding was the collaboration with NSCSA, while the expansionary phase was to set forth an aggressive policy of newbuilding and second-hand purchase. Odfjell acquired several tankers through second-hand purchases, consisting of ships previously employed by Odfjell on a time charter or pool basis.

Odfjell proceeded with their newbuilding program in 1991. They planned to build six advanced IMO Type 1 37,500 dwt parcel carriers at different Kværner shipyards. This program was extended in the mid 1990s, as Odfjell placed orders for two more 37,500 dwt sophisticated tankers from Kværner Florø. The total number of newbuildings had reached 16 vessels at the end of 1998. The newbuildings have all been of advanced design making them among the most sophisticated vessels on the market today along the newbuildings of Stolt-Nielsen and JO Tankers (Drewry, 1999). Odfjell’s fleet in the deep-sea segment in the beginning of 1999 was 49. Of those ships, the Odfjell group owned 30 while the rest were time-chartered. In addition Odfjell has two further vessels due for delivery in 1999 and 2000 (Odfjell annual report, 1998).

Odfjell has, as noted in the last sub-section, like Stolt-Nielsen built up competence in related logistic services. This includes 9 vessels in regional trade, increasing involvement in tank terminals and a joint venture with Hoyer¹⁹ to provide a worldwide tank container service.

The financial performance of Odfjell has also been relatively impressive since it went public in 1985. Its operating margin has fallen below double digits on three occasions only. The company has also produced double digit return on equity in every year but two. There has been considerable

fluctuation in the freight rates during this period, proving the company to be well managed (Lazard, 1998).

2.5.3 JO Tankers

This company was founded in early 1980, as the two Odfjell cousins decided to go their separate ways and reorganise Odfjell into two independent companies. One was named J.O. Odfjell, while the other retained the old company name. The company JO Tankers was initially a joint venture between J.O. Odfjell and the Swedish company Johnson Line to operate chemical tankers under 10,000 dwt. It expanded into the deep sea chemical niche in 1981, and in 1988 J.O. Odfjell agreed to purchase Johnson Line's 50% share in JO Tankers and the three tankers owned by Johnson Line (Østensjø, 1992).

JO Tankers is exclusively concerned with the management and operation of chemical tankers and controls the most modern fleet of the leading operators. This has been achieved by an active strategy to increase their market share in the parcel tanker market. The strategy was undertaken by adopting a gradual programme of fleet expansion. The programme was based on newbuilding, second-hand purchase and long-term time charter. According to Drewry (Drewry, 1999) JO Tanker's fleet increased from 8 to 21 vessels between 1988 and 1998, while the chartered pool increased from 10 to 34²⁰. The company has an 8 % market share of the chemical carriers market over 10,000 dwt (Ibid.), but has a very sophisticated fleet with nearly 55 % in stainless capacity. This seems to have been a long-term strategy as JO Tankers had a large share in stainless steel capacity already in the beginning of this decade (Drewry, 1991).

¹⁹ Hoyer GmbH is a German company involved in the operation and management of tank containers.

²⁰ This number is a bit controversial. Richardson Lawrie Associates notes JO Tankers fleet of 1. January 1999 to be 32 vessels, where 26 of them habitually trade in the deep-sea market.

2.5.4 Seachem Tankers

Seachem Tankers was formed in 1990 as a pooling arrangement between Ceres Hellenic, Nedlloyd and Fearnley & Eger. The company was centred at Seachem's head office in London. The other pool partners later pulled out, as Fearnley & Eger went bankrupt and Nedlloyd wanted to concentrate on its core liner business. Seachem is still operating as a pool company and owns no ships, thus drawing its ships from Ceres Hellenic Shipping Enterprises of Greece and Finaval from Italy. At present time 23 vessels are operated in the Seachem pool (Drewry, 1999).

Its first step into the business was taken as late as in 1987, when Ceres Hellenic took delivery of a series of seven 45,000 dwt newbuildings from Hyundai. This was followed by another big purchase, this time of six vessels from the Canadian Pacific fleet for \$100 million (Drewry, 1999). Seachem is the youngest company of the major operators and has as the other major operators focused on expanding their market share in the parcel tanker market. Seachem is also the only "major" to focus on chemical/product tankers, operating several vessels in this segment. While the other major owners have spent huge resources on newbuildings, Ceres Hellenic has adopted an aggressive second-hand acquisition policy. Their main target has been 1980s built tankers around 10,000 dwt and 40,000 dwt. Even though the company has concentrated on second-hand vessels, Seachem controls one of the youngest of the independent chemical tanker fleets (Drewry, 1999).

2.6 MARKET COMPETITION

The market for deep-sea trade of chemicals is fragmented, where competition can be divided into distinct geographical trading lanes. These routes can be

identified as the trading patterns between the five continents. According to Richardson Lawrie Associates Stolt-Nielsen, Odfjell and JO Tankers are all active in routes involving North America, North Pacific, South East Asia, the Middle East and Europe.

The two largest shipping companies, Stolt-Nielsen and Odfjell operate liner service between all continents, including South America and South Africa. Being the largest chemical tanker operator Stolt-Nielsen is the most important owner (in terms of port calls) in North America, OECD Europe, Latin America, South East Asia, Japan and Australia. The most important regions for Stolt-Nielsen are OECD Europe, North America and South East Asia (Drewry, 1999). Like Stolt-Nielsen, Odfjell also spreads its fleet across the world's chemical trading lanes. The map in appendix 2 shows the deep-sea trading pattern of Odfjell Tankers, with the major ports of call also displayed. As we can see, Odfjell is well represented all over the world.

JO Tankers is the major operator which is most strongly dedicated to this transatlantic trade, with more than 60% of its calls in the North America and OECD Europe regions (Drewry, 1999).

Seachem is according to Richardson Lawrie Associates predominately involved in the trans-Pacific business to various parts of East Asia, but particularly the North Pacific and the Middle East to the USA.

One can observe that the major players meet in several distinct geographical markets and that they compete with each other on a wide variety of routes. On the senior routes, for instance the transatlantic, the major operators also compete with smaller, 'non-major' companies. Other routes are distinguished by the fact that only a small number of operators compete for market shares. There is an analogy here to the airline business where the major airlines compete on several destinations and face smaller competitors as well on some of these destinations. This multimarket situation

can affect market competition, which will be developed further in chapter four.

One specific notion about chemical shipping is that around 50%²¹ of all chemical movements are covered by contracts of affreightment (coa). The spot market covers approximately 35%, while the remainder is made up from other charter agreements and cargoes moved in tonnage controlled by exporters or importers. These estimates are highly uncertain, but the large amount of coa coverage makes the chemical tanker freight market quite secretive and details of actual contract rates are rarely divulged.

2.7 ENTRY BARRIERS IN DEEP-SEA CHEMICALS SHIPPING

Chemicals shipping is distinguished by difficult entry barriers, which makes it unlikely that the number of major parcel tanker owners will increase significantly in the future. I will give an overview of the main barriers to entry in this section.

The sophisticated chemical carriers naturally create a barrier to entry. Chemical carriers are, as noted in section 2.4, very costly to build compared to other simpler vessels. The newbuildings of Odfjell and Stolt-Nielsen are estimated to cost around \$65 – \$75 million for each ship. High newbuilding prices are coupled with a very small second-hand market, which means that newbuildings could be essential for a large-scale entrant. In addition, due to the complexity of the chemical carriers, there are only a small number of yards worldwide that are able to build these vessels, making the capacity for newbuildings limited.

²¹ This is a rough estimate from Drewry (1999) as the real number is difficult to obtain. Odfjell (Annual report, 1998) states for instance that their coa was about 55% in 1998.

Not only are newbuilding prices astronomical, a barrier to entry is also created by fleet size. To be able to compete with the major operators a newcomer would have to control more than a couple of ships. It is hard to say how many vessels are needed, but Drewry (1999) suggests that at least five parcel tankers are necessary to take up competition on some of the deep-sea routes, which seems like a plausible number. Operators like Odfjell and Stolt-Nielsen, that have a large number of vessels, can have a high frequency on their liner shipping, making it easier to adjust to the customers' needs. It is quite obvious that a smaller player would find it difficult to offer the same kind of service with a smaller number of ships. A new major operator could of course invest in less sophisticated vessels or even hire vessels on a time charter basis. But still, if he wanted to take up competition with the major operators, some sophisticated vessels would be needed, and they seem more difficult to hire as the major operators already control most of these ships.

Another barrier to entry is operational skills. The skills to operate a chemical fleet are developed through experience, and in addition to extensive marketing expertise, they are needed to ensure a high fleet utilisation. Hans Petter Amundsen of Odfjell emphasised the element of human capital in chemicals shipping and underlined that Odfjell attaches great importance in constantly improving their human capital level. For a newcomer it is obvious that these skills must be obtained by some of the current operators and this adds to the cost of a potential entry. Operational skills are thus regarded to be an important factor to prevent entry.

The close relation between the existing operators and their customers also creates an entry barrier. For instance, Stolt-Nielsen's top 10 customers are all leaders in the chemical industry. Among them one finds Arco Chemical, BASF, Exxon Chemical, Hoechst Celanese, Shell and Union Carbide (Lazard, 1998). The strong client relations of the existing operators mean that they are difficult and costly to achieve for a newcomer. This makes

entry more difficult as a new entrant must convince potential customers that they are serious players and that they intend to stay in the business on a long-term commitment.

Investment in information technology is a new strategic factor that can establish a future barrier to entry. Both Stolt-Nielsen and Odfjell have invested heavily in developing information systems customised to their own operations. Hans Petter Amundsen of Odfjell claimed that when their system was fully developed, an integrated network would make the company serve their customers better and faster. A customer will for instance be able to enter the Odfjell information system and find out exactly where in the world their chemical parcel is. The implementation of an effective and integrated information system can give the leading incumbents a cost advantage, which can be used to deter potential entrants.

The increasingly stringent environmental and safety requirements cause another barrier to entry. International regulations to ensure safer handling of cargoes at sea increase the costs a new operator will have to incur and this adds to the investment needed to enter chemicals shipping.

The integrated land-sea transportation and storage systems also produce a barrier to entry. The two major operators both own facilities on land for the storage of chemicals and are involved in the chemical tank container business. Odfjell has for instance a 100% stake in one of the most modern tanker terminals in the world, Baytank Inc. in Houston. This enables the companies to offer their customers complete “door to door” freight services and both Odfjell and Stolt-Nielsen seem to focus heavily on the development of these integrated services. This can make entry into chemicals shipping more difficult as the customers are “locked” to the leading incumbents, who offer a total logistical package.

2.8 NEW ENTRIES?

A new study has suggested that the returns on investment for the major chemical operators on average have been higher compared to shipping companies in other segments. (Birkeland, Eide & Hvide, 1999). And as we know, high returns on investment will always attract newcomers.

In recent years there have been a number of companies entering the deep-sea chemicals market according to Richardson Lawrie Associates. Some of them have succeeded to stay, while others have failed to survive²². Richardson Lawrie Associates also point out the fact that other operators, like Team Tankers, have expanded their operations in the parcel tanker business by building from a base of simple product/chemical tankers. One would expect that somebody would try to become a major player due to the high returns on investment, but it seems that these minor companies have remained small and that none of them have tried to threaten the major operators' market share.

