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PRICING AND COMPETITIVE BEHAVIOUR OF AN OLIGOPOLY: A GAME THEORETIC APPROACH

Licentiate thesis

ACKNOWLEDGEMENTS

I started my post-graduate studies in 1998 but it was actually not until summer 1999 when I got truly bitten by the research bug. During that year I visited more than once as an invited researcher at the university of Groningen. After many hours of stimulating conversations with my superiors and colleagues over there, I came across the research path that eventually led to the birth of this Licenciate Thesis.

First of all, I would like to express my gratitude to my supervisor Professor Tapio Pento, to whom I feel I am indebted for many things. He was the one person who not once questioned my mental faculties nor commitment and my heartfelt thanks belong to him for that. This outstanding innovator and supporter believed in me and showed me the way throughout this research project.

I also own a lot to Professor Shawn Daly, the reviewer and opponent, for his advice and insightful comments that were very useful in the final revision of the manuscript. I'm hoping to see our cooperation to continue for many more years yet to come. At this point, I would also like to thank the other reviewer, Professor Paul Arsenault, for taking the time to read and comment the manuscript.

From the university of Groningen I am grateful to Professor P. Leeflang, Professor P. Kooreman, Professor L. Schoonbeek, Ph.D. Candidate M. Kornelis, Ph.D. Candidate H. van Heerde, Ph.D. Candidate C. Horvath, and J. Wiersema. Dr. Professor Peter Leeflang kindly agreed to be a co-superviser of my study and with you, Csilla, my soulmate, I have always had the opportunity to exchange feelings and ideas. Without all you wonderful people I most likely would not have made it this far.

I own a special debt of gratitude to my husband, Anssi, and to our son, Lauri. What can I say except that I love you. No words would do justice of how I feel about your being there for me. You cannot say enough in praise of the understanding and support coming from one's family. A big hug goes also to my parents, Senja and Pekka Seppälä, who so often came to our rescue and lifted time constraints and other burdens off my shoulders.

I'm grateful for the opportunity that Finnish Graduate School of Marketing FINNMARK and its chairman Professor Martti Laaksonen gave me when I was admitted a position in the Graduate School in August 1999. I would also like to thank Hannu Laitinen, the CEO of Suomalainen Energia Osuuskunta SEO, who at a time when all the others backed out, was still convinced about the importance of my study.

Finally, I would like to thank all of you people who have in your own special ways taken my study closer to its end. Just to name few of you, Sofia, Javier, Hanna, Jean, Dennis, Otto, Arja, Jaana, Vrinda, and Brian, you gave me hope at a times of despair.

I gratefully acknowledge funding from FINNMARK, Liikesivistysrahasto, Jyväskylän Kauppalaisseuran Säätiö, and Ellen ja Artturi Nyyssösen Säätiö. Since a researcher doesn't live out of intellectual nourishment alone, all the financial support was well needed and I assure you, well spent.

The journey has just begun,

Minna Mattila

Jyväskylä 23.1.2000

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CHAPTER 1. INTRODUCTION

1.1 Motivation

It has been argued that the competitive environment becomes increasingly dynamic. Due to that managers need fresh perspectives and a sharply tuned understanding of the true nature of competition. Managers find themselves haunted by the interactions between their decision and other people's decision: in order to decide what you should do, you must reason through how they are going to act or react. Knowledge about competitive reaction effects allows management to determine whether the net effect of a promotion or other competitive tool is expected to be positive.

Firms constantly undertake offensive and defensive actions in pursuit of competitive advantage and tend to respond to rivals' adjustments of their marketing mix (Chen et at. 1992). The firms' marketing instruments may also depend on the predicted values of the competitors' marketing instruments. A reduction in sales for one brand may be offset if another brand retaliates. Thus the actual benefit due to the increased marketing activities depends crucially on the nature of competitive reactions.(Mattila et al. 1999).

Competition is a driving force behind the dynamics of today's markets and the pressure is on marketing managers to devise strategies that can cope effectively with changing market conditions. A few empirical papers have attempted to test for tacit collusion. This line of research deals with the wealth of equilibria provided by game theory (Leeflang 1999a). So far the papers have focused on one particular specification of collusive behaviour, appealing in particular to the simplicity of some strategies such as trigger strategies, or the continuity of reaction functions (Gasmi et al. 1992).

In oligopoly markets, the micro theory no longer supports the use of a supply curve as the primary marketing decision tool, and deterministic market solutions based on costs and demand alone are not possible. The reason is that the members of an oligopolistic industry are not price-takers but price-setters (Mulhern et al. 1995). Particularly short-run variable costs are normally seen to provide a reasonably solid lower bound to pricing behaviour. However, in the oligopolistic markets other factors such as explicit/implicit behaviour rules developed by the oligopoly itself, can contribute to pricing strategies well above marginal cost.(Hartman 1982).

The final motivation for this research came from the price wars on the Finnish gasoline retail markets in 1998 and 1999. They proved that managers could benefit from more 'economics of strategy'-like marketing models in coping with the competition. If you sell with a dollar and buy in with two, how much profits can you make? Such a models that besides generating understanding about the competitive behaviour in general, could be easily implemented in the interfirm strategies such as pricing and competitive behaviour, are in the focal point of this Thesis.

1.2 Research Rationale

The primary assertion of this Thesis is that game theory and formal modelling can be applied in marketing and in social exchange situations. The foundation for the models presented in the chapters 4-7 rests in the body of work known as mathematical modelling in social sciences. While the application of game theory to competitive behaviour and pricing decisions is not novel, the development of causal models of marketing decision variables from the fundamental premises of economic decision theory and game theory is new.

The most straightforward empirical approach is to collect key informant data from firms and calculate a correlation matrix. However, taking into account the sensible nature of the competitive strategies, this would be most likely impossible. Especially price war data is hard to collect. Prices alone are not enough but the exact pricing times, sales volumes, and gladly even costs must be knows before any kind of rational outcome can be reached. Hence, building models for marketing decisions becomes a reasonable alternative to primary data collection.

A model is a representation of the most important elements of a perceived real world system. In other words, models are condensed representations, simplified pictures of reality (Bagozzi 1980, 64). A well constructed model can be compared to a map, which is also just a simplified picture of reality but would be useless, if all the tiny details from the real world would be included in it. As the Rabbit in Winnie the Pooh's Most Grand Adventure said: "Why would anyone wanna wonder around wondering which way to go when they have a map to follow. A map is not a guess, an estimation or a hunch, a feeling or a foolish intuition."

Econometrics refer to the estimation and testing of economic models. However, the scope of econometric research as applied to marketing must be broadened to include the theory development as well as measurement and testing processes. The use of marketing decision model depends upon how well the model represents a real market and also upon how compatible the model is with the organization (Harvey 1999, 33-36).

The primary academic question to be addressed is

- the validity of the game theoretic paradigms for describing the competitive behaviour.

The validity of game theoretic paradigms has been questioned in the literature but our hypothesis is that along the study the validity of the game theoretic paradigms for describing the competitive behaviour will become apparent. The ideas about this validity issue based on the literature review in chapter 2 will be tested and analyzed in the research articles in chapters 4-7. By doing this, we will also take a stand on the question is there a quantifiable dimension in marketing and if so, how much intuition can be used as the basis for marketing problem solving.

Second, once the benefits of rational reactions are shown,

- the causality amongst various marketing instrument effects will be more completely indicated.

We will show the interdependence between different firms' different marketing instruments and their effects on the current market situation. The marketing instrument causing certain effects will be analyzed and their appearance in cycles will be proven.

Another contribution of this work is

- to demonstrate a taxonomy and framework which related the econometric constructs describing marketing behaviour.

Once the theoretical foundation has been laid in chapter 2, the major applied results will be presented in chapter 4-7. The taxonomy and framework which related the econometric constructs describing marketing behaviour will be present throughout the research articles, in which the marketing decisions will be modelled in econometrics as well as in game-theoretic terms.

The proposed Licenciate Thesis also makes

- a methodological contribution by investigating a new, practitioner-focused method for mathematical modelling in behavioural sciences.

What is clearly new in our approach is the application of behavioural sciences such as (mathematical) psychology and marketing to the formal modelling style. In our methodology the marketing instruments will be combined with psychological decision making to better capture the dynamic nature of the marketing decisions.

If successful, it

- demonstrates a more fundamentally sound scheme for the quantitative methods in marketing research.

Generally the use of intuition as the basis for marketing problem solving is justified by the argument that marketing problems are of a non-quantifiable nature. A mathematical model may not be the appropriate one to approach every marketing problem but a quantitative treatment can give valuable information about the quantifiable dimension of marketing (Naert et al. 1978, 21-22). Thus, in the discussion between those who feel that a mathematical model would constitute a complete solution or that such a sophisticated method is useless in marketing, both of these extremes should be avoided.

For practising managers, the refinement of a comprehensive, yet simple, models of environment, competitive behaviour, pricing, and tacit collusion should

- allow the formulation of prescriptive answers to crucial marketing decisions.

Managers will particularly benefit from models of marketing phenomena if they understand what the models do and do not capture. With this understanding they can, for example, augment model-based conclusions with their own expertise about complexities that fall outside the modeller's purview (Baltagi 1995, 5-6). Leeflang et al. (1999b, 23-27) has listed altogether 12 benefits from marketing decision models.

Importantly, the systematic analysis of the data in their use can provide competitive advantage to managers. Model benefits include cost savings resulting from improvements in resource allocations as discussed in various applications. And the leaders or first movers in the modelling of marketing phenomena can pursue strategies not available nor transparent to managers lagging in the use of data.

The following questions will be addressed when formulating the prescriptive answers to crucial marketing decision:

- What responses do firms utilize to react?
- Who are the players?
- How are the optimal results gained?

Since the actual benefit due to the increased marketing activities depends crucially on the nature of competitive reactions, the answers to these questions become of an utmost importance for this study. Managers often use rules of thumb for decisions. If a new marketing initiative occurs for one of the other brands, the brand manager will have a strong inclination to react. An economic perspective, however, would suggest that the need for a reaction depends on the impact of the marketing activity for the other brand on the demand for the manager's brand (Harvey 1994, 74). The models that are presented and discussed in this Thesis are designed to provide managers with such information.

1.3 Outline of Thesis

The format for this proposed Thesis follows that of an article form. In Chapter 2, a literature review will be presented describing the basics of game theory, economic theory of business behaviour, and decision theory. Next comes a short discussion of methodological issues. The successes and limitations of game theory will be discussed. Chapter from 4 to 7 comprise of four research articles, of which two have been presented in international conferences and two have been already accepted to be presented in international conferences in couple of months time from now. The common thread to these papers is methodological. Collectively they all share the same game theoretic approach and model the different dimensions of competitive behaviour on the oligopolistic markets.

In chapter 4 the influence of a change of firm's actions in one market on the competitors' strategies in a second market will be discussed. A noncooperative game is being used in describing the case of a multimarket oligopoly, in which the pioneer's adoptation of follower/leader role with respect to a marketing mix variables raises competitive reactions. In chapter 5 we analyze the dynamic pricing in a market where symmetric oligopolists produce quite a homogenous product and use prices as strategic variables. We attempt to model a price war behaviour as an equilibrium strategy of a repeated game. In chapter 6 the relationship between competitive effects and firm's market position will be studied. Managers under/overreactions will be estimated and the managers will be provided with marketing tool effect equations to better avoid unproductive competition and to find more optimal competitive responses. In chapter 7 the benefits and disadvantages of a tacit collusion will be analyzed. Empirical findings suggest that players who meet daily to compete are better off in terms of profits if they cooperate rather than if they'd play their noncooperative strategies in every period.

In chapter 8 the Thesis is concluded and more discussion on the applicability of the models is presented. The reader will be now aware of the basics of game-theory, how economics can be of an assistance in marketing decisions, and the ways of applying mathematical modelling in behavioural sciences. Also all the research questions outlined in chapter 1.2 have been answered by now.

CHAPTER 2. LITERATURE REVIEW

This chapter 2 forms the theoretical basis of the four research articles presented in the chapters 4-7. The main body of the game theory and the relevant parts for this study from the economic theory will be introduced. Chapter 2 has been divided into four major themes: static and dynamic games of complete and incomplete information and their implications. From economics the theories of oligopoly, kinked demand curve, tacit collusion, price wars, and decision theory will be shortly presented.

This chapter is essential because it is impossible to present all the theoretical background that has influenced the models and conclusions in the research articles themselves. The literature review helps the reader to get acquainted with the basic terminology used in the research articles and to better understand their message.

2.1 Basics of Game Theory

Close to 60 years ago John von Neumann and Oskar Morgenstern (1944) published their modern classic "Theory of Games and Economic Behaviour". Since then many general introductory text books on the theory of games have been published, and there are also many scholarly journals specialized in game theory, such as "International Journal of Game Theory" and "Games and Economic Behavior". The classical cooperative theory got a companion, when Nash (1950) developed agreement games and the concept of agreement drawing.

Wiberg (1996, 7-10) has written the following in answering the question *what* is game theory:

> "Game theory is interested in modelling social situations where the actors' may have at least partially conflicting interests. Game theory is thus the study of multilateral decision making. A game theorist is interested in modelling interdependent decisions. This means that game theory is interested in that subgroup of social situations in which the decisions of two or more players jointly determine the outcome of a situation. Game theory provides tools for thinking systematically about questions of strategy."

What about the question *how* game theory is used. Fink et al. (1998, 1-6) define three major manners how game theory can be used. First, they say, game theory is used to explore theoretical problems that arise directly from the development of game theory. Second, game theory has been used to analyze actual strategic interactions in order to either predict or explain the actions of the actors involved. For example, how can a leader get a follower to do what he wants her to do or, how effective are sanctions in international relations. Third, game theory has been used to analyze the logical consistency of certain arguments. For example, are various models of crisis bargaining and extended deterrence consistent with their hypotheses.

Game theory is divided into two branches, cooperative and noncooperative game theory. Essentially, in noncooperative game theory the unit of analysis is the individual participant in the game who is concerned with doing as well for himself as possible subject to clearly defined rules and possibilities. If individuals happen to undertake seemingly cooperative behaviour, it is done because it is in the best interests of each individual singly and each fears retaliation from others if cooperation breaks down.(Schelling 1980, 13-15).

In comparison, in cooperative game theory the unit of analysis is most often the group or the coalition. Even though in cooperative games also an individual is better off cooperating than not cooperating, the success of the game is measured in the paymentfunction for the whole coalition, not in the profits gained by an individual itself.(Widgrén 1990, 14-15). In literature noncooperative game theory is clearly much more general approach than is the cooperative (Kreps 1990a, 5-8).

Let us begin with a simple, informal example of a game quoted by John McMillan (1992 , 13-15):

> "Two pigs, one dominant and the other subordinate, are put in a box. There is a lever at one end of the box which, when pressed, dispenses food at the other end. Thus the pig that presses the lever must run to the other end; by the time it gets there, the other pig has eaten most, but not all, of the food. The dominant pig is able to prevent the subordinate pig from getting any of the food when both are at the food. Assuming the pigs can reason like game theorists, which pig will press the lever?"

Suppose 6 units of grain are delivered whenever the lever is pushed. If the subordinate pig presses the lever, the dominant pig eats all 6 units; but if the dominant pig pushes the lever, the subordinate pig eats 5 of the 6 units before the dominant pig pushes it away. Suppose now the subordinate pig can run faster so, if both press, it gets 2 units of the food before the dominant pig arrives. Finally, suppose pressing the lever and running to the other end requires some effort, the equivalent of one-half a unit of food. All the assumptions are drawn together in figure 2.1.

SUBORDINATE PIG \ DOMINANT PIG	Press	Don't Press
Press	(1.5, 3.5)	(-0.5, 6.0)
Don't Press	(5.0, 0.5)	(0, 0)

Figure 2.1 Game Matrix for Rational Pigs

Consider first the subordinate pig's reasoning: "Suppose I predict that the big pig will press the lever. The I get 1.5 if I press and 5 if I don't. If, on the other hand, I predict it will not press, I get -0.5 if I press and 0 if I don't. Thus regardless of what it does, I am better off not pressing than pressing."

Now imagine the dominant pig's thought process: "If I predict the small pig will press the lever, I get 3.5 if I press and 6 if I don't. If I predict it will not press the lever, I get 0.5 if I press and 0 if I don't." Our dominant pig now does seem to face a dilemma. Its best response is different depending on what it conjectures its rival will do. It should not press if it conjectures the subordinate pig will press, but it should press if it conjectures the subordinate pig will not. To resolve this quandary, the dominant pig must put itself in the shoes of the subordinate pig. Doing so, it sees, that the subordinate pig's best rational action is unambiguous: don't press. Thus it is in its interest to press the lever. In this case rational behaviour indicates a surprising conclusion. The dominant pig presses the lever, and the subordinate pig gets most of the food. Weakness, in this case, is strength.(quoted by McMillan 1992, 13-15).

2.2 Static Games of Complete Information

In static (or simultaneous-move) games players first simultaneously choose actions, then players receive payoffs that depend on the combination of actions just chosen (Kreps 1990a, 11). Let us first restrict attention to games of complete[1] information, by which it is meant that each player's payoff function[2] is common knowledge among all the players (Aumann et al. 1974, 15).

There are two basic forms or types of formal models that are employed in noncooperative game theory. With static games of complete information the strategic form or normal form is used. It is comprised of three things: a list of players, for each player a list of strategies, and for each array of strategies (one for each player) a list of payoffs. A two-player game of this kind can be depicted in a two-dimensional table. The sum of the payoffs in each cell is zero. Because of this, this is called a zero-sum game, and moreover, because the sum is constant, instead of zero-sum game the terminology constant-sum game is often used.(Gibbons 1992a, 9-12). The strategic form of game's table is illustrated in figure 2.2.

Player A:	Player B: Strategy 1_B	Strategy 2_B	Strategy 3_B
Strategy 1_A	0,0	-1,1	1,-1
Strategy 2_A	1,-1	0,0	-1,1
Strategy 3_A	-1,1	1,-1	0,0

Figure 2.2 The Strategic Form of Game's Hypothetical Table

[1] Notice, that complete information ≠ perfect information, and incomplete information ≠ imperfect information.

[2] The function which determines the player's payoff from the combination of actions chosen by the players, is called a payoff function.