One incident from spring 1990 is described in Østensjø (1992) and Seim & Stoutland (1991). Former employees from the two major operators, Odfjell and Stolt-Nielsen established a new company. They had a well founded knowledge of chemical tankers operations and Chemteam, as the company was called intended to become one of the "big" operators and compete with the established majors. Chemteam did not own any vessels, but hired vessels on 3 to 12 months basis and operated them. At the time when Chemteam started, freight rates where expected to rise significantly (Østensjø, 1992). But when the Kuwait crisis ended in May 1991, rates fell below what the vessels had been contracted for and Chemteam withdrew from all activities in autumn 1991. When Chemteam first started they also experienced attempts from Odfjell and Stolt-Nielsen to take over the

²² These companies include Aurora Tankers, Westchart, The Novamar pool, Copenhagen Tankers and Seatrans-Ermefer.

company (Seim & Stoutland, 1991), which we can take as an indication of the leading operators' willingness to fight hard to sustain their positions. The attempt did not succeed, but was followed by an agreement to co-operate (ibid.).

The following chapter will try to explain how potential entrants effectively can be deterred from a certain market. It is assumed that the major operators can act as a monopolist. This is not obvious the case in chemicals shipping, but it simplifies the theoretical analysis in chapter three as we can study how a monopolist can deter entry from a newcomer.

Chapter four will derive models of tacit collusion and multimarket contact, which can arise in a market dominated by a small number of firms.

Even though the financial power that is needed to become a major player in the most sophisticated segment of the chemical carrier market can be huge, there are several players that would meet these requirements. The big chemical companies, usually large multinationals have the financial strength to make such an investment. They may lack the skills to operate a chemical fleet, but they could easily buy several small operators and/or persuade key people from the existing operators to change jobs. There is therefore a possible danger of vertical integration. But up till today the overseas shipment volume of these companies has been small compared to total volume, not justifying building a fleet of their own. This was noted by Østensjø (1992) and still seems plausible today.

The major players have long dominated the parcel tanker business, and especially companies with a Norwegian background. "*The Norwegian presence in the long haul parcel tanker market is so strong that outsiders have been trying and failing to get into the business for the last 20 years*" writes Drewry Chemical Carrier Quarterly (1999). This statement seems a bit over the top, but still, the major incumbents have consequently managed to

sustain their position, possibly through the exercise of market power, which will be elaborated further in the next chapters.

CHAPTER THREE

ENTRY BARRIERS

A striking observation from chemicals shipping was that there had been few attempts to challenge the major operators. This could indicate that the incumbents have taken entry-detering actions to restrain potential entrants. This chapter will focus on the theoretical side of entry barriers and how this can affect market competition. A normative approach will derive the optimal business strategies for an incumbent facing potential newcomers. We will see that even when entry-accommodation is chosen, an incumbent can take strategic measures to improve his post-entry position.

3.1 DEFINITION OF ENTRY BARRIERS

Throughout the last decades there have been several different approaches to capture the strategic and economic consequences of barriers to entry. I shall briefly review some in this section.

Bain (1956) formulated the concept as a “condition to entry” equivalent to the state of potential competition from possible new competitors. He evaluated it roughly by the advantages established sellers in an industry have over potential entrants, with *“these advantages being reflected in the*

extent to which established sellers can persistently raise their prices above a competitive level without attracting new firms to enter the industry” (Bain, 1956). He was interested in the empirical element, and wanted to examine closer what actually happened in different markets. Later theories have focused more on the formal side of entry barriers, and examined why they are present in some markets and how an incumbent can take advantage of this.

Lieberman and Montgomery (1988) survey the theoretical and empirical literature that gives rise to first-mover advantages and disadvantages. First-mover advantages are related to entry barriers, as firms that are pioneers in one market can exploit this and prevent potential entry from competitors. In their article first-mover advantages are defined in terms of the ability of the first firm’s opportunity to earn positive economic profits, i.e. profits in excess of the cost of capital (Lieberman and Montgomery, 1988). This coincides with Bain’s approach, where entry barriers are seen as a possibility to earn economic rent for the incumbents.

Yip (1982) emphasises this further, and comments that entry barriers are the disadvantages a newcomer faces relative to an incumbent. The important point here is to note that there arises a disadvantage merely due to the fact of entry versus an established incumbent. This can also be found in Stigler’s definition of barriers to entry. According to Stigler (1968), *“[a] barrier to entry may be defined as a cost of producing (at some or every rate of output) which must be borne by a firm which seeks to enter an industry but is not borne by firms already in the industry”*.

One can also find definitions where attention is on the economic efficiency of a market with entry barriers. Ferguson is noted in Gilbert (1989) and defines barriers to entry as *“factors that make entry unprofitable while permitting established firms to set prices above marginal cost, and to persistently earn monopoly return”*. The different approaches do not cover the topic too precisely. For instance it is important to bear in mind that the

mobility of capital into an industry can depend on the mobility of capital out of an industry. This is noted in Gilbert (1989). He points out that “[t]he central question in entry deterrence is the value that is attached to incumbency: Why is it that an established firm may lay claim to a profitable market while other (equally efficient) firms are excluded?” This leaves him with a more general definition of what a barrier to entry is. He defines a barrier to entry to be a rent that is derived from incumbency. In other words the extra profit an established firm can earn due to the fact that he is an incumbent.

3.2 THE GAME OF ENTRY

An important aspect of entry deterrence is to make it credible. This implies that threats put forward to a potential entrant must have some sort of commitment value. If the threat is just “cheap talk” a newcomer will see through this and enter the market with the incumbent as a passive spectator. The formal side of this has been analysed through game theory²³. A simple, but instructive example of this entry deterrence game is shown in extensive form in figure 3.1 on the next page.

The entrant has the choice of entering or staying out of the market. If he enters the incumbent can respond with aggression or accommodation. In this example there is complete information, so both players know each other’s payoff from the different outcomes. The threat in question is the possibility that the incumbent chooses the aggressive option if the newcomer decides to enter the market. This could be exemplified as a situation where the incumbent starts a price war with the result that the involved parties receive

²³ For a short introduction to game theory, see for instance Fudenberg and Tirole (1989) or Gibbons (1992).

negative or zero profit. The incumbent wants to convince the entrant that an entry will be unprofitable and hence, that he should stay out of the market and not undertake any start-up costs. The entrant of course, wants the incumbent to choose accommodation and thereby let the entrant receive a share of the market. This implies that the incumbent's market share declines and that his profits drop.

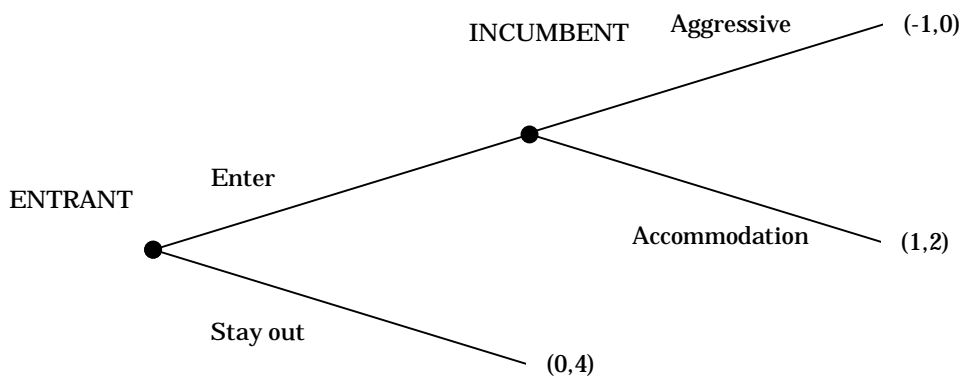


Figure 3.1: Typical game of entry.

To solve this game one has to look for a Nash equilibrium, which is not only an overall equilibrium, but also an equilibrium in all subgames. A Nash equilibrium with this property is known as a subgame perfect equilibrium (Varian, 1992). In the game in figure 3.1, the obvious solution is for the entrant to enter the market. This is due to the fact that the incumbent's threat is not credible. If the newcomer enters the market, it is better for the incumbent to play soft and split the market, than to play tough and not make any profit at all. The incumbent's threat of a price war to remain a monopolist should not discourage the entrant from going into the market. We

see that an incumbent, who wants to remain a sole player in one market, has to make credible threats to keep entrants out of their lucrative business.

The question is whether the incumbent can change the game and present a credible threat. Can he invest in extra capital or take other strategic actions that would make it optimal to choose the aggressive action if someone tries to enter the market? Viewed through the game in figure 3.1, one can think of an action that changes the payoffs to the different players. If the aggressive option becomes the rational choice for an incumbent, the entrant will be aware of this and by reasoning backwards conclude not to enter the market.

Brandenburger and Nalebuff (1995) presented a popular and practical approach to this subject. They pointed out that “*[t]he essence of business success lies in making sure you’re playing the right game.*” They emphasised that game theory gives a systematic way to understand the behaviour of players in situations where their payoffs are interdependent. The authors also stressed that a company should not just play the game they find, but actively shape the game they want to play. This coincides with the above-mentioned game of entry. Incumbents have an incentive to shape the game, such that their threats towards entrants become credible. One way to shape the game you play is to enhance the entry barriers in an industry. An entry barrier makes it more difficult to enter an industry and could deter potential entrants to remain out. Entry barriers can be a natural factor in one market, but incumbent firms can also actively take action to create barriers for newcomers as noted by Salop (1979).

3.3 A TAXONOMY OF ENTRY DETERRENCE STRATEGIES

Stackelberg developed in the early 1930s a model that showed how a first-mover advantage could be of strategic importance. He did not analyse entry deterrence, but showed as Tirole (1988) remarks “*that commitments matter because of their influence on their rivals’ actions.*” The model focuses on how a player in a duopoly can influence the other player by making an observable commitment before his opponent can respond and set his quantity. We want to take this further and see how an incumbent player can influence a newcomer’s entry decision by strategic investment. Fudenberg and Tirole (1984) built a normative framework to formalise these ideas. They provide a taxonomy of business strategies, which can be used to analyse situations of strategic interaction between an incumbent and an entrant.

To simplify we narrow the time perspective to a two-period model with only two players, an incumbent and a potential entrant. In the first period the incumbent²⁴, being the only player in market, determines the amount of capital he wants to accumulate. Capital should be understood in very broad terms here, as it could be investment in larger production capacity, but also investment in knowledge or human capital. The important point is that the action taken by the incumbent in the first period can influence the entry decision taken by the entrant in the second period. This means that the incumbent has to consider all his options and choose the one that will maximise his total payoff.

In the first period the incumbent chooses how much he wants to invest in capital, denoted K_1 . As noted above, the term capital must be widely understood. Firm number 2 observes K_1 and decides whether to enter the market or not. If the entrant decides to stay out he makes no profit. The incumbent’s profit is then given by

²⁴ I denote the incumbent as firm 1 and the entrant as firm 2.

$$\Pi^{1m}(K_1, x_1^m(K_1)),$$

where m denotes the incumbent remaining a monopolist. If firm 2 decides to enter, they simultaneously choose output in the second period. Their profits are then

$$\Pi^1(K_1, x_1, x_2)$$

and

$$\Pi^2(K_1, x_1, x_2).$$

One should note that the optimal choice of x_1 and x_2 is dependent the size of K_1 . This is because the invested capital on stage one determines what the incumbent can produce in the second period. The entrant must also take K_1 into consideration when finding his optimal choice of x_2 . Any entry costs for firm 2 are assumed to be a part of Π^2 .