2.2.1 Nash Equilibrium

To make an optimal decision, a player must generally foresee how his opponents will behave. The first basis for such a conjecture is that one's opponents should not play dominated strategies. If an action always gives a lower payoff to a player than another action, whatever the other players do, it may be assumed that the player will not pick that action. Unfortunately, in many games the elimination of dominated strategies does not go very far toward selecting a unique reasonable outcome or a limited set of them (Shubik 1975a, 160-162).

The notion of Nash equilibrium yields a weaker concept of reasonable outcome (Kreps 1990b, 403).

Definition A set of strategies $\{a^*_i\}^n_{i=1}$ is a pure-strategy Nash equilibrium if and only if, for all a_i in A_i, $\Pi^i(a^*_i, a^*_{-i}) \geq \Pi^i(a_i, a^*_{-i})$, where $a^*_{-i} \equiv (a^*_i, \ldots, a^*_{i-1}, a^*_{I+1}, \ldots, a^*_n)$.

In other words, a Nash equilibrium is a set of actions such that no player, taking his opponents' actions as given, wishes to change his own actions. This definition is straight-forwardly extended to allow mixed strategies by letting $\tilde{A}_i$ (= the set of probability distributions over A_i), be player i's strategy set and letting Π^i denote the expectations over the mixed strategies.(Weibull 1996, 14-16).

One way to motivate the definition of Nash equilibrium is to argue that if game theory is to provide a unique solution to a game theoretic problem then the solution must be a Nash equilibrium in the following sense. Suppose that game theory makes a unique prediction about the strategy each player will choose. In order for this prediction to be correct, it is necessary that each player be willing to choose the strategy predicted by the theory.(Kreps 1990a, 8-10). Thus, each player's predicted strategy must be that player's best response to the predicted strategies of the other players. Such a prediction could be called strategically stable or self-enforcing, because no single player wants to deviate from his predicted strategy. Such a prediction is also called a Nash equilibrium.(Shubik 1975b, 33-37).

2.2.2 Strictly Dominated Strategy

Another important aspect in the static games of complete information is the notion of strictly dominated strategy. It has been defined, for example, in Kreps (1990a, 5) and Fudenberg et al. (1998, 45-46). In some situations the Nash concept seems too demanding. The notion of (iterated) strict dominance derives predictions using only the assumptions that the structure of the game, for example the strategy spaces and the payoffs, are common knowledge (Tirole 1998 ,424).

Definition In the normal-form game $G = \{S_1, \dots ,S_n; u_1, \dots ,u_n\}$, let s'_i and s''_i be feasible strategies for player i (i.e., s'_i and s''_i are members of S_i). Strategy s'_i is strictly dominated by strategy s''_i if for each feasible combination of the other players' strategies, i's payoff from playing s'_i is strictly less than i's payoff from playing s''_i: $u_i(s_1, \dots ,s_{i-1}, s'_i ,s_{i+1}, \dots ,s_n) < u_i(s_1, \dots ,s_{i-1}, s''_i, s_{i+1}, \dots ,s_n)$ for each $(s_1, \dots ,s_{i-1}, s_{i+1}, \dots , s_n)$ that can be constructed from the other players' strategy spaces $S_1, \dots ,S_{i-1}, S_{i-1}, \dots ,S_n$.

Besides the formal definition presented above, the strict dominance can also be expressed informally. Strategy M is strictly dominated, if no matter how player 1 plays, R gives player 2 a strictly higher payoff than M does. Thus a rational player 2 should not play M. Furthermore, if player 1 knows that player 2 will not play M, then U is a better choice than M or C. Finally, if player 2 knows that player 1 knows that player 2 will not play M, then player 2 knows that player 1 will play U, and so player 2 should play L. The set of strategies that survive iterated strict dominance do not depend on the order in which strategies are eliminated. This process of elimination is called iterated strict dominance.(Fudenberg et al. 1998, 6-7).

2.3 Static Games of Incomplete Information

In static games of incomplete information some player is uncertain about another player's payoff function as in an sealed-bit auction where each bidder's willingness to pay for the good being sold is unknown to the other bidders (Gibbons 1992a, 144). Incomplete information games are also called Bayesian games (Mariotti 1997). Another example of an Bayesian game is the one of an incumbent (player 1) and an entrant (player 2) in a certain market. Consider player 1 deciding whether to extent its operations in the selected market, and simultaneously player 2 decided whether to enter. Imagine, that player 2 is uncertain whether player's 1 cost of extending is high or low, while player 1 knows his own cost. Player's 2 payoff depends on whether player 1 extents, but is not directly influenced by player's 1 cost. Thus, player 1 must try to predict player's 2 behaviour to choose her own action, and player 2 cannot infer player's 1 action from his knowledge of player's 1 payoffs alone.

Bayesian game has been widely formally defined in the literature (see e.g. Gibbons 1992a, 148; Gibbons 1992b, 146-147; Fudenberg et al. 1998, 210-214; Tirole 1998; 432-433).

Definition The normal-form representation of an n-player static Bayesian game specifies the players' action spaces $A_1, \dots, A_n$, their type spaces $T_1, \dots, T_n$, their beliefs $p_1, \dots, p_n$, and their payoff functions $u_1, \dots, u_n$. Player's i type, t_i, is privately known by player i, determines player's i payoff function, $u_i(a_1, \dots, a_n; t_i)$, and is a member of the set of possible types, T_i. Player's i belief $p_i(t_{-i} \mid t_i)$[3] describes its uncertainty about the n-1 other players' possible types, t_{-i}, given i's own type, t_i. We denote this game by $G = \{A_1, \dots, A_n; T_1, \dots, T_n; p_1, \dots, p_n; u_1, \dots, u_n\}$.

There are games in which player i has private information not only about his own payoff function but also about another player's payoff function. Since the level of demand affects both players' payoff functions, the informed firm's type enters the uninformed firm's payoff function. In the n-player case we capture this possibility by allowing player's i payoff to depend not only on the actions $(a_1, \dots, a_n)$ but also on all types $(t_1, \dots, t_n)$. This payoff is written as $u_i(a_1, \dots, a_n; t_1, \dots, t_n)$.(Gibbons 1992a, 148-149).

[3] When nature reveals t_i to player i, he can compute the belief $p_i(t_{-i} \mid t_i)$ (= conditional probability that t_{-i} will occur given that t_i has already occurred), using Bayes' rule:

$$p_i(t_{-i} \mid t_i) = \frac{p(t_{-i}, t_i)}{p(t_i)} = \frac{p(t_{-i}, t_i)}{\sum_{t_{-i} \in T_{-i}} p(t_{-i}, t_i)}$$ (e.g. Gibbons 1992b, 149).

2.3.1 Bayesian Equilibrium

Bayesian equilibrium is precisely the Nash equilibrium of the imperfect-information representation of the game (Mariotti 1997). Unlike in games of complete information, in a Bayesian game the strategy spaces are not given in the normal-form representation of the game (Fink et al. 1998, 17-18). In a static Bayesian game the strategy spaces are constructed from the type and action spaces (Shubik 1991, 243). Player's i set of possible strategies, S_i, is the set of all possible functions with domain T'_i, and range A_i. In a separating strategy, for example, each type t_i in T_i chooses a different action a_i from A_i. In a pooling strategy all types choose the same action.(Kreps 1990b, 465-467).

Definition In the static Bayesian game $G = \{A_1, \ldots ,A_n; T_1, \ldots ,T_n; p_1, \ldots ,p_n; u_1, \ldots ,u_n \}$, the strategies $s^* = (s^*_1, \ldots ,s^*_n)$ are a Bayesian equilibrium if for each player i and for each of i's types t_i in T_i, $s^*_i(t_i)$ solves

$$\max_{a_i \in A_i} \sum_{t_{-i} \in T_{-i}} u_i(s^*_1(t_1), \ldots , s^*_{i-1}(t_{i-1}), a_i, s^*_{i+1}(t_{i+1}), \ldots ,s^*_n(t_n);t)p_i (t_{-i} \mid t_i).$$

That is, no player wants to change his strategy, even if the change involves only one action by one type. In a finite static Bayesian game there exists a Bayesian equilibrium (Weibull 1996, 94). The proof[4] of it is omitted here, because it is not in the spirit of this Thesis to get that into the technical points.

[4] The proof of the existence of a Bayesian Nash equilibrium is well-known and its detailed presentation is unnecessary for this study.

2.3.2 Revelation Principle

The Revelation Principle in the context of incomplete information game is an important tool for designing games when the players have private information. According to the Revelation Principle any Bayesian equilibrium of any Bayesian game can be represented by a new Bayesian equilibrium in an appropriately chosen new Bayesian game, where by represented it is meant that for each possible combination of the players' types ($t_1, \dots, t_n$), the players' actions and payoffs in the new equilibrium are identical to those in the old equilibrium. No matter what the original equilibrium, the new equilibrium in the new game is always truth-telling.(Day et al. 1997, 133-134).

The seller who wishes to design an auction to maximize his expected revenue, can use the Revelation Principle to simplify his problem in two ways. First, let's asume that the bidders simultaneously make (dishonest) claims about their types e.g. in this case their valuations. Bidder *i* can claim to be any type τ_i from *i*'s set of feasible types T_i, no matter what *i*'s true type, t_i. Given the bidders' claims ($\tau_1, \dots, \tau_n$), bidder *i* pays $x_i(\tau_1, \dots, \tau_n)$, and receives the good with probability $q_i(\tau_1, \dots, \tau_n)$. For each possible combination of claims ($\tau_1, \dots, \tau_n$), the sum of the probabilities $q_1(\tau_1, \dots, \tau_n) + \dots + q_n(\tau_1, \dots, \tau_n) \leq 1$.(McMillan 1992, 137-147).

The second way the seller can use the Revelation Principle is to restrict attention to those direct mechanisms in which it is a Bayesian equilibrium for each bidder to tell the truth. In this case the payment and probability functions $\{x_1(\tau_1, \dots, \tau_n), \dots, x_n(\tau_1, \dots, \tau_n); q_1(\tau_1, \dots, \tau_n), \dots, q_n(\tau_1, \dots, \tau_n)\}$ are such that each player's *i* equilibrium strategy is to claim $\tau_i(t_i) = t_i$ for each t_i in T_i.(Ghemawat 1997, 207-213).

2.4 Dynamic Games of Complete Information

In dynamic (or sequental-move) games player 1 first moves, then player 2 observes player's 1 move, then player 2 moves, and so on until the game ends. The players' payoffs from each feasible combination of moves are common knowledge (Kreps 1990a, 17). There are two basic forms or types of formal models that are employed in noncooperative game theory. With dynamic games of complete information the extensive form game is used. Here attention is given to the timing of actions that players may take and the information they will have when they must take those actions (Gibbons 1992a, 55-56).

The extensive form games in general are composed of (see figure 2.3): dots, which are often called nodes, vectors of numbers, arrows which point from some of the dots to others and to the vectors, and labels for the nodes and for the arrows. Each node is a point at which some player must choose some action. The game begins at the open dot. The letters index the players in the game and the letter next to any node gives the identity of the player who must choose an action, if that position in the game is reached.(Kreps 1990a, 13-14).

In these figures two rules are never violated. First, each node has at least one arrow pointing out from it and at most one arrow is pointing into it. Second, if we backtrack from any node we never cycle back to the node with which we began. Eventually we do indeed get to the initial node. The effect of these two rules is that the pictures illustrating this form of game always look like trees with branches.(Shubik 1991, 35-38).

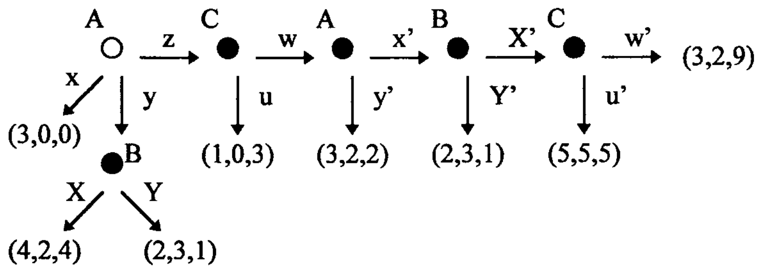

Figure 2.3 An Extensive Form Game (three players)

2.4.1 Backward Induction and Subgame Perfection

When player 2 gets the move at the second stage of the game, he will face the following problem, given the action a_1 previously chose by player 1: max $u_2(a_1, a_2)$, $a_2 \in A_2$. Assume that for each a_1 in A_1, player's 2 optimization problem has a unique solution, denoted by $R_2(a_1)$. This is player's 2 best response to player's 1 action. Since player 1 can solve 2's problem as well as 2 can, player 1 should anticipate player's 2 reaction to each action a_1, that 1 might take, so 1's problem at the first stage amounts to: max $u_1(a_1, R_2(a_1))$, $a_1 \in A_1$. Assume that this optimization problem for player 1 also has a unique solution, denoted by a^*_1, then $(a^*_1, R_2(a^*_1))$ is called the bakcward induction outcome of this game.(Binmore 1997).

Consider the following three-move game (illustrated in figure 2.4): Player 1 chooses V or W, where v ends the game with payoffs of 2 to player 1 and 0 to player 2. Player 2 observes 1's choice. If 1 chose W then 2 chooses V' or W', where V' ends the game with payoffs of 1 to both players. Player 1 observes 2's choice and recalls his own choice in the first stage. If the earlier choices were W and W' then 1 chooses V'' or W'', both of which end the game, V'' with payoffs of 3 to player 1 and 0 to player 2 and W'' with analogous payoffs of 0 and 2.(Gibbons 1992a, 59).

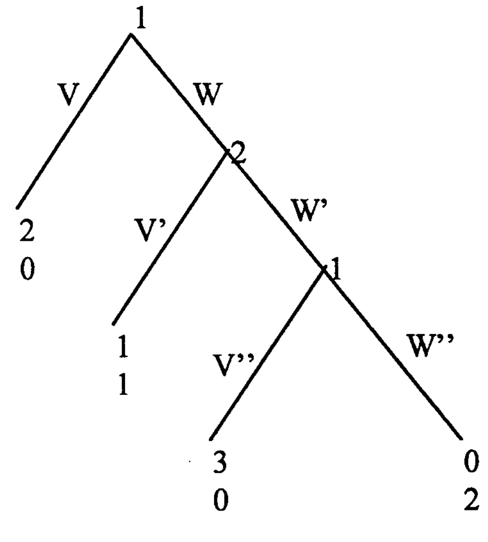

Figure 2.4 Game Tree for Computing Backward Induction in One Dynamic Game of Complete Information

To illuminate backward induction, let's begin at the third stage, which in this example game is player's 1 second move. Here player 1 faces a choice between a payoff of 3 from V'' and a payoff of 0 from W'', so V'' is optimal. Thus, at the second stage, player 2 anticipates that if the game reaches the third stage then 1 will play V'', which would yield a payoff of 0 for player 2. The second-stage choice for player 2 therefore is between a payoff of 1 from L' and a payoff of 0 from W', so V' is optimal. Thus, at the first stage, player 1 anticipates that if the game reaches the second stage then 2 will play V', which would yield a payoff of 1 for player 1. The first-stage choice for player 1 therefore is between a payoff of 2 from V and a payoff of 1 from W, so V is optimal. This argumentation establishes that the backward induction outcome of this game is for player 1 to choose V in the first stage thereby ending the game. Notice, that both the players are assumed to be rational. Backward induction loses much of its appeal as a prediction of play, if both or the other one of the player's is irrational.

The subgame-perfect outcome is the natural analog of the backward induction outcome in games of complete and perfect information. Let's analyze a simple two-stage game of complete but imperfect information, in which there is allowed to be simultaneous moves within each stage. Players 1 and 2 simultaneously choose actions a_1 and a_2 from feasible sets A_1 and A_2, respectively. Players 3 and 4 observe the outcome of the first stage, (a_1, a_2), and then simultaneously choose actions a_3 and a_4 from feasible sets A_3 and A_4, respectively. Payoffs are $u_i(a_1, a_2, a_3, a_4)$ for $i = 1,2,3,4$ (Weibull 1996, 25-27).

This game can be solved by using an approach in the spirit of backward induction, but this time the first step in working backwards from the end of the game involves solving the simultaneous-move game between players 3 and 4 in stage two, given the outcome from stage one, rather than solving a single-person optimization problem. It is assumed that for each feasible outcome of the first-stage game, (a_1, a_2), the second-stage game that remains between players 3 and 4 has unique Nash equilibrium, denoted by $(a^*_3(a_1, a_2), a^*_4(a_1, a_2))$.(Gibbons 1992b, 72).

If players 1 and 2 anticipate that the second-stage behaviour of players 3 and 4 will be given by $(a^*_3(a_1, a_2), a^*_4(a_1, a_2))$, then the first-stage interaction between players 1 and 2 amounts to the following simultaneous-move game: Players 1 and 2 simultaneously choose actions a_1 and a_2 from feasible sets A_1 and A_2, respectively. Payoffs are $u_i(a_1, a_2, (a^*_3(a_1, a_2), a^*_4(a_1, a_2))$ for $i = 1,2$ and (a^*_1, a^*_2) is supposed to be the unique Nash equilibrium of this simultaneous-move game. In this two-stage game, $(a_1, a_2, (a^*_3(a_1, a_2), a^*_4(a_1, a_2))$ is called the subgame-perfect outcome.(Gibbons 1992a, 71-73).

2.4.2 Repeated Games

The best-understood class of dynamic games is that of repeated games, in which players face the same stage game or constituent game in every period, and the player's overall payoff is a weighted average of the payoffs in each stage. If the players' actions are observed at the end of each period, it becomes possible for players to condition their play on the past play of their opponents, which can lead to equilibrium outcomes that do not arise when the game is played only once.(Fudenberg et al. 1998, 145).

The reason repeated play introduces new equilibrium outcomes is that players can condition their play on the information they have received in previous stages. Repeated games may be a good approximation of some long-term relationships - particularly those where trust and social pressure play important part, such as when informal agreements are used to enforce mutually beneficial trades without legally enforced contracts.(Fink et al. 1998, 32-34).