I will first show equilibrium where entry is deterred by firm 1's choice of K_1 . The incumbent deters entry if K_1 is chosen such that

$$\Pi^2(K_1, x_1^*(K_1), x_2^*(K_1)) = 0.$$

There are two effects we have to focus on here. If we take the total derivative of Π^2 with respect to K_1 we get

$$\frac{d\Pi^2}{dK_1} = \frac{\partial\Pi^2}{\partial K_1} + \frac{\partial\Pi^2}{\partial x_1} \frac{dx_1^*}{dK_1}.$$

The first term on the right hand side is the direct effect. This shows how the incumbent's choice of K_1 directly influences the entrant's profit. The second term is the strategic effect. The strategic effect shows how the investment in

K_1 will affect the incumbent's output, and hence how this will influence the entrant's profit. Using Tirole's words we will say that investment makes the incumbent firm tough if $d\Pi^2/dK_1 < 0$ and soft if $d\Pi^2/dK_1 > 0$ (Tirole, 1988). This will affect the optimal entry deterring strategies for the incumbent, which will be explained more closely below. But first we look at the case where entry is met by accommodation from the incumbent.

What if the incumbent firm finds it too costly to deter entry? In this situation firm 1's optimal behaviour is given by its own profit post-entry. The incentive to invest is given by the total derivative of

$$\Pi^1(K_1, x_1^*(K_1), x_2^*(K_1))$$

with respect to K_1 . We know from the envelope theorem that since $x_1^*(K_1)$ is the choice of x_1 that maximises profits, we have

$$\frac{\partial \Pi^1(K_1, x_1, x_2)}{\partial x_1} = 0.$$

The basic equation in the entry-accommodation case is then

$$\frac{d\Pi^1}{dK_1} = \frac{\partial \Pi^1}{\partial K_1} + \frac{\partial \Pi^1}{\partial x_2} \frac{dx_2^*}{dK_1}.$$

Once again we can decompose this derivative into two effects. The direct effect is the first term on the right hand side. This effect would have existed even if the entrant did not observe K_1 before making his choice of x_2 , and could therefore not affect x_2 . Thus for the purpose of the classification I will ignore this. The strategic effect results from the influence the incumbent's investment has on firm 2's second-period action. Again using Tirole's words

we can say that in the case of entry accommodation the incumbent should overinvest if the strategic effect is positive and underinvest if the strategic effect is negative (ibid.).

We can elaborate the sign of the strategic effect by relating it to the investment making firm 1 tough or soft and to the slope of the reaction curves²⁵. We assume that the second-period actions of both firms have the same nature, in the sense that $\partial\Pi^1/\partial x_2$ and $\partial\Pi^2/\partial x_1$ have the same sign. We can then use the fact that

$$\frac{dx_2^*}{dK_1} = \left(\frac{dx_2^*}{dx_1} \right) \left(\frac{dx_1^*}{dK_1} \right) = [R_2'(x_1^*)] \left(\frac{dx_1^*}{dK_1} \right),$$

where R_2' is the entrants reaction curve. We can use the chain rule and rearrange to obtain

$$\text{sign} \left(\frac{\partial\Pi^1}{\partial x_2} \frac{dx_2^*}{dK_1} \right) = \text{sign} \left(\frac{\partial\Pi^2}{\partial x_1} \frac{dx_1^*}{dK_1} \right) \times \text{sign} (R_2').$$

This shows that two relations determine the strategic effect, the sign of the strategic effect in the entry-deterrence case and the sign of the slope of firm 2's reaction curve. We can now distinguish four cases, depending on whether investment makes the incumbent tough or soft and on whether second-period actions are strategic substitutes or complements. It is important to remember that in all these cases, firm 1 tries to induce a softer behaviour by firm 2 through its investment strategy.

We have now the following taxonomy of business strategies regarding entry deterrence and accommodation, where A denotes accommodation of entry and D deterrence.

²⁵ See section 4.2 for further description of a reaction curve.

		Investment makes firm 1	
		Tough	Soft
Strategic complements ($R' > 0$)	A: Puppy Dog D: Top Dog	A: Fat Cat D: Lean and Hungry	
Strategic substitutes ($R' < 0$)	A and D: Top Dog	A and D: Lean and hungry	

Figure 3.2. Optimal business strategies.

Fudenberg and Tirole (1984) describe the different strategies where “[t]he fat-cat strategy is overinvestment that accommodates entry by committing the incumbent to play less aggressively post-entry. The lean and hungry strategy is underinvestment to be tougher. The top dog strategy is overinvestment to be tough; this is the familiar result of Spence and Dixit. Last, the puppy-dog strategy is underinvestment that accommodates entry by turning the incumbent into a small, friendly, nonaggressive puppy dog.” The colourful language of Fudenberg and Tirole needs some more explanation. It is perhaps easiest to see the intuitive in the top dog strategy. An example here is to build extra capacity to deter entry by looking tough and aggressive. A potential newcomer will observe this overinvestment and know that if he tries to enter, the incumbent can increase his production and flood the market, driving the price down.

The lean and hungry strategy is more diffuse. Why would an incumbent want to underinvest? The incumbent wants to look small and hungry to convince the newcomer that he is ready to fight hard over market shares and cut prices if necessary. Fudenberg and Tirole (1984) present an

example where it is optimal to underinvest in advertising. The incumbent wants to commit itself to an aggressive pricing policy if entry occurs. By underinvesting the incumbent serves fewer customers prior to entry, and will thus fight harder to sustain these customers if a newcomer enters.

The last two strategies describe situations where entry occurs. The fat cat strategy is overinvestment to become soft and thereby induce a newcomer be less aggressive post-entry. Once again we can use advertising to exemplify this strategy, as an incumbent that finds it optimal to accommodate entry should overinvest in advertising. By overinvesting the incumbent will serve a larger customer base prior to entry and thereby, by being contempt with a smaller market share, be less willing to fight hard post-entry. This induces the entrant to price less aggressively as well.

The puppy-dog ploy is underinvestment in order to make the incumbent firm appear friendlier to a new entrant. Gelman and Salop (1983) provide an example where the entrant is the puppy dog. By committing itself to a low investment strategy, the entrant projects a friendly image that is intended to spur a more accommodating strategy by the incumbent.

3.4 DETERMINANTS OF BARRIERS TO ENTRY

The last passage states that over- or underinvestment is the crucial way for the incumbent to deter or accommodate entry. This is however a very technical approach and I will therefore in this section describe more explicitly some strategic actions that could create barriers to entry.

One obvious observation is to invest in physical capital, for instance a plant or a chemical carrier. By investing in large capacity and sinking this investment, the incumbent can make a credible threat to increase production and diminish the potential entrant's profit. This is the case in Dixit's (1980)

model, which will be described in the next section. Higher investment in capital can also have economies of scale advantages. By investing in more capital, an incumbent can achieve a more efficient production facility and thereby making it more difficult for a newcomer to enter. The existence of a minimum efficient scale as a significant proportion of the market demand could lead to a market sustainable of only a few firms (Tirole, 1988).

Industries where “learning by doing” is important have often been seen as a way for an incumbent to deter entry. In this case the incumbent will pre-entry invest in skills that can be used in the second period to prevent entry. This is noted in Tirole (1988), where the experience acquired by an incumbent during the first stage of the game can reduce production costs in the second period, giving the established firm a cost advantage to deter newcomers. If the experience acquired today means that a firm can reduce its price tomorrow, entry will be difficult, as a newcomer will always lag behind in the race to cut costs and thus market price. The incumbent will here gain a technological leadership it can exploit. Lieberman & Montgomery (1988) note however that “*[i]t is now generally recognised that diffusion occurs rapidly in most industries, and learning-based advantages are less widespread than was commonly believed in the 1970s*”. Considering the ambiguous results from the empirical research it is questionable how important “learning by doing” is to deter entry.

Building up close relationships with customers can also be seen as a strategic investment to deter entry. If an incumbent can make an investment to establish a clientele it could increase the demand for its product. If the demand for the incumbent’s product is considerable, this could make the potential demand for the entrant so low that an entry would be unprofitable. Firms have recognised this in some markets where advertising is vital to the turnover of a product. By launching an advertising campaign they do not only make their product known, but also “pre-empt” demand (Tirole, 1988).

Customers become loyal to a product, making it difficult for a new firm to enter. This is not always the case, as we saw in the last section that overinvestment in advertising could encourage entry as the incumbent became a “fat cat”.

Establishing a clientele is related to switching costs, which also can produce a barrier to entry. When there exit switching costs, late entrants must invest extra resources to attract customers away from the incumbent firm (Lieberman & Montgomery, 1988). Lieberman and Montgomery (ibid.) note that switching costs typically enhance the value of a market share obtained early in a new market, thus making it rational to create switching costs in pursuit of market share.

Another barrier to entry is product differentiation. This implies that the incumbent chooses a “strategic place” in a geographical or product space to deter entry. The incumbent can often choose the most attractive niches and may be able to take strategic actions that limit the amount of space available for subsequent entrants (Lieberman & Montgomery, 1988). One has to think of the preemptable “space” broadly as mentioned above. A study of Wal-Mart²⁶ by Ghemawat is mentioned as a successful example in Lieberman and Montgomery (1988). According to the study Wal-Mart targeted small southern towns located in adjacent regions that competitors initially found unprofitable to service. By coupling spatial pre-emption at the retail level with an extremely efficient distribution network, the firm was able to defend its position and earn sustained high profits (ibid.). This could also be related to chemical shipping, as the major operators can be seen to pre-empt the niche of the sophisticated chemical segment. Eaton and Lipsey (1980) note that if capacity has a finite lifetime, the incumbent must renew it prematurely to avoid pre-emptive investment by an entrant that would eliminate the incumbent’s incentive to continue (Wilson, 1992). This model

²⁶ A discount retailing firm in the U.S.A.

will be presented in more detail in section 3.6. Lieberman and Montgomery (1988) also suggest that another pre-emption strategy can create a barrier to entry, as the incumbent firm can gain an advantage by pre-empting potential rivals in the acquisition of scarce assets.

3.5 CAPITAL COMMITMENT TO DETER ENTRY

In this section I will present a model that formally shows how capital commitment by an incumbent can deter entry. Dixit (1980) developed this model in a “classic” article, which is still important today.

In this model we have two firms as earlier, an incumbent and a potential entrant. The two players play a similar game to the one presented before in section 3.2. This time the extensive form of the game is divided into three stages²⁷. In the first stage the incumbent firm, referred to as firm 1 invests in capacity. This capacity is fully observed by the potential entrant, called firm 2. In stage two, after observing firm 1’s choice of capacity the potential entrant makes a decision to enter or not. If firm 2 decides to enter he has to set both capacity and output in stage three. In this stage the two firms engage in a standard Cournot competition. Thus the two firms make simultaneous quantity decisions. Firm 2 has to build a plant capacity equal to the quantity he wants to produce, but it is also possible for firm 1 to add to his capacity. If entry does not occur firm 1 remains a monopolist and sets quantum accordingly in the third stage of the game. The revenue for firm i is noted by $R_i(q_1, q_2)$ and has the following properties

$$\frac{\partial^2 R_i(q_1, q_2)}{\partial q_i^2} < 0, \frac{\partial^2 R_i(q_1, q_2)}{\partial q_i \partial q_j} < 0.$$

We see that the choice variables are strategic substitutes. This means that if firm 1 increases his output, it is optimal for firm 2 to lower his production and vice versa. It is further assumed that both firms have constant variable

²⁷ Dixit (1980) sets up a two-stage game, but I divide the last stage in two as I think this make the situation more comprehensible.

cost of output, constant unit cost of capacity expansion and a set up cost. Firm i's cost function per period is expressed as follows

$$C_i(q_i; k_i) = f_i + w_i q_i + r_i k_i,$$

where k_i is firm i's capacity, f_i is the fixed set-up cost, r_i the constant cost per unit of capacity and w_i the constant average variable cost for output. The capacity a firm invests is sunk and can not be reduced at a later stage. A firm needs one unit of capacity to produce one unit of quantity, which means that $q_i \in [0, k_i]$.