2.5 Dynamic Games of Incomplete Information

The complications that incomplete information causes are easiest to see in so-called signaling games or leader-follower games, as they are also often called. In this type of games only the leader has private information. As the leader moves first, the follower observes the leader's action, but not the leader's type, before choosing his own action (Ghemawat 1997, 187-188). The equilibrium of dynamic games of incomplete information is called perfect Bayesian equilibrium, which has been defined in many different ways in literature. Gibbons (1992b, 177-180) presents four requirements for perfect Bayesian equilibrium, and says that all the different definitions of perfect Bayesian equilibrium share the first three requirements defined by him but differ by the fourth requirement. His conclusion is supported e.g. in Fudenberg et al. (1998, 324-331). The common requirements are:

- At each information set, the player with the move must have a belief about which node in the information set has been reached by the play of the game. For a nonsingleton information set, a belief is a probability distribution over the nodes in the information set; for a singleton information set, the player's belief puts probability one on the single decision node.
- Given their beliefs, the players' strategies must be sequentially rational. That is, at each information set the action taken by the player with the move (and the player's subsequent strategy) must be optimal given the player's belief at that information set and the other players' subsequent strategies (where a "subsequent strategy" is a complete plan of action covering every contingency that might arise after the given information set has been reached).
- At information sets on the equilibrium path, beliefs are determined by Bayer' rule[5] and the players' equilibrium strategies.

Therefore, the perfect Bayesian equilibrium can be informally defined as consisting of strategies and beliefs that satisfy requirements 1 through 3.

Reputation effects are closely related to dynamic games of incomplete information as with games of incomplete information in general. If the player always plays in the same way, his opponents will come to expect him to play that way in the future and will adjust their own play accordingly. The question then is when and whether a player will be able to develop or maintain the reputation he desires. Intuitively, since reputations are like assets, a player is most likely to be willing to incur short-run costs to build up his reputation when he is patient and his planning horizon is long. Investments in reputation are more likely in long relationships than in short ones, and more likely at the beginning of the game than at its end.(Day et al. 1997, 143-147).

2.6 Economic Theory of Business Behaviour

2.6.1 Oligopoly

Oligopoly is a market structure, in which there are only a few sellers, all of whom may affect prices, and all of whom must take into account the reactions of competitors when adjusting prices or output. It is possible in oligopolistic situations for a number of outcomes to develop. For example, oligopoly could result in conflict or collusion among rivals, in price leadership, basing point systems, extensive advertising campaigns, independent actions, and so on. In oligopoly, a limited number of sellers creates price/output decision interdependence.(McGuire 1964, 63-64).

Oligopoly describes markets that can be characterized as follows:

- Few Sellers. A handfull of firms produce that bulk of industry output.
- Homogeneous or unique product. Oligopoly output can be perceived as homogeneous or distinctibe.
- Blockaded entry and exit. Firms are heavily restricted from entering or leaving the industry.
- Imperfect dissemination of information. Cost, price, and product quality information is withheld from uninformed buyers.(Hirschey et al. 1995, 630-631).

[5] Presented in footnote number 3.

Oligopoly can also be present in a number of local markets. In many rural or semi-rural retail markets for petrol and food, only a few service stations and grocery stores compete within a small geographic area.

One variable that is typically assumed to remain fixed is the price charged by competing firms. In an oligopolistic market structure, however, if one firm changes its price, other firms are assumed to react by changing their prices. The demand curve for the initial firm shifts position, so that instead of moving along a single demand curve as it changes price, the firm moves to an entirely new demand curve (Kuenne 1989). The phenomenon of shifting demand curves is illustrated in figure 2.5.

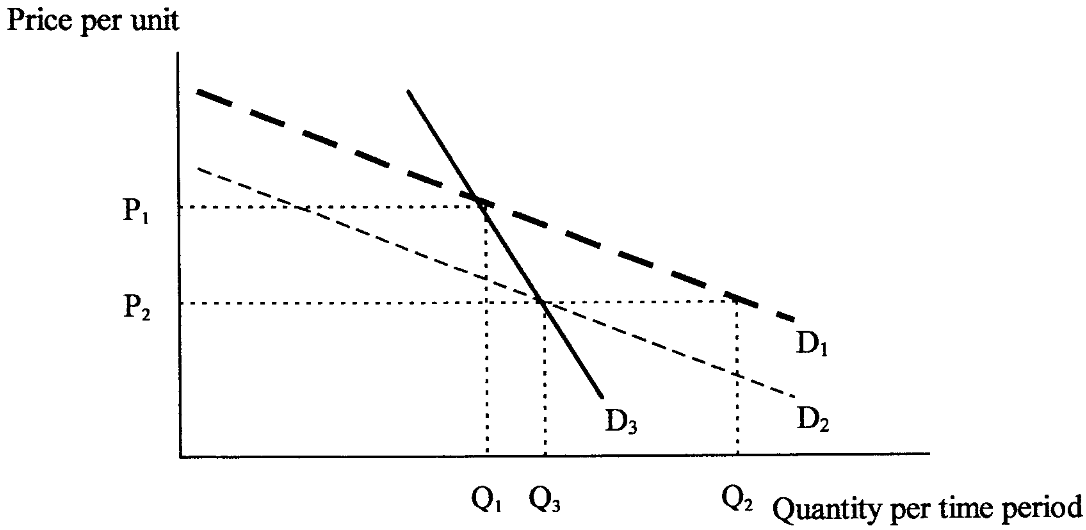

Figure 2.5 Demand Curve that Recognizes Reactions

In contrast to D_1 and D_2, the demand curve D_3 reflects firm's A projections of the price reactions of competitors. A price cut from P_1 to P_2 would increase demand to Q_2. However, if only a few firms operate in the market and that each has a fairly large share of total sales, if one firm cuts its price and obtains a substantial increase in volume, other firms lose a large part of their business. They know exactly why their sales have fallen and react by cutting their own prices. This action shifts firm A down to the second demand curve, D_2, reducing its demand at P_2 from Q_2 to Q_3 units. The new curve is just as unstable as the old one, so knowledge of its shape is useless to firm A; if it tries to move along D_2, competitors will react, forcing the company to yet another demand curve.(Hirschey et al. 1995, 630-633). Curve D_3 represents a reaction-based demand curve. It shows how price reductions affect quantity demanded after competitive reactions have been taken into account. The problem with this approach is that different interfirm behaviour leads to different pricing decision rules.

2.6.2 Kinked Demand Curve

One model of oligopoly is described by kinked demand curves. It was first introduced by Hall et al. (1939) and Sweeny (1939). This model employs the concept of imagined demand: the demand envisaged by firm *i* for its output at all relevant prices except the prevailing price. The demand at the present price is real. The firm *i*, in its effort to anticipate the reactions of its rivals to any movements in its price, imagines that its competitors will also lower their prices should it lower its, and will not raise their prices should its price be raised.(McGuire 1964, 63-66). This means that the firm *i* imagines its demand curve to be kinked at the prevailing price, so that any increase in its price will result in a rather substantial reduction in its sales (because its rivals will not follow its price increase), and any decrease in its price will not gain much in additional sales (because its rivals will follow its downward price changes). The general form of kinked demand curve is illustrated in figure 2.6.

A kinked demand curve is a firm demand curve that has different slopes for price increases as compared with price decreases. Kinked demand curve theory assumes that rival firms follow any decrease in price in order to maintain their respective market shares but refrain from following increases, allowing their market share to increase at the expense of the firm making the initial price increase. When price cuts are followed but price increases are not, a kink develops in the firm's demand curve. At the kink, the optimal price remains stable despite moderate changes in marginal costs (Kreps 1990b, 335-340).

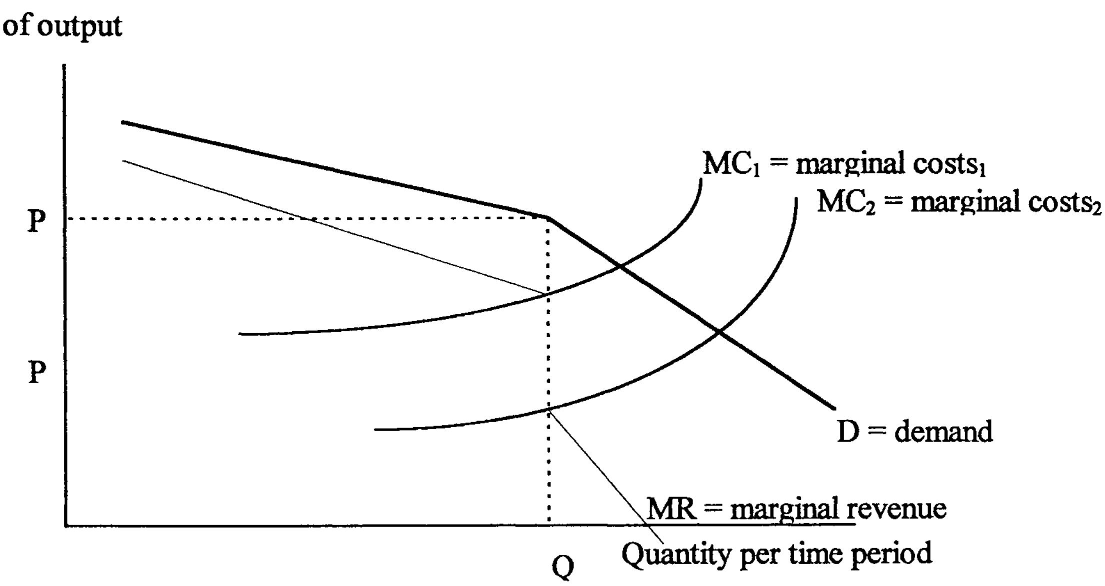

Figure 2.6 Kinked Demand Curve

Associated with the kink in the demand curve is a point of discontinuity in the marginal revenue cost. As a result, the firm's marginal revenue curve has a gap at the current price/output level, which results in price rigidity. With a gap in the marginal revenue curve, the price/output combination at the kink can remain optimal despite fluctuations in marginal costs. As illustrated in figure 2.6, the firm's marginal cost curve can vary between MC_1 and MC_2 without causing any change in the profit-maximizing price/output combination. Small changes in marginal costs have no effect. Only large changes in marginal cost lead to price changes. In the oligopolistic market, prices change only infrequently (Parsons et al. 1976, 38-44).

2.6.3 Tacit Collusion

The notion that oligopolists collude has been around since the virtual inception of economics (Kreps 1990b, 524). Consider a small number of identical firms producing a homogeneous product. Chamberlin (1933, 48) conjectured that in such a situation the firms in the industry would charge the monopoly price, i.e., the price that maximizes industry profit:

> "If each seeks his maximum profit rationally and intelligently, he will realize that when there are only two or a few sellers his own move has a considerable effect upon his competitors, and that this makes it idle to suppose that they will accept without retaliation the losses he forces upon them. Since the result of a cut by any one is inevitably to decrease his own profits, no one will cut, and although the sellers are entirely independent, the equilibrium result is the same as though there were a monopolistic agreement between them."

Factors that weaken price competition in a static context might also facilitate collusion in a repeated-price-interaction situation. In particular, decreasing returns to scale or capacity constraints make undercutting less profitable. They also weaken the strength of future retaliations, as they limit the output that firms can supply in the market. Multimarket contact is also thought to blunt the incentives for rivalry. Firms that compete against each other in many markets may hesitate to fight vigorously. However, there are also factors hindering collusion, for example, detection lags and asymmetries between firms. (Tirole 1998, 240-243).

Martin (1993, 98-100) has derived conditions for internal and external stability in a standard model of quantity-setting oligopoly. He found, that a complete cartel[6] is internally stable if there are four or fewer firms supplying the market. If there are five or more firms in the cartel, each cartel member's share of cartel profit is so small that the most profitable course for a single firm is to defect and act as an independent firm. For external stability, it is required, that only cartels with F + 2 and F + 3 firms are stable, where F represents the number of firms in the fringe.

To collusion are closely related so-called trigger strategies. Trigger strategies include the grim reaper, stick and carrot strategies, and demons and repentance. A trigger strategy sustains cooperative behaviour by a severe threat: if any player defects from the cooperative path, all players forgo collusive returns to punish the defector. The resulting strategy vector is a subgame-perfect equilibrium (see chapter 2.4.1). The structures of trigger strategies vary.(Martin 1993, 103-105). For the sake of simplicity, we present here only the definition of trigger strategies in general.[7]

Modified from Friedman (1971) each player begins by playing his part with a strategic variable of $s_{collude}$ and continues to do so as long as all other players do the same. In the period following any defection from $s_{collude}$, firms revert to $s_{Cournot}$, and continue to play $s_{Cournot}$ thereafter. In Cournot duopoly[8] each firm knows what its rival produces, and selects its own output to maximize its own profit, taking its rival's output as given (Cournot 1897, 15). Formally, the trigger strategy is defined by Friedman (1971) as

[6] With 'cartel' here is meant any coalition of firms colluding (tacitly) - not particularly explicit collusion.
[7] For more information on trigger strategies, see e.g. Martin (1993, 103-117), and Saajo (1996).
[8] A special case of oligopoly with only two firms on the market.

$\sigma_i(1) = s_{i,\text{collude}}$

$$\sigma_i(t) = \begin{cases} s_{i,\text{collude}} & \text{if } \sigma_j(\chi) = s_{j,\text{collude}}, j \neq i; \chi = 1, \dots, t-1; t = 2, 3, \dots \\ s_{i,\text{Cournot}} & \text{otherwise} \end{cases}$$

Whether or not a player prefers to produce his part of $s_{i,\text{collude}}$, $s_{i,\text{Cournot}}$ depends on a comparison of the payoff from defecting and the payoff from adhering to the cartel strategy. If defection has not yet take place, payoff streams following defection or adherence in period t are the same as payoff streams following defection or adherence in period 1.(Shubik 1975a, 157-161).

2.6.4 Price Wars

No tacit collusion can go on forever - even though at the moment the exact time of defection or third party intervention can't be seen. For one, the use of trigger strategies easily leads the oligopoly from tacit collusion into a full price war. How far the firms are willing to go, depends on their interfirm behavioural culture. Or traditionally, a sufficient fall in demand induces firms to defect from noncooperatively collusive behaviour.

In Porter-Green model of price wars in Porter (1983) sufficiently large slump pulls price below the trigger level and initiates a reversionary period. No defection actually occurs in the Porter-Green model.

Rotemberg and Saloner (1986) argue that the Porter-Green model is sensitive to assumptions about the timing of information. They present an econometric analysis of the real price of cement that seems to support their theoretical analysis describing certain types of markets, in which noncooperative collusion will be upset by episodes of actual defection. Price wars occur during booms, not slumps in demand. In

Rosemberg and Saloner (1986) they are seen to be triggered by actual defection, not by slack demand that cannot be distinguished from defection.

Slade (1989) shoes that price wars may emerge as an optimal response to infrequent random shifts in demand. If a demand shock occurs, firms have to collect information about the changed market conditions, and they accomplish this by pricing low during the post-shock period. For this reason, post-shock experimentation with different prices is likely to take the form of a price war.

2.7 Decision Theory

The behaviour of managers may be thought of as a function of the amount of information they possess about the potential future outcomes of their decisions. The state of information or ignorance possessed by a decision maker may range along a continuum from certainty to uncertainty. In the middle of this continuum may be placed risk.

Probability and decision theory utilize a convenient device known as the payoff matrix, which will help us to distinguish between certainty, risk, and uncertainty. The row vector of a payoff matrix represent the strategies available to the managers, whereas the column vectors are the states of nature, that is, environmental conditions over which the executive has no control. Each element of the matrix, therefore, is called a payoff: it is the joint outcome of a particular strategy and a given state of nature(McGuire 1964, 112-113). Figure 2.7 depicts a generalized payoff matrix. The *N*'s are states of nature, *S*'s are alternative strategies, and the *P*'s are payoffs.

States of Nature

Strategies		N_1	N_2	...	N_j
	S_1	N_{11}	P_{12}	...	P_{1j}
	S_2	P_{21}	P_{22}	...	P_{2j}
	...	...	...	...	...
	S_i	P_{i1}	P_{i2}	...	P_{ij}

Figure 2.7 Generalized Payoff Matrix

Under certainty there exists only one state of nature, although there may be vast number of strategies under some circumstances. Thus in figure 2.7 a decision would have to be made among strategies S_1, S_2, ... ,S_i, given say the state of nature N_1. Under risk the parameters of the frequency distributions in a risk situation are thought to be known to the decision maker. It means that the manager is assumed to know with what mathematical probabilities each of two or more states of nature will occur.(Irwin, et al. 1953, 27-34).

In theory the decision to undertake a particular course of action in a certain environment is reached by selecting that valued result or payoff which is most satisfactory for the attainment of desired goals (Cyert et al. 1963, 44). The mathematical probability theory and decision theory are both concerned primarily with rational behaviour in an environment in which the decision maker's knowledge of the nature is limited. The decision maker is assumed to possess a goal or goals toward which he desires to move. In order to attain this end or ends, a selection must be made from alternative strategies which will tend to bring about the desired outcome (Bowman 1958, 2).

Under conditions of uncertainty a manager finds it impossible to assign objective mathematical probabilities to the states of nature which affect the payoffs of his strategies. Therefore many scholars assume that the manager establishes his own individual or personal probabilities subjectively, and constructs a payoff table which may be unique in the sense that other observers might enter completely different payoff probabilities in it. In order to draw up such a payoff matrix, the manager must base his probabilities upon some criterion, such as the Laplace criterion.[9] One the criterion is selected, the matter of deciding on strategy resembles that described above for risk.(Hart 1942, 110-118).

[9] In Laplace criterion because the probabilities of future states of nature are unknown, they are assumed to be equal (McGuire 1964, 125).

CHAPTER 3. METHODOLOGY JUSTIFICATION

In the previous chapter the theoretical background of this study was presented. The formal definitions of static/dynamic games of (in)complete information were analyzed and the basic terminology of economic theory was introduced. This literature review forms the basis of models and conclusions presented in this study and was essential for the understanding of the research articles presented in the chapters 4-7.

Chapter 3 is also crucial for this study, because the methodological issues form the common threat of the whole study. Methodology provides important guidelines for any study and makes it easier to follow the logic of a certain study. In chapter 3.1 we will show why the game-theoretical approach was selected and its suitability for our purposes will be examined. In chapter 3.2 the limitations of the game theory will be discussed. We will return to general methodological limitations of this study in Chapter 8.2.

3.1 Why Game Theory?

Game theory provides a taxonomy for economic context and situations based on the strategic form. You may think that the strategic form taxonomy is too weak to be much of a use because most of the situations have a dynamic aspect that the simple strategic form games miss. However, the great successes of game theory in economics (marketing) have arisen in large measure because game theory gives us a language for modelling and techniques for analyzing specific dynamic competitive interactions.(Kreps 1990a, 37-39).