Initially suppose that firm 1 has installed capacity \bar{k}_1 . If the firm produces within the limit of its production capacity ($q_1 \leq \bar{k}_1$) total cost will be given by

$$C_1 = f_1 + w_1 q_1 + r_1 \bar{k}_1.$$

If the firm wants to produce more than \bar{k}_1 it has to increase its capacity, and the total cost function will become

$$C_1 = f_1 + (w_1 + r_1) q_1.$$

We can therefore observe that firm 1's marginal cost will be w_1 as long as it produces within \bar{k}_1 and $w_1 + r_1$ if it sets production above this level. The potential entrant does not have any prior commitment in capacity, thus its cost function for any positive production will be

$$C_2 = f_2 + (w_2 + r_2) q_2.$$

Firm 2's marginal cost will be $w_2 + r_2$. It is easy to see that firm 1's choice of \bar{k}_1 will affect its marginal cost curve and influence its reaction curve. Thus if the two firms interact the resulting Cournot competition will depend on \bar{k}_1 , and hence affect the profits of the two firms. Firm 2 will enter the market if it makes a positive profit and remain out if it does not. Firm 1 will choose the \bar{k}_1 that maximises total payoff given firm 2's optimal response. It will be assumed that this will always be positive, such that exit is never optimal for firm 1.

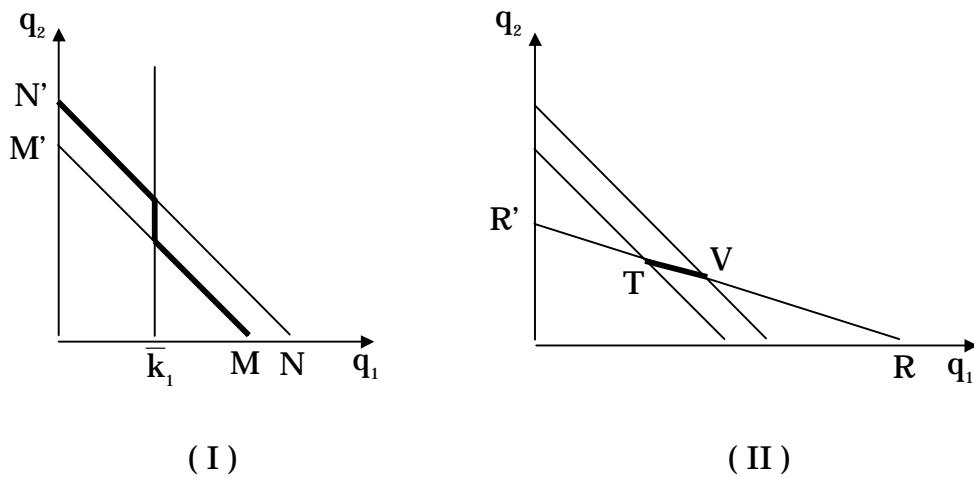


Figure 3.3: Typical reaction functions for firm 1 and 2.

By the assumptions of the profit functions, the firms' reaction functions are as illustrated in figure 3.3 above. In figure 3.3 (I) two reaction functions for the incumbent are drawn. The curve NN' represents the low marginal cost w_1 while the curve MM' is the case where firm 1 has high marginal costs, $w_1 + r_1$. The first curve is relevant when firm 1's production is lower or equal to \bar{k}_1 , and the latter otherwise. The incumbent's reaction function is thus given by the kinked curve shown in thick lines. The reaction function for the entrant is shown in (II). Let the points M and N have respective co-ordinates $(M_1, 0)$ and

$(N_1, 0)$. These two points are interpreted as the profit maximising quanta if firm 2 does not produce any output. The first point is the profit maximising point when the cost of increasing capacity is relevant, while the latter is profit maximising when this cost is not the case.

The reaction function for the potential entrant behaves more naturally. It is assumed that this reaction function, RR' crosses both NN' and MM' . Equilibrium is found where the reaction functions intersect. Since firm 1 can decide its first stage production capacity, \bar{k}_1 , the incumbent can to a certain degree influence the equilibrium of the game.

The point T is assumed to have the co-ordinates (T_1, T_2) and correspondingly the point V has the co-ordinates (V_1, V_2) . If $\bar{k}_1 \leq T_1$ it is clear that the Cournot equilibrium will be at point T . It will be optimal for the incumbent to increase his capacity to the point T_1 , if he has installed less than this in the first stage. Also, building a larger capacity than V_1 in the first stage is not a credible threat, as the entrant will know that the incumbent's best response here is V_1 . It follows that the established firm under no circumstance will set a higher capacity than V_1 , and that the optimal \bar{k}_1 can be found in the interval $[T_1, V_1]$. In this interval the incumbent firm can act as a quantity leader, which leads to the point that any capacity level within this interval is a credible output level for the incumbent following an entry. An incumbent monopolist will thus always set his pre-entry capacity within this interval and produce this quantity if the entrant decides to enter.

We would now like to find equilibrium in this game. As we have seen above, at all points that are ever going to be observed with or without entry, the incumbent will always produce an output equal its pre-entry chosen capacity. Thus, we can write the firms profit functions as

$$\pi_i(q_1, q_2) = R_i(q_1, q_2) - f_i - (w_i + r_i)q_i.$$

By assumption π_1 is positive, so we can solve the game by examining the sign of the entrant's profit, π_2 . This gives us three different cases to expand further.

Case 1: $\pi_2(T) < 0$. Here there exists no post-entry equilibrium where the potential entrant can make positive profit and will hence stay out of the market. The incumbent will here enjoy a monopoly situation and set capacity and quantum to M_1 . The incumbent will receive payoff equal to $\pi_1(M_1, 0)$.

Case 2: $\pi_2(V) > 0$. In this case firm 2 will always make positive profit by entering the market in any post-entry equilibrium. Since the incumbent can not deter entry, it will seek to optimise its best duopoly situation. If firm 1's iso-profit contour has a Stackelberg tangency to the left of V , that is the incumbent's best choice. There is a corner solution at V however if the tangency occurs to the right of V . Dixit (1980) comments that this could be thought of as a generalised Stackelberg leadership point.

Case 3: $\pi_2(T) \geq 0 \geq \pi_2(V)$. It is clear that there exists a point $B = (B_1, B_2)$ on the line segment between TV such that $\pi_2(B) = 0$. If $\bar{k}_1 > B_1$ then firm 2 will be deterred not being able to make positive profits post-entry. If $\bar{k}_1 < B_1$ firm 2 will make positive profit post-entry and will enter the market. Knowing that B_1 is the entry deterring level, firm 1 wants to know whether it is worth its while to prevent entry.

If $B_1 < M_1$, then the incumbent will deter entry by setting $\bar{k}_1 = M_1$. This will also be optimal, as setting M_1 is firm 1's best response if firm 2 sets his quantity equal to zero.

If $B_1 > M_1$, then the incumbent will not be able to deter entry by setting his pre-entry capacity equal to the monopolistic quantity. To be able to deter entry by firm 2 the incumbent must undertake the cost to increase his capacity further. This cost has to be measured against the payoff the incumbent receives from remaining a monopolist. The alternative is to play according to the optimal Stackelberg solution, which lies on the line segment

TV. Assume this Stackelberg solution is given by the point $S = (S_1, S_2)$. To determine the best choice for the incumbent we have to compare $\pi_1(S)$ against $\pi_1(B)$. If $\pi_1(S) < \pi_1(B_1, 0)$ it is optimal to prevent entry and set first stage capacity $\bar{k}_1 = B_1$. On the other hand, if $\pi_1(S) > \pi_1(B_1, 0)$ it is optimal to allow entry and set $\bar{k} = S_1$.

Following Dixit (1980) we can modify the model to include a Bertrand equilibrium in the post-entry game. He comments that some added complications can arise due to possible non-convexities even with reasonable demand and cost functions, but this will be ignored here and only the simplest case will be shown.

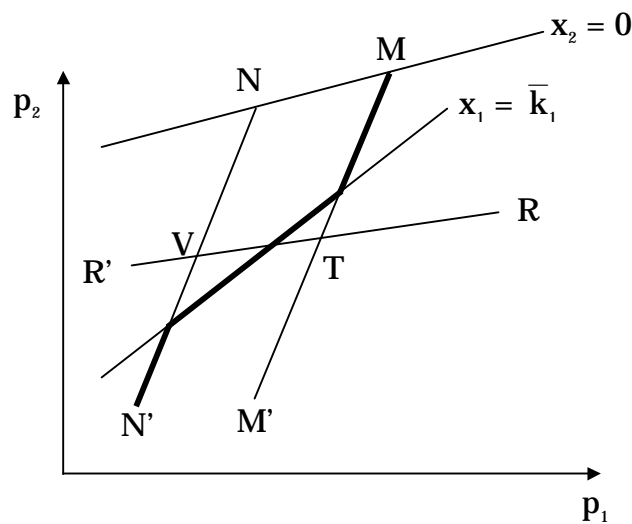


Figure 3.4 Bertrand Nash Equilibrium.

Once again RR' gives the potential entrant's reaction function. The incumbent has two reference curves, MM' and NN' , the former when expansion costs matter and the latter when they do not. The curve MM' is relevant when $x_1 > \bar{k}_1$ while the curve NN' holds when $x_1 \leq \bar{k}_1$, where x_1 is found from the demand function $D^1(p_1, p_2)$. The curve ' $x_1 = \bar{k}_1$ ' is shown for a particular k_1 , which gives the incumbent's reaction curve shown in thick

lines. In the post-entry Bertrand equilibrium firm 1 can secure any point along the segment TV of the potential entrant's reaction function. Dixit (1980) notes that "*[o]nce again, we observe a limited leadership possibility arise by virtue of the established firm's advantage in being the first to make a commitment to capacity*".

The main theme of this model is that an irrevocable commitment of investment can be a credible threat to deter entry from a newcomer. We observe that whichever post-entry game is played, the incumbent can influence the outcome by making a pre-commitment in capacity. Strategic investments can thus be used for the established firm to remain the sole player and earn monopoly profits. Worth noting is also that the incumbent can alter the conditions of the post-entry game to his advantage, even if it is optimal to let the newcomer enter.

The model I have presented here is equipped with the simplest scenario, one incumbent and one potential entrant. What happens when we allow for several incumbents facing potential entry from one entrant? When there are several incumbents, entry prevention can become a free rider problem as the established players have an incentive to "cheat" on the others and not participate in the costly action of overinvestment to deter entry. A formal model elaborating this will not be discussed here, but Gilbert and Vives (1986) show that although incumbent firms do not act co-operatively, underinvest in entry deterrence does not occur. They point out that incumbents may find themselves in a Pareto dominated arrangement (in terms of profit) by preventing entry. Another free rider problem can arise when several incumbents acting noncooperatively face multiple potential entrants. Eaton and Ware (1987), who look at a generalisation of Dixit (1980), find that this problem is not an important factor. This is however criticised by Waldman (1991). He shows that by changing Eaton and Ware's (1987) assumption of decreasing average capacity costs and allowing them to be

increasing, the free rider problem can become an important factor. Waldman (1991) argues that this leads to firms underinvesting in entry deterrence.