Moreover, the major successes have come primarily from formalizing common-sense intuition in ways that allow analysts to see how such intuitions can be applied in fresh context, permit analysts to explore intuition, and extend it to slightly more complex formulations of situations.(Kreps 1990a, 87-88). Generally the use of intuition as the basis for marketing problem solving is justified by the argument that marketing problems are of a non-quantifiable nature. However, the leaders and first movers in the modelling of marketing phenomena can pursue strategies not available nor transparent to managers lagging in the use of data. Game theory allows us to begin with an intuitive insight in one context and build out in two directions, either taking the intuition from one context to another or extending and probing intuition in somewhat more complex settings.

"Drawing on game theory and other strange techniques, (Tirole's) approach began to make sense of strategic behaviour that had seemed theoretically unmanageable." was wrote in a story about famous young economists in the Economist newspaper 24.12.1998. So far the papers have focused on one particular specification of collusive behaviour, appealing in particular to the simplicity of some strategies such as trigger strategies, or the continuity of reaction functions (Gasmi et al. 1992). Game theory provides us with the needed tools to cope with the dynamic strategic variables.

Successful game theoretic analysis contributes

- a unified language for comparing and contrasting common-sense intuitions in different context
- the ability to push intuitions into slightly more complex contexts
- the means of checking on the logical consistency of specific insight, and a way of thinking through logically which of our conclusions may change drastically with small changes in the assumptions.

These are not attributes unique to game theoretic techniques. Much of the benefit of mathematical modelling and analysis in marketing generally stems from these sorts of contributions. But if this is true in general about many of the useful mathematical models in marketing, it is especially true for virtually all of the game-theoretic models that have successfully contributed to our understanding of economic phenomena.

3.2 The Limitations of Game Theory

Game theoretic techniques require clear and distinct rules of the game yet the rules of the game tend to be taken too much for granted, without asking where the rules come from. And they do not consider very well whether the rules that prevail are influenced by outcomes.(Kreps 1990a, 91-100). Since the game theory hasn't been empirically proven, and will not get proven in this study either, this kind of theoretical assumptions possess a threat to the validity of the research results. We can never be certain, whether these quite fundamental assumptions really underlie the real world or whether they are just formally correct.

Game theory hasn't been especially useful when applied formally to contexts that are too far removed from its intuitive base, and it has not been successful in explaining or organizing the sources of intuition. In particular, it has left relatively untouched the following fundamental question of how do the exogenously given rules of the game evolve and change, and what to make of relatively free-form competitive interactions. In this study an attempt was made to clarify this question but without a unquestionable success. The question still remained unanswered even though we feel that we managed to move the curtain of shadow to some extent.

It would seem only rational, that the rules are actually influenced by the outcomes but in what way can be only guessed. The rules and rationality assumptions of game theory represent a weakness of its applicability in practise. One can't be without wondering if we are always truly rational in our decision making in a way that the game theory expects us to be. Clearly firms follow some rational rules in their games but what about the actions, that are so unconscious, that even an outsider can't always detect them. That is also one of the limitations of this study. We have most likely missed several variables that should have been included when modelling competitive behaviour. This might be because they can't be identified or because the game-theoretic methodology doesn't allow their inclusion.

Another problem of game theoretic techniques is that some important sorts of games have many equilibria, and the theory is of no help in sorting out whether any one is the solution and, if one is, which one is. The point is that in some games with multiple equilibria, players still know what to do. This knowledge comes from both directly relevant past experience and a sense of how individuals act generally yet formal mathematical game theory has said little or nothing about where these expectations come from, how and why they persist, or when and why we might expect them to arise.(Kreps 1990a, 125-130).

We must come to grips with the behaviour of individuals who are boundedly rational and who learn from the past – who engage in retrospection – if we are to provide answers to questions like when is equilibrium analysis appropriate, how do players select among equilibria, and how do players behave when equilibrium analysis is inappropriate. The literature provides us with many definitions of bounded rationality. Let me quote here the one by Herbert Simon (in Kreps 1990a, 151) who has said that boundedly rational behaviour is behaviour that is intendly rational, but limitedly so. That is, the individual strives consciously to achieve some goals, but does so in a way that reflects cognitive and computational limitations.

The importance of coming to grips with bounded rationality is obvious from the example of chess; we must take into account the cognitive (in)abilities of the participants in competitive situations if we are to separate out situations where the participants are able to evaluate all the options that they consider they have from those where they cannot.(Kreps 1990a, 152-153). When we model a competitive situation by simplifying some options and ignoring others, we are using our instincts and intuition to guess how the participants themselves frame the situation they are in. Insofar as their frame is determined by their cognitive (in)abilities, we are taking their bounded rationality into account implicitly if not explicitly.

We have seen that in the game which includes as a subgame the greatest-integer game, it might be useful to formalize the notion that pieces of a game might have a self-evident way to play, but that other pieces might not. For the game with the greatest-integer subgame, and more generally if we think of 'economic life' as a very complex game in which only some relatively isolable pieces have evident ways to play, we might want a solution concept that allows part of the solution to be evident and other parts not. The concept of a Nash equilibrium may well be too constraining, and any programme of justifying or explaining the Nash concept should be critical, willing to abandon the concept in cases where it asks for more than is reasonable.

Moreover, there are nonequilibrium (disequilibrium) and equilibrium notions in formal game theory but game theory does not offer much at all of this middle ground.(Kreps 1990b, 529-531). The two extreme notions can be seen deriving from the natural sciences, in which it is said that the materia always tries to get on its lowest energy level, and in this way search for equilibrium in a constant inertia. Any other state different from equilibrium is seen as nonequilibrium. Presumably, periods of disequilibrium are those periods in which players begin with different expectations and are trying to learn what to expect of others. Hence it would seem clear that the behavioural specification of the learning process will strongly colour the flow of disequilibrium actions. And, therefore, according to Gibbons (1992a) researchers who dare to make predictions of such periods without resorting to some equilibrium model with hyperrational agents will be accused of ad hockery.

A middle ground case in this study might be for example the collusive behaviour in which there are different equilibria for different players and to the best equilibrium will be arrived after a repeated game. In many economic contexts, such a middle ground theory is tremendously important and yet the methodology in hands isn't much of a help in such situations because it has depended so heavily on equilibrium analysis.

CHAPTER 4. PAPER #1:

WHO'S AFRAID OF THE BIG BAD WOLF: WHEN PREDATOR BECOMES HUNTED[10]

Abstract A firm's actions in one market can change competitors' strategies in a second market. This paper models what happens when, due to the variations in competitive and cooperative positions, a market leader finds itself in the follower's position, and vice versa. Such a case would occur in a multimarket oligopoly, in which the pioneer's adoption of follower/leader role with respect to a marketing mix variable raises competitive reactions. Such situations are characterized by asymmetric[11] and strategic competition, and therefore a noncooperative game theory is a good way to study them.

(Competitive Strategy; Asymmetric Market-Share Models; Game Theory)

1 Introduction

Academic research in competitive strategy is almost as exciting as competition itself. The generic competitive strategy problem has several competitors, 1,…,n, each of whom chooses of some marketing-mix variables to maximize its objective function. In game-theoretic terms, a strategy is a complete specification of the firm's actions in

[10] Institute for Operations Research and the Management Sciences INFORMS Conference, 7.-9.11.1999 Philadelphia.

all the contingencies it may find itself in. The competitive situation arises because firm's i demand function D_i is a function not only of its own strategy s_i, but also competitive strategies s_j ($j \neq i$) (Oster 1994, 122-126). For example, in so-called Stackelberg game in which one firm moves and commits to its strategy before the others - with the others observing the first firm's move - the strategies of the followers must consider every possible move of the leader.

Changes in a firm's opportunities in one market may affect its profits by influencing its competitors marginal costs in a second market. In the same way, if the two markets exhibit joint economies and the products are regarded as strategic substitutes or complements, changes in competitors' strategies will raise or lower profits (Stenborg 1996). This strategic effect on profits exists in virtually any oligopolistic setting, including price competition, and collusive behaviour (Bulow et al. 1985).

Asymmetric information coupled with strategic interaction often results in inefficient outcomes. Therefore the contracts may be used as devices enforcing cooperation and as punishments. The problem with contracting is often the high threshold in information revelation (Schelling 1980, 124,132). Player i could describe her opponent j in details her own type t_i but player j has no way of knowing, if any of that is true. However, if player j tells detailed information to player i about her type t_i, player i has to conclude that j knows her (Salonen 1995, 3-5).

[11] Competition between two brands is said to be asymmetric when one brand gains more from a price reduction than the other one (Sivakumar, 1997).

2 Switching Costs in Competition

In many markets, there are significant switching costs for consumers in moving from one brand to a competing brand. One source of this switching cost is learning cost. As a result of all the switching costs, a customer will be more loyal to a certain brand (Besanko et al 1996, 538-539). Switching costs segment the market into submarkets. The resulting noncooperative equilibrium looks the same as the collusive solution in an otherwise identical market with no switching costs (Klemperer 1987). With switching costs it is sufficient to agree not to price discriminate in favor of competitors' consumers which agreement may be easy to monitor and enforce.

Thus switching costs can be thought of as making collusion easier. In prescriptive game theory it is often required that various things are common knowledge: the rules of the game, the preferences of the players over the outcomes, and the players' beliefs about chance moves in the game (Binmore 1997). For example, all Nash equilibria in the N-times repeated Prisoners' Dilemma result in each player defecting at each stage with probability 1. However, this conclusion evaporates if the value of N is not common knowledge (Binmore 1991, 10).