The strategic results of the capital commitment model rest on the assumption that only the incumbent firm bears sunk cost through installation of capacity. Ware (1984) notes that if installed capacity is sunk cost, which is must be for the incumbent to acquire any strategic advantage at all, then the entrant's capacity is equally sunk, and must also be committed before production. If this observation is correct, our first model should be extended to include another stage prior to the stage with post-entry Cournot competition²⁸. The final-period should therefore involve both firms incurring only variable costs, conditional on their sunken capacity. This reduces the strategic asymmetry for the incumbent, but he can still maintain a strategic advantage because he sinks his capacity first. Ware (1984) specifies a model where the incumbent commits his sunk cost first. If the entrant decides to enter, he will follow and install his capacity. Finally quantity equilibrium is established based on the sunken capacity of the two firms. The game can be solved backwards and a perfect equilibrium identified. Compared to Dixit (1980), Ware (1984) finds that the strategic advantage available to the incumbent is lessened as there is less inequality between the output and profits of the two firm compared to the results showed earlier. The qualitative results are however similar and do not alter the conclusions we made of entry deterrence. But Ware (1984) notes that accommodation is a less likely outcome in the four-stage model if entry deterrence is feasible. This is because profits post-entry are lower in this model for the incumbent, whereas profits under entry deterrence are unchanged.

²⁸ Ware presents a three-stage game in contrast to Dixit's two-stage game. Following my previous notes I will see this as four-stage game.

3.6 DURABILITY OF CAPITAL AS A BARRIER TO ENTRY

The commitment value of capital as a barrier to entry can depend on the extent to which the capital is sunk. In this section I will present a model where capital is sunk only on a short-term basis. Eaton and Lipsey (1980) presented this idea in two models, examining how the durability of capital can influence entry deterrence. I will focus on the second model (“maintaining plant”) but briefly sum up the findings from the first (“one-hoss shay capital”). In the first model capital is sunk only in the short run and must be “renewed” periodically. There is room for only one firm in this market, which will be the equilibrium. The basic idea is that strategic renewal of capital will deter potential entrants from taking over the incumbent’s position. There exists a capital element, for instance a chemical carrier and only one unit of capital is necessary to supply the market demand. The incumbent in this market has a carrier of some durability. If the incumbent does not replace this carrier before it expires, it will for certain be profitable for an entrant to enter with a new carrier just before the monopolist replaces his. Eaton and Lipsey (1980) show that the incumbent resolves this by replacing his carrier before the old one expires, at such a time that an entrant will not find it profitable to enter.

In the second model the capital requires maintenance affecting the incumbent’s choice of maintenance level. Once again we think of capital as a chemical carrier to pep up the presentation. I assume capital costs K , where $K > 0$, and that maintenance costs, m , are a convex function of age of plant, a :

$$m = g(a), \quad g'(a) > 0, \quad g''(a) \geq 0.$$

There are three different costs in this model. First of all there is a sunk cost from the investment in capital. Then there is marginal cost of production and finally the costs of maintaining the carrier, which are invariant with respect to output and avoidable only by not having any production. The discounted present cost of a new plant over a service life of S is given by

$$C(S) = K + \int_0^S g(a) e^{-ra} da .$$

The restrictions on $g(a)$ imply that $C'(S) > 0$ and $C''(S) > 0$. Let R_1 denote the rate of flow of revenues over variable costs when one firm serves the market. R_2 is the rate of flows of revenues over variable costs for either firm when two firms serve the market. It is assumed that R_1 and R_2 are time invariant and deterministic. The duopoly resolution is not joint profit maximising as we assume that $R_1 > 2R_2 > 0$.

We define S to be the policy of replacing the carrier every S periods. The present value to a monopolist of this policy is

$$V(S) = \frac{R_1}{r} - \frac{C(S)}{1 - e^{-rS}} .$$

According to Eaton and Lipsey (1980) it can be easily verified that $V(S)$ is pseudoconcave²⁹ in S . $V(S)$ decreases without bound as S goes to zero and as S goes to infinity, generating a unique maximum. Let \bar{S} be the value of S that maximises $V(S)$.

Eaton and Lipsey (1980) argue that, in the event of entry, the incumbent would stay in the market until his maintenance cost rose to R_2 . They argue that if $g(a)$ were less than R_2 , and if the monopolist paid $g(a)$,

²⁹ Pseudoconcavity of $V(S)$ requires that when $V'(S)=0$, $V''(S)<0$.

then he and the entrant would face identical avoidable costs, the resolution of the duopoly problem would be symmetric, and the monopolist would enjoy the flow R_2 ; therefore the incumbent will incur the maintenance costs if and only if $g(a) \leq R_2$. Alternatively, in the event of entry the incumbent could sign a binding maintenance contract with a third party, his avoidable costs would then be just the marginal cost of production. An optimal maintenance contract would run until $g(a) = R_2$.

We let A be the age of the carrier such that $g(A) = R_2$. If the incumbent chooses a policy $S \leq A$, his minimum commitment to the market is $A - S$. If he chooses $S > A$, his minimum commitment to the market is zero. Eaton and Lipsey (ibid.) go on to seek the existence of a policy S^* which solves

$$\text{subject to } \left. \begin{array}{l} \max_S V(S) \\ E(S, S^*) \leq 0, \end{array} \right\} \quad (1)$$

where

$$E(S, S^*) = \begin{cases} V(S^*) - (R_1 - R_2) \int_0^{A-S} e^{-rt} dt, & \text{if } S \leq A, \\ V(S^*), & \text{if } S > A. \end{cases} \quad (2)$$

$E(S, S^*)$ is interpreted as the present value of an entrant pursuing policy S^* when the monopolist's policy is S .

Eaton and Lipsey (1980) discuss several cases and first draw attention to the case where the incumbent adopts a policy \bar{S} . From (2) it is clear that if A is large enough relative to \bar{S} , the incumbent need not pursue an active policy of entry prevention. We let \bar{A} be the value of A in (2) such that $E(\bar{S}, \bar{S}) = 0$. Then, if $A \geq \bar{A}$, $S^* = \bar{S}$, and entry prevention is without costs.

In the next case we denote S_1 and S_2 the minimum and maximum values of S such that $V(S) = 0$. Pseudoconcavity of $V(S)$ then implies that

$V(S) > 0$ in the open interval (S_1, S_2) and $V(S) < 0$ for $S < S_1$ and for $S > S_2$. When $A \leq S_1$, the constraint in (1) cannot be satisfied in the profitable range of production. Thus $S^* = S_1$ and $S^* = S_2$ are the only solutions to the problem posed in (1) and $V(S^*) = 0$. In this case it is clear that the use of prepaid maintenance contract to deter entry is the preferred strategy (ibid.).

Finally, and for us most relevant, is the case when $S_1 < A < \bar{A}$. $E(S_1, S_1) < 0$, since $S_1 < A$, and $E(\bar{S}, \bar{S}) > 0$, since $A < \bar{A}$. Both $V(S)$ and $E(S, S^*)$ are increasing in S when $S_1 < S < \bar{S}$, and thus S^* must satisfy $E(S, S^*) = 0$. Since $E(S, S)$ is increasing in S in this interval, there exists a unique S^* , $S_1 < S^* < \bar{S}$ such that $E(S^*, S^*) = 0$. It can be shown that S^* is the unique entry preventing policy, which maximises the incumbent's present value evaluated at any point in time. Since $S^* < \bar{S}$, the carrier is replaced before its economically useful life is over. We have seen here that when an active policy of entry deterrence is necessary, the incumbent has two options, both of which require the replacement of capital before its economically useful life is over. This could also be interpreted as "too well maintained" capital as Eaton and Lipsey (1980) note. This means that the incumbent uses more resources on capital maintenance than is actually necessary if he were cost minimising. The extra resources used to maintain the carrier are thus to deter potential entrants.

In this model greater durability implies greater strategic advantage to incumbent firms, so that firms will choose capital that is "too durable," maintain it "too well," or replace it "too soon." Davies (1991) shows in contrasts that even though a very brief commitment to capital conveys no strategic advantage to incumbency, if the commitment is large relative to short-term profits, it allows the lower-cost firm to deter entry and earn monopoly profits. The consequence is that neither incumbency nor the order of moves has any affect on a firm's ability to deter entry, and according to Davies (1991) there exist several equilibria when costs are symmetric. She

finds, however, that a small cost advantage gives rise to a unique equilibrium: the lower-cost firm deters entry and charges the monopoly price.

CHAPTER FOUR

TACIT COLLUSION

Chemicals shipping is dominated by four companies, which to a different extent provide global tanker services. As described in chapter two, the leading operators compete on several distinct geographical routes, sometimes along other smaller operators. When few firms compete in one or several distinct markets this could influence market behaviour, as players obviously would benefit from “softer” competition. This can be achieved through tacit collusion, where the players can increase their profits without explicit communication. I will again take a normative approach and derive optimal behaviour for firms in the described setting. It will be shown that tacit collusion can be sustained when players meet repeatedly in one market and that multimarket contact can enhance the sustainability of tacit collusion.

4.1 TACIT COLLUSION

Firms in a market would like to collude as it gives them an opportunity to manipulate the market price and thereby increase their profits. Rees (1993)

splits the concept of collusion into two elements. First there is a process of communication. Here information is exchanged and discussed with the aim of reaching an agreement. The second element consists of a mechanism to punish any violation of the agreement to secure its enforcement. In most cases however explicit collusion is illegal, excluding legally binding agreements. But this can be overcome if the players can sustain tacit collusion. Is it possible that firms could co-ordinate their activities without explicit communication and discussion? Rees (1993) gives a simple example of a market where it tacitly has become practise to match the price changes of the largest firm. This makes collusion difficult to disclose, as long as it is more profitable for a firm to continue this practise than to defect.

Rees (1993) discusses shortly if one can ever talk of tacit collusion. Could it not be that a case that appears to be tacit collusion in reality is explicit collusion in which the process of agreement is simply concealed? His main point³⁰ is that hindering “innocent” business meetings, even if they end up in connivance to restrict competition is almost impossible. I will leave this digression here and refer to this behaviour as tacit collusion in the further discussion.

One of major problems with collusion is that there exists an incentive to renege on an agreement. I will review this problem in a one-shot game, which will show that collusion is not sustainable if competitors meet only once in the market. This conclusion can be extended to a finitely repeated game. To simplify the analytical framework, I assume the usual Cournot model with two rivalling firms setting quantity as their strategic variable. This is consistent with chapter three where the incumbent and the potential entrant engaged in quantity competition post-entry. Kreps and Scheinkman (1983) showed that a game where firms build capacity in the first period and then set price in the second, under specific circumstances was equivalent to a

³⁰ Rees is here referring to a famous statement by Adam Smith.

one-stage quantity game. Cournot developed this model in 1838, but the analytical description in the next section will be based on Gibbons (1992) and Tirole (1988).

After reviewing the one-shot game I turn to the theory of infinitely repeated games to show how tacit collusion can be sustained. We will continue to study the Cournot quantity game, but replicate it an infinitely number of times. These repeated games are often called *supergames*. The main difference from the one-shot game is that credible threats about a player's future behaviour can be made in this setting, which will influence his current behaviour.

4.2 ONE SHOT GAME: COURNOT-NASH EQUILIBRIUM

We have two firms producing an identical product. Let their produced quantity be noted q_1 and q_2 respectively. The market-clearing price is given by the function $P(Q)$, where Q is total quantity produced (q_1+q_2). It is further assumed that the firms have identical cost structure. Both firms maximise their profit function given the quantity of the other

$$\max_{q_i} \Pi_i = P(Q) \cdot q_i - C_i(q_i).$$

The strategic edge here is of course that the firms have to choose their respective output without observing the other's choice, i.e. they choose their quantities simultaneously. Assuming that the profit function is strictly concave in q_i and twice differentiable, we get the first order condition:

$$\frac{\partial \Pi_i}{\partial q_i} = P(Q) + \frac{\partial P}{\partial q_i} \cdot q_i - \frac{\partial C_i}{\partial q_i} = 0.$$

We can solve this for q_i and get firm i 's reaction curve:

$$q_i = R_i(q_j).$$

The reaction curve gives the optimal quantity produced for a fixed quantity of the rival firm. It depicts how a firm will react given various beliefs it might have about the other firm's choice. If we depict the two firms' reaction curves we find the Cournot-Nash equilibrium as shown in figure 4.1 below.

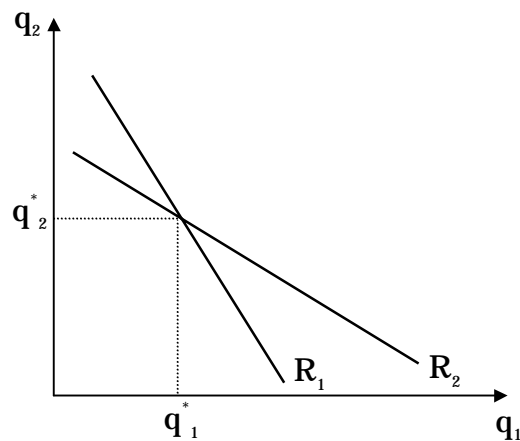


Figure 4.1

It is assumed that the system is stable, so that equilibrium is given by q_1^* and q_2^* . We see that the reaction curve has a negative slope, indicating that if the rival firm increases its production, it is optimal for the other firm to lower its own production; i.e. the choice variables are strategic substitutes. Problems arise because there exists a negative externality between the firms. When choosing his output, firm i will take into account the adverse effect of the market-price change on its own output, rather than the effect on aggregate output (Tirole, 1988). This leads to each firm choosing an output

that exceeds the optimal output from the industry's point of view. As Tirole (1988) remarks "[] the market price will be lower than the monopoly price, and the aggregate profit will be lower than the monopoly profit". One can also note that this equilibrium does not equalise marginal cost, such that not only is too little produced, but the industry's cost of production is not minimised.

It is clear that if they could, the two firms involved would want to operate as a cartel, gaining each $\frac{1}{2}$ of the monopoly profits. Why don't they? The problem is the lack of credible punishments if one of the players should deviate. A legally binding agreement to co-operate is usually prohibited thus making open collusion impossible. The only way to increase their profits is to enter a secret or tacit agreement. What would happen if they tried to enter a tacit "understanding"? We can think of this as a game where the duopolists have reached a secret agreement and are about to meet in the market. They have two strategies, act according to the agreement³¹ or defect and play according to their reaction curve. We can illustrate this game on normal form with the players' pure strategies.

		Firm 2	
		Collude	Defect
Firm 1	Collude	Π^3, Π^3	Π^1, Π^4
	Defect	Π^4, Π^1	Π^2, Π^2

Figure 4.2

³¹ This is of course to play the monopoly quantity divided by two.

To solve this game we look for the Nash equilibrium. The payoff for each player is to be interpreted in the following way. Π^4 is the highest payoff and is received when your rival co-operates and you defect. Your rival then receives Π^1 , which is the lowest payoff possible. Π^3 is the second highest payoff and is the payoff both players obtain when they act as a cartel, thus receiving $\frac{1}{2}$ of the monopoly profits. Π^2 is the second lowest payoff and will naturally be the profit a player earns in a Cournot equilibrium. This is a version of the “classic” Prisoners’ Dilemma game (Gibbons, 1992) and the solution is easy to elaborate. The strategy “Collude” is strictly dominated for each player by “Defect”, thus leading to the sub-optimal outcome “Defect, Defect” as the Nash equilibrium. Since both players have an incentive to defect a collusive agreement is not possible. This argument can easily be extended to a game over a finite number of periods (Gibbons, 1992).

4.3 TACIT COLLUSION IN AN INFINITELY REPEATED GAME

We start with the same simple setting as in the last section, a two-player³² game with Cournot competition. But we now assume that the two players meet an infinitely number of times in the market. To find equilibrium we need each player to have a strategy set based on the player’s information in period t . The strategy set gives quantity in each period as a function of the player’s information. We assume that all past quantities and prices are common knowledge among the two players. The payoff for player i is the sum of the discounted single-period profits

³² The result can easily be extended to an n -player game.

$$\sum_{t=1}^{\infty} \delta^{t-1} \pi_i(q_i^t, q_j^t).$$

δ is the discount factor each period³³, while q_1 and q_2 give the quantity produced in period t by the two players. We further assume that the firms produce homogenous products hence the profit function is

$$\pi_i(q_i^t, q_j^t) \equiv P(q_1^t + q_2^t) \cdot q_i^t - C(q_i^t).$$

To solve this game and find a Nash-equilibrium that is also a subgame perfect equilibrium we have to make some assumptions about the simple stage game outcomes. Let q^s note the static Nash equilibrium quantity, which can be mathematically defined as:

$$q^s \in \arg \max \pi(q, q_i^s).$$

Furthermore let q^m represent the joint profit-maximising defined by:

$$q^m \in \arg \max \pi(q, q_i).$$

We now have to define a strategy for the players in this game. It is assumed that the players play according to the following grim trigger strategy. In the first period they both play a quantity q^0 , where q^0 is defined as

$$q^0 \in [q^m, q^s)$$

In the rest of the game the players set quantity in each period to

³³ $\delta_i \in (0, 1)$.

$$q^0 \text{ if } q_j^\tau = q^0 \forall \tau \leq t-1, \forall j \text{ or}$$

$$q_i^s \text{ otherwise; } t \geq 2, i = 1, 2,$$

where τ represents the previously played stages in the game. The following definitions are made of the firms profit functions:

$$\pi(q) \equiv P(q_1 + q_2)q - C(q)$$

$$\pi^*(q) \equiv P(\varphi_i(q_j) + q_j)\varphi(q_j) - C(\varphi(q_j)) \text{ where}$$

$$\varphi(q_j) \in \arg \max \pi_i(q_i^t, q_j^t).$$

The second definition maximises player i 's current profit by playing best response when the other player produces q . We set up the following necessary and sufficient conditions for this strategy to be a subgame perfect equilibrium. First we consider period 1 or a period t history such that $q_j^\tau = q^0 \forall \tau \leq t-1, \forall j$. For this to be a subgame perfect equilibrium we require that

$$\frac{\pi(q^0)}{1-\delta_i} \geq \pi^*(q^0) + \frac{\delta_i \pi(q^s)}{1-\delta_i} \forall q$$

or

$$\delta_i \geq \frac{\pi^*(q^0) - \pi(q^0)}{\pi^*(q^0) - \pi(q^s)}.$$

Second we consider a history such that $q_j^\tau \neq q^0$ for some $\tau \leq t-1$ and for some j

$$\frac{\pi(q^s)}{1-\delta_i} \geq \pi(q, q_j^s) + \frac{\delta_i \pi(q^s)}{1-\delta_i} \forall q.$$

This strategy profile is a subgame perfect equilibrium if:

$$\delta_i \geq \frac{\pi(q, q_j^s) - \pi(q^s)}{\pi(q, q_j^s) - \pi(q^s)} \forall i = 1, 2.$$

We can observe here that a tacit collusion is self-enforcing if δ is close to one. This means that if these conditions are met, a cartel can be sustainable without the need of direct communication. Critics of this model have pointed to the fact that the grim trigger strategy is not renegotiation-proof. This means that once one of the parties has defected they both have an incentive to sit down and negotiate a new deal. Abreu (1986) showed that there existed more severe punishments to deter defection, but this will not be elaborated further in this thesis.

4.4 MULTIMARKET CONTACT

In chapter two it was noted that the chemical companies competed on several distinct geographical markets, which could be compared to the airline industry as airlines normally compete on several different destinations. The influence multimarket contact could have on market competition was first presented by Corwin Edwards, who eloquently stated that “*[w]hen one large conglomerate enterprise competes with another, the two are likely to encounter each other in a considerable number of markets. The multiplicity of their contact may blunt the edge of their competition*”. (Corwin Edwards quoted in Bernheim and Whinston (1990)) Although Edwards was thinking of conglomerates, this also applies to “single-product” firms that operate in a number of distinct geographical markets. Edwards’ statement seems like a plausible observation, but we need a more formal understanding of how

multimarket contact affects competition. I will present a model by Bernheim and Whinston (1990), who were some of the first to explore multimarket contact in a theoretical model. This will show how firms can take advantage of multimarket contact and enhance their ability to sustain non-competitive outcomes. Relating it to the previous sections, multimarket contact can thus make tacit collusion easier to sustain.

We have previously looked at quantity competition and the Cournot equilibrium. In this setting however, we examine competition between established players and will simplify this to a game of price competition. This means that we take their quantities for given and concentrate on the second stage game where competitors set prices. This introduces a simple model of multimarket contact with repeated (Bertrand³⁴) price competition.

It is easy to see that multimarket contact cannot reduce firms' abilities to collude when markets are not inherently linked. Since firms can always treat each market in isolation the set of subgame perfect equilibria cannot be reduced by the introduction of multimarket contact. The basic idea is that multimarket contact makes collusive outcomes easier to sustain because there is more scope for punishing deviation in one market. We start by showing what Bernheim and Whinston (1990) call the irrelevance result.

We assume N firms with differentiated products. Let P_i^* denote price set by firm i in the static Bertrand equilibrium. P_i' gives the price firm i sets according to a cartel agreement. Let δ be the discount factor and $R_i(P_{-i}')$ be firm i's reaction curve if all other firms set price equal to P' . If there exists only one market, a cartel will be sustainable if

$$\pi_i' \frac{1}{1-\delta} \geq \pi_i(R_i(P_{-i}'), P_{-i}') + \pi_i^* \frac{\delta}{1-\delta}. \quad (1)$$

³⁴ When firms are identical the static Bertrand equilibrium is distinguished by price equal to marginal cost. For a short introduction to the Bertrand-game, see for instance Tirole (1988).

Let P_i' be the minimum of $\{P_i^m, P_i^+\}$, where P_i^m is the monopoly price and P_i^+ is the highest price where (1) is valid. We can say that the price P_i' is a function of the monopoly price and the discount factor.

We now expand this model and assume that all N firms operate in K markets. Each firm follows a simple grim trigger strategy. This means that if one firm deviate in one market, labelled k it will be followed by punishment in all K markets³⁵. The condition for sustainable cartel equilibrium is thus given by

$$\sum_{k=1}^K \pi_{ik}' \frac{1}{1-\delta_k} \geq \sum_{k=1}^K \left\{ \pi_{ik}(R_{ik}(P_{-ik}', P_{-ik}')) + \pi_{ik}^* \frac{\delta_k}{1-\delta_k} \right\} \quad (2)$$

We assume further that all firms have the same technology, that all markets are identical and that the discount factor is the same for all markets. Then (2) can be transformed to

$$K \cdot \left[\pi_i' \frac{1}{1-\delta} \right] \geq K \cdot \left[\pi_i(R_i(P_{-i}', P_{-i}')) \right] + K \cdot \left[\pi_i^* \frac{\delta}{1-\delta} \right]. \quad (3)$$

As shown in (3) and in Bernheim and Whinston (1990), both gain and loss from deviation can be multiplied with the total number of markets in which the firms compete. This means that multimarket contact has no relevance for sustaining a cartel. Bernheim and Whinston call this the irrelevance result. In this simple model multimarket contact does not facilitate collusive behaviour. If the discount factor is too low it is impossible to sustain collusion in any markets. If the discount factor is sufficiently close to one tacit collusion is sustainable even without multimarket contact. It is important to note the

³⁵ The punishment is playing the static Bertrand equilibrium.

three central assumptions this result rests on; i) markets are identical; ii) firms are identical; iii) technology is constant.

By relaxing the first assumption and analysing a situation where markets are not identical, I will show that conglomerates can increase their profits due to multimarket contact. We now assume that we have a situation where there exist two markets, denoted A and B. Market A is a duopoly, while market B consists of $N > 2$ competitors. Bernheim and Whinston (1990) show that if there are N identical firms, collusion is sustainable in a stationary symmetric-payoff equilibrium if and only if

$$N \leq \frac{1}{1-\delta}. \quad (4)$$

We can then make the following assumptions to focus on the interesting case.

Assumption 1. $2(1 - \delta) < 1$.

Assumption 2. $N(1 - \delta) > 1$.

Assumption 3. $(N - 2)(1 - \delta) < 1$.

The first assumption implies that tacit collusion can be sustained in market A. Assumption 2 implies that, in the absence of multimarket contact, the only outcome in the N -firm market, B, involves pricing at cost.³⁶ The last assumption implies that if market B had only $(N - 2)$ firms, then complete collusion would be sustainable.

We now let each of the market A duopolists own a market B firm, establishing a multimarket connection between these companies. Suppose that price in market A is $p_A > c$, which yields aggregate profits in market A of $\Pi_A = (P_A - c)Q(P_A)$. By assumption 1, the incentive constraint for each of the

³⁶ This is due to the equilibrium outcome of the static Bertrand price game.

multimarket firms in market A is not binding. This gives us that the net gain of deviating for each conglomerate is

$$\Pi_A \left[1 - \frac{1}{2} \left(\frac{1}{1-\delta} \right) \right] < 0. \quad (5)$$

The multimarket firms can potentially use this slack enforcement power to induce a partially or completely collusive outcome in market B. Bernheim and Whinston (1990) show how this outcome can occur. Each multimarket firm sets output so that the market share of market B is less than $(1 / N)$. This leaves the firms operating in market B only, with a greater share of the market. A single firm, i , with market share λ_i will not undercut a price $p_B \in (c, p^m]$ if and only if

$$(p_B - c)Q(p_B) \leq \left(\frac{1}{1-\delta} \right) \lambda_i (p_B - c)Q(p_B), \quad (6)$$

or

$$\lambda_i \geq (1-\delta). \quad (7)$$

We see that if the market share of the single-market firms is at least $(1 - \delta)$, they will not undercut a collusive arrangement.

But this strategy violates the market B incentive constraint for each of the multimarket companies. Suppose that the price in market B is p_B , then if the multimarket companies each have a market share of λ_c the net gain from deviating in market B (considered in isolation) is

$$\Pi_B \left[1 - \lambda_c \left(\frac{1}{1-\delta} \right) \right], \quad (8)$$

where $\Pi_B = (p_B - c)Q(p_B)$ is the aggregate profit level in market B. Bernheim and Whinston (1990) state that the preceding discussion implies that $\lambda_c \leq [1 - (N - 2)(1 - \delta)]$ so (8) is strictly positive. However, as long as the sum of expressions in (5) and (8) is nonpositive, neither of the multimarket firms will deviate. Multimarket contact thus allows these companies to transfer the ability to collude from market A to market B by pooling their incentive constraints across markets.

Bernheim and Whinston (1990) extend this discussion to other factors that may cause firms to attach more weight to future outcomes in some markets than in others. I will develop one of these factors in detail and investigate how multimarket contact can influence competition when demand fluctuates from period to period within each market.

As before we have two firms, 1 and 2, operating simultaneously in two markets, A and B. All previous assumptions about market demand and production cost are maintained, but we now distinguish between two demand states, denoted h (high) and l (low). Market demand is denoted by $Q^s(\square)$ for either market in state $s = h, l$. We assume that $Q^h(p) > Q^l(p)$ for all $p \geq 0$. It is further assumed that the realisations of these states are independent across periods, and for illustrative purposes we assume perfect negative correlation between the demand shocks in these two markets. Thus, with probability .5, market A is in state h and market B is in state l, while with probability .5 the reverse is true. If a firm deviates, the optimal punishment in this model is reversion to the static Bertrand solution in every period in every state, in which the players will receive net discounted profits of zero. Bernheim and Whinston (1990) show that we can restrict ourselves to an equilibrium characterised by two prices, p_h and p_l . Both firms set prices equal to p_l in the low demand market and equal to p_h in the high demand market. Let π_s denote the corresponding profits for each firm in the market for which realisation is s. In the multimarket setting by undercutting his opponent, either firm can

temporarily capture all the business in both markets, earning profits that are arbitrarily close to $2(\pi_l + \pi_h)$. Thus, each firm's incentive constraint is

$$\frac{\delta}{1-\delta} [\pi_l + \pi_h] \geq \pi_l + \pi_h,$$

or $\delta \geq 1/2$. As long as this condition is satisfied, the firms can jointly achieve monopoly profits in both markets. When $\delta < 1/2$, no price above cost is feasible.

To measure the gains from multimarket contact, we have to consider the opportunities for co-operation in a single market, assuming that there are no multimarket firms. Following Bernheim and Whinston (1990) we can find an equilibrium characterised by two prices, p_h and p_l , where p_s denotes the price quoted by both firms in state s . Again, letting π_s be the associated level of profits for each firm, incentive compatibility requires that

$$\frac{\delta}{1-\delta} \left[\frac{\pi_h}{2} + \frac{\pi_l}{2} \right] \geq \max \{ \pi_h, \pi_l \}.$$

For $\delta < 1/2$, the only nonnegative solution to this inequality is $\pi_l = \pi_h = 0$. For $\delta \geq 1/2$, the most collusive outcome yields

$$\pi_l = \pi_l^m$$

and

$$\pi_h = \min \left\{ \left[\frac{1-\delta}{2-3\delta} \right] \pi_l^m, \pi_h^m \right\},$$

where $2 \pi_s^m$ is the aggregate monopoly profit in state s . Thus, in the single-market setting, firms can sustain full co-operation in both states only when $\delta \geq \delta^*$, where

$$\delta^* = \left[\frac{2\pi_h^m - \pi_l^m}{3\pi_h^m - \pi_l^m} \right] > \frac{1}{2}.$$

We see that for $\frac{1}{2} \leq \delta < \delta^*$, multimarket contact increases the ability to sustain collusive outcomes.

Although the theoretical literature is scarce, there have been some empirical studies of multimarket contact and the impact this can have on market competition. The airline industry has for instance received attention from researchers of multimarket effects. Evans and Kessides (1994) examine multimarket contact in the U.S. airline industry. They remark that the airline industry seems to be an ideal candidate for testing multimarket effects for three reasons. First, the market seems to obey most conditions outlined in Bernheim and Whinston (1990) giving rise to collusive gains from multimarket contact. Second, it has clearly identified regional markets and finally precise measure of performance is available through airline fares. Evans and Kessides (1994) analyse airline fares in the 1000 largest U.S. city-pair routes and this reveals the presence of statistically significant and quantitatively important multimarket effects: fares are higher in city-pair routes served by carriers with extensive interroute contacts.

Fernández and Marín (1998) examine the effects of multimarket contact on pricing in the Spanish hotel industry. They find relevant strategic multimarket effects supporting the theoretical research of Bernheim and Whinston (1990). In particular, in the presence of multimarket contact, prices are higher in markets where it is difficult to collude and lower in markets where collusion is easier to achieve.

CHAPTER FIVE

CONCLUDING REMARKS

In chapter three and four I have given theoretical predictions of optimal behaviour when markets are distinguished by entry barriers and concentration. We saw how an incumbent firm or several incumbents could deter entry from a newcomer, or how they could induce optimal entry through accommodation strategies. It was also shown that established firms in a concentrated market could increase their profits through tacit collusion and that multimarket contact could make this collusion more sustainable, even if one of the markets was characterised by hard competition. But how do these theoretical models fit the chemicals shipping market? In this chapter I will compare these theoretical predictions with observed behaviour from chemicals shipping. My aim is as outlined in chapter one to confront factual behaviour with theoretical predictions to gain insight in the underlying mechanisms that are active in this market.

First, one should note that it is difficult to draw any clear and distinct conclusions from the observations we see in chemicals shipping. The market is complex and with lack of testable data econometric models are not of much help. Another problem is that different sources do not seem to be consistent

with their analyses of this market. This is a bit confusing and leaves some questions concerning strategic aspects of chemicals shipping inadequately answered.

Second, whereas the empirical observations can be influenced by a set of different factors, the theoretical models are stylised and normally focus on one specific factor to explain observed behaviour. Bearing this in mind I will try to avoid overestimating a factor's significance when analysing chemicals shipping.

There are certainly entry barriers in this market, but they are not absolute. According to Richardson Lawrie Associates several newcomers have tried to enter the market in recent years. Some have managed to stay, while others have failed. Can we then draw the conclusion that the major players have acted strategically to make these entry-attempts fail, and how can we explain the successful entries? The major players quite understandably do not openly admit that they act strategically to deter potential entrants, but this does not exclude the possibility that they actually do. Although there have been some successful entries, the fact remains that the same few firms dominate the market. Thus it seems plausible that the incumbents have taken some actions to hinder a new firm becoming a major player.

We saw earlier that the game described in chapter three was distinguished by strategic substitutes when we had quantity competition. According to Fudenberg and Tirole's (1984) taxonomy this called for a top dog strategy if investment made the incumbent firm tough. The top dog strategy prescribes overinvestment to deter entry by looking tough and aggressive, which is consistent with both Dixit (1980) and Eaton and Lipsey (1980). We should also bear in mind that even if the incumbent finds it optimal to accommodate entry, the suggested strategy is still to be a top dog. This is in accordance with the facts we observe in chemicals shipping. Irrespective of whether the incumbents have tried to deter entry or seek an optimal

accommodation strategy, they have invested significantly in new capacity. According to Chemical Week (1996) the major operators started to take delivery in big, expensive vessels in the last half of the 1990s. Both Stolt-Nielsen and Odfjell initiated new-building programmes of almost \$1 billion. The third largest operator, JO Tankers also started an expansion program without any plans to scrap ships simultaneously. Chemical Week (ibid.) explains this expansion program as a result of a long “bear” market for the operators through most of the late 1980s and early 1990s. When business conditions improved in the middle of the 1990s, it moved up sharply catching the carriers short of capacity. This is not inconsistent with Dixit’s (1980) model. Even if the newbuilding programmes were driven by market demand, we can still notice that the major operators seemed to be among the first to invest in new capacity when the market recovered. By investing, and probably overinvesting in new capacity, the incumbents could deter newcomers from entry and smaller established firms from seeking a larger share of the parcel tanker business.

There is another advantage of being first to place orders. The parcel tankers are complex to build and this restricts the number of yards capable of undertaking such an assignment. Hans Petter Amundsen of Odfjell predicted that only some specified yards in Poland, Spain, Norway and South Korea would remain competent to build parcel tankers in the next decade. By taking up shipyard capacity, the incumbents can limit the number of orders other operators can place for new vessels.

But do we observe overinvestment in the chemical carriers market? Unfortunately the market structure makes it problematic to unfold this question. The large amount of different chemical packages being freighted on liner services leaves much unanswered when it comes to capacity. This makes it hard to measure how much excess capacity a company has available from the existing data. Drewry (1999) has tried to estimate the total demand for

chemical carriers. The accuracy of this estimate is difficult to validate, but it should give us some tendencies of investment in chemicals shipping. Their research shows the relationship between total chemicals trade, tonne-mile demand and the consequent demand. They have included the aggregate supply assessment and the overall market balance to 2005 (Drewry, 1999). This research includes details of the anticipated development of the chemical carrier fleet including forecast deletions and deliveries to 2005. The surplus of capacity in relation to total fleet declined from 1993 to 1995. It has increased steadily since, from 5% in 1995 to almost 20% today. Drewry (ibid.) predicts that the trend after this will be reversed, bringing the surplus down. There thus seems to have been a trend in the last years of a large surplus of chemical carrier capacity. One can not identify the major operators in this statistic, making it impossible to derive if they overinvested in relation to their market share. But clearly, as mentioned above, they all expanded their fleets heavily after 1995, so it seems plausible that the leading operators accounted for some of this surplus.

The model by Eaton and Lipsey (1980) suggested that an incumbent could overinvest in maintenance to deter entry by a newcomer. A chemical carrier is a specialised ship that needs a high degree of maintenance. International safety codes and environmental regulations, which are very strict for chemicals shipping, are some of the factors creating this situation. But can we find any indication of “too much” maintenance in chemicals shipping, as proposed by Eaton and Lipsey (1980)? This would mean that the incurred maintenance costs would be higher than if the firm were cost minimising these activities. Once again it is difficult to draw any clear conclusions, as it is hard to clarify what we are searching for. What does cost minimising maintenance include, and what is meant by excess maintenance? These terms are difficult to define and probably even more difficult to measure.

We can however study one of the main players to achieve some insight. We look closer at Odfjell, the second largest operator with a global network. Being one of the major operators its processes should be similar to the other leading operators in chemicals shipping. Odfjell has a stated policy to keep their vessels in a “state of the art” shape. Looking further at Odfjell’s (1998) annual report, they declare that one of their strategies to maintain their market share is through fleet development. Their objective is to manage a gradual renewal of their vessels and have a high maintenance level of their fleet. Odfjells policy is thus in accordance with both models by Eaton and Lipsey (1980). This could indicate that the company engages in too much maintenance for strategic purposes and also that they replace their carriers before their economical lives are over. These indications are in line with the top dog strategy discussed earlier; the incumbent firms in chemicals shipping overinvest to look tough and aggressive to deter potential global competitors.

In fact there are other observations from chemicals shipping pointing to the same conclusion, especially when looking at the two leading operators, Stolt-Nielsen and Odfjell. Their recent investment in information technology can be interpreted as a top dog strategy. These two leading operators, controlling nearly 45% of the market will be offering freight services in a class of their own when these systems are up and running. Stolt-Nielsen and Odfjell are also the only operators building competence in the four connected business areas of chemical freight. These areas include global and regional shipping, tank terminals and tank containers. While other companies are strong in one or two of these businesses, Stolt-Nielsen and Odfjell operate in all four. Odfjell (Annual report, 1998) claims that “*[i]ntegrating services in this way is a major advantage in a market where customers are making ever tougher demands in terms of efficiency, frequency, flexibility and competitiveness.*” This can also be seen as a top dog strategy as the firms by investing in integrated business areas will look tougher to competitors. By

building competence in information technology and integrated services, Stolt-Nielsen and Odfjell continue to build the impression of tough offensive players, i.e. top dogs ready to meet and fight newcomers in several markets.

Viewing the market from the opposite side, the successful entrants seem to have remained small players not appearing to challenge the major operators. This is in accordance with the top dog strategy as the incumbents have accomplished optimal accommodation from the newcomers. We can see this in combination with the entry strategy presented by Gelman and Salop (1983). By limiting the scale of its entry, newcomers play the role of a puppy dog and do not trigger an aggressive response by the larger incumbents.

We have now identified what seems to be a top dog strategy for the incumbents and a puppy dog strategy for the newcomers in chemicals shipping. But what about competition between the established players, can we identify tacit collusion in deep-sea chemicals shipping? It is quite obvious that there is not a formal cartel in this market, and competition seems hard between the major operators. But there are perhaps some leads that can substantiate our theoretical models. It seems plausible that the major operators would benefit if there were some sort of tacit agreement to soften market competition. They all compete for the same customers, and it is not unlikely that this situation could create incentives to engage in some sort of tacit arrangement. This does not mean that the operators are co-operating, but more that they have a tacit “understanding” of what the price range should be. It is in every operator’s interest that the competition is not too tough, as this will hurt everybody in the next “game”. This was observed in the supergames presented in chapter four. There are of course factors restraining the price the incumbents can charge. A “high” price will attract newcomers or perhaps vertical integration by the chemical producers. Instefjord (1990) shows that this possibility might give rise to limit pricing from the incumbents. If the incumbents charged too much, the suppliers

would rather carry the chemicals themselves making a vertical integration. We have not seen any sign of the latter and entry from other shipping companies has been discussed earlier in this chapter.

Indications of tacit collusion can be found. The most clear-cut reference is found in Seim and Stoutland (1991), where an employee from Seachem is quoted. One should be careful when handling such second hand sources, but the statement matches quite nicely the observations from the market. The statement suggests that the major companies tacitly have divided the deep-sea chemical market and contrived an “understanding” to keep the situation like this. It would thus be natural that the investment in capacity should be proportional to keep the market shares steady. By inspecting the market shares for the major operators, one observes that they have not changed significantly the last decade, which coincides with the statement from Seim and Stoutland (ibid.).

Jacob Stolt-Nielsen Jr is quoted in Drewry 1996. He raises an offensive against other chemical tanker owners, saying: “*One could ask how many ships (other companies) have scrapped. If there is anyone involved in senseless ordering of ships, it must be the players that are seeking to increase their fleets and bolster their market share.*” We know from economic theory that excess capacity can strengthen tacit collusion as the punishment from deviation can be harsher. One problem, which was not discussed in the last chapter, is how the market shares between the involved parties should be divided. In chapter four we assumed that this was split equally between the two incumbents. In chemicals shipping the market shares differ a lot between the major incumbents. Since the market is quite secretive, there could be an incentive to try to gain a larger share of the market but still hope to maintain the tacit arrangement. The referred statement could be a signal to encourage other operators to refrain from pursuing a higher market share, “warning” them that they could risk a breakdown in this tacit understanding.

Chemicals shipping also fits nicely into the setting of the multimarket models by Bernheim and Whinston (1990). The chemical market is divided between different trading routes where the same competitors meet. On some of these routes the major operators compete with several smaller “non-major” companies, which is akin to one of the settings described in Bernheim and Whinston (1990). It is not unlikely that this could affect competition between the companies involved, and Bernheim and Whinston (1990) explain how this situation could make a tacit cartel sustainable. As stressed before, tacit collusion here does not necessarily mean that the different companies have made some sort of agreement. Tacit collusion is understood as a realisation from the players that if they meet several times in a market, or several markets it would be optimal to compete less hard than the equilibrium in the one-shot game. Evidence of multimarket contact is naturally hard to find, but the different players must certainly be aware of this strategic aspect which could make it profitable for them to redistribute market power among the markets where they are operating. The other model presented by Bernheim and Whinston (1990) could also be relevant for sustaining tacit collusion in chemicals shipping. Demand fluctuates from period to period within the different trades and, as Drewry (1999) describes, rates fell heavily on some destinations in 1998, while they remained somewhat firmer on other trades. This coincides with Bernheim and Whinston (1990) and could make it easier to sustain tacit collusion due to multimarket contact.

What does the future hold for chemicals shipping? The leading operators look to remain strong, but the forthcoming period can according to Hans Petter Amundsen of Odfjell see some changes in the concentration of the deep-sea segment. Data from Odfjell show that at the present time the four major companies only account for 36% of the order book for the core fleet over 10,000 dwt. Other “non major” operators divide the rest and some of them, like MISC and Team Tankers, have a significant share of these orders.

These firms are some of the biggest operators in the group below the five largest companies and have at the moment orders for new tonnage larger than some of the four majors. This means that a lot of new tonnage will enter the market operated by smaller companies. Amundsen predicts that perhaps one or two of the smaller companies could take the step up and establish itself among the major players. He does not see this as a threat to Odfjell's position but more as a restructuring of the market share not controlled by the major operators. This could be accomplished by gaining market shares from other smaller operators driving them out of business or establishing joint ventures, as several minor operators already do. This could make it even more difficult for newcomers to enter in the coming years, as the concentration in chemicals shipping would become even stronger.

The chemicals shipping market has not been widely analysed from an academic point of view. One of the reasons is naturally the amount of contracts of affreightment that makes it difficult to obtain comparable data from the market. Testing for entry barriers is also hard due to the problems of estimating excess capacity in the chemical fleet. Lieberman (1987) also presents empirical evidence suggesting that excess capacity, as a barrier to entry, is not so common in practise as identified in theory. A proposal to further research would therefore be to focus on multimarket contact and how this can effect competition in chemicals shipping. If comparable prices could be estimated, a similar regression on chemicals shipping as Fernández and Marín (1998) do on the Spanish hotel industry, could derive more precise conclusions of the exercise of market power in chemicals shipping.

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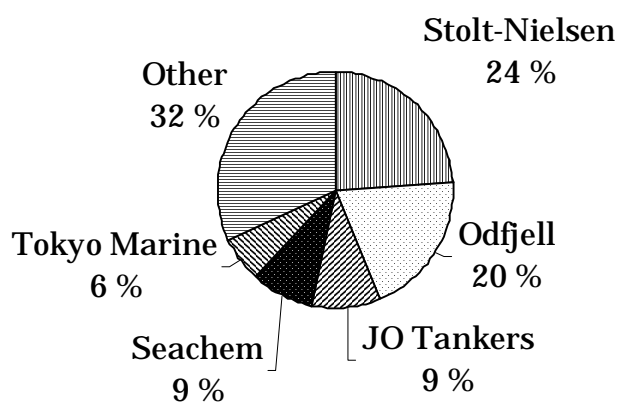
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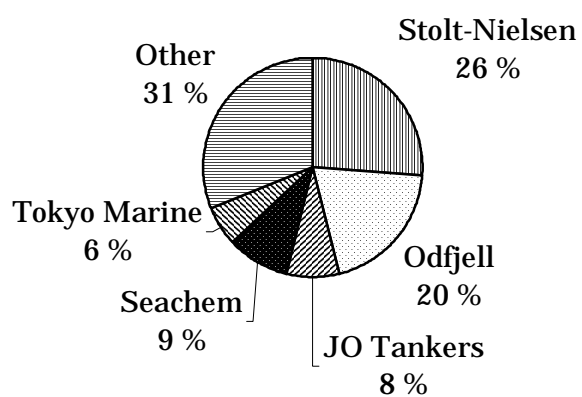
APPENDIX 1.

Parcel Tanker Market 1995



Source: Stolt-Nielsen/Chemical Week

Parcel Tanker Market 1998



Source: Odfjell/Lazard Capital Markets

APPENDIX 2.

Odfjell Tankers global trade lanes and major ports of calls.



Source: Odfjell