An entrant may shift the elasticities of incumbents, thereby affecting their reactions and complicating the prediction of competitive response (Gatignon et al, 1989). The pioneer's role in its competitive game with the late mover (e.g. leader or follower) may significantly influence the pioneer's response and the outcome of the competition. Shankar (1997) defines four classes of factors, of which the pioneer's response to a new entry depends: the market demand conditions, the pioneer's characteristics, the competitive structure and behavior, and the anticipated strategy and impact of the late mover. If the switching costs are noticable, it will be easier for the pioneer to ignore above mentioned four broad classes and simply retaliate while in the case of no switching costs, a nondominant incumbent is adviced to accommodate (Midgley et al. 1997).

3 Substitutes and Complements

The nature of competitive response is determined by the nature of strategic dependence (Moorthy 1992). In the case of strategic complementary (substitutability), an aggressive move elicits an aggressive (defensive) response, but with strategic indepence, there is no response at all. Even in this case, the firm's profits are still dependent on the strategies chosen by its competitors (Bulow et al. 1985). Sivakumar (1997) argues that the strategic independence mentioned above might be because of the products are in strikingly different price categories. For example, although economy brands compete among themselves, they have little influence on other brands according to Sivakumar (1997). So two different kinds of complementary and substitutability can be observed to exist: on a strategy and product level.

The strategically defined substitutes and complements will be analyzed in detail in this paper's chapter 4, because of their effect on the firm's reaction curves and therefore market share distribution. Let us now examine substitutes on a product level. For a consumer, who uses brands M and N, these two brands could be either independent or substitutes. To illustrate this possible (in)dependence of purchases we present the following equation

$$(1) \qquad Y_{MN} = \alpha_M Q_M \left[1 + \frac{Q_{NM}}{Q_M} \right]^{\beta_{MN}}.$$

in which $\qquad Y_{MN}$ = interpurchase interval between two successive purchases of M

α_M = time taken to consume one unit of brand M

Q_M = quantity of brand M bought at the first occasion

Q_{NM} = quantity of N brought during the interval

β_{MN} = parameter, measure of substitutability of N for M

According to Grover et al. (1988) if $\beta_{MN} = 0$, it implies that the buying of N has no effect on the buying of M. On the other hand, if $\beta_{MN} = 1$, M and N are perfect substitutes. Any values between 0 and 1 imply that A and B are imperfect substitutes.

The above model is illustrated in figure 4.1, from which it can be easily observed how the different values of β define the products' substitutability.

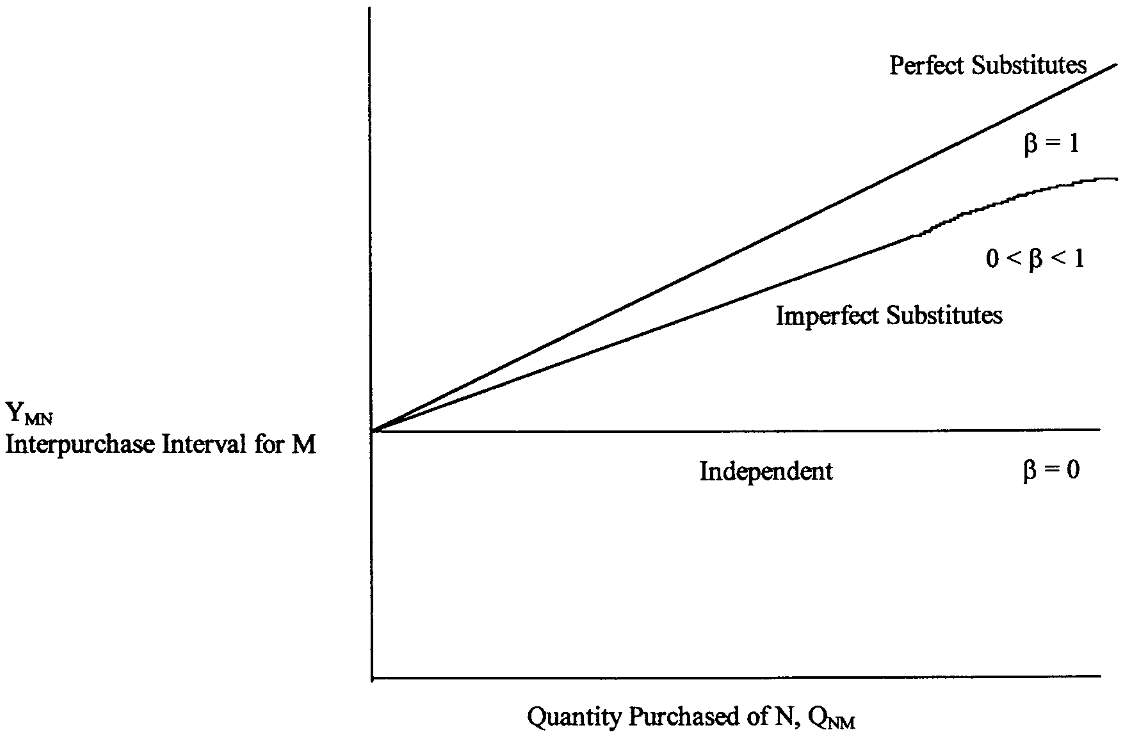

Figure 4.1 Substitutability of Two Competing Brands (adapted from Grover et al, 1988).

4 Predation as a Strategic Behaviour

Concentration is perhaps the most prominent aspect of market structure. For an industry producing a homogenous product, the concentration of sales is completely described by the cumulative distribution of sales or, equivalently, of market shares (Martin 1993, 164). Predatory pricing is a strategy that requires a dominant incumbent firm to cut price below rivals' average cost, even if this means accepting short-run losses, to drive rivals from the market. Game theoretic analyses of predatory behaviour suggest that the static models miss essential aspects of the phenomenon. Unless information is complete and reasoning power is unlimited, a dominant incumbent firm that engages in predatory behaviour in one market and time period can create an asset - reputation - that will allow it to extract profit in other markets and time periods.(Martin 1993, 74-85).

According to Kreps et al. (1982) deterrence may emerge as an equilibrium strategy if it is possible that the incumbent earns a greater payoff by fighting than cooperating, and entrants are uncertain about the incumbent's payoffs. The entrant earns zero if it stays out, loses money if it comes in and the (strong) incumbent fights, and makes a profit if it comes in and the (weak) incumbent cooperates. A strong incumbent always fights entry. A weak incumbent's strategy is

- to fight if $n > 1$ and $p_n \geq b^{n-1}$
- to fight with probability $[(1 - b^{n-1})p_n] / [(1 - p_n) b^{n-1}]$ and otherwise cooperate, if $n > 1$ and $p_n < b^{n-1}$
- to cooperate in the final period ($n = 1$).

Each potential entrant

- stays out if $p_n > b^n$
- stays out with probability $1/a$ if $p_n = b^n$

- enters if $p_n < b^n$.

p_n is the probability that entrant n assigns to the possibility that it faces a strong incumbent. The game begins with $p_N = \delta$, and p_n is updated whenever the incumbent's action provide additional information. The rule for updating beliefs forms part of the sequential equilibrium. Each entrant's equilibrium strategy maximizes its payoff, given beliefs and the incumbent's strategy whereas the incumbent's strategy maximizes its payoff, given beliefs and the entrants' strategies.(Kreps et al. 1982).

The incumbent's will and ability to fight the entrant varies in different periods of the game. For example, during period 4 the entrant stays out, if the probability of incumbent to fight is higher that the probability to cooperate. But as the entrant acquires more information about the incumbent, according to backward induction the equilibrium strategy for the entrant changes and he might learn that the equilibrium strategy e.g. for the period 3 is to come into the market. If the incumbent indeed cooperates in period 3, after one incident of uncontested entry, entrant believes the incumbent is weak and concludes that the incumbent does not fight entry either on periods 2 or 1, since to do so would involve an avoidable loss. If the incumbent still fights, then p_n rises and the entrant has an opportunity to update beliefs.

5 Competing for Market Share

Increased sales in the first-period increase market share and profits in the second-period. With switching costs in the second period, firms will compete more aggressively in the first period (Hunt et al. 1997). Let's assume, that in the period 1 firm i chooses its first-period strategic variable (v_{i1}) to maximize its total discounted future profits

(2) $$\pi_i \equiv \pi_{i1}(v_{i1},v_{j1}) + \lambda\pi_{i2}(\sigma_i(v_{i1}, v_{j1}))$$

in which
v_{i1} = firm's i first-period strategic variable
v_{j1} = firm's j first-period strategic variable (given)
π_{i1} = firm's i first-period profits
π_{i2} = firm's i second-period profits (can be written as a function of the firm's first-period market share σ_i)
σ_i = firm's i first-period market share
λ = random factor in first-period terms.

The higher value of v_{i1} represents more aggressive play so that $\partial\sigma_i/\partial v_{i1} > 0$. In noncooperative equilibrium

(3) $$0 = \frac{\partial\pi_i}{\partial v_{i1}} = \frac{\partial\pi_{i1}}{\partial v_{i1}} + \frac{\lambda\partial\pi_{i2}}{\partial\sigma_i} \cdot \frac{\partial\sigma_i}{\partial v_{i1}}.$$

Therefore, $\partial\pi_{i1}/\partial v_{i1} < 0$ when $\partial\pi_{i2}/\partial\sigma_i > 0$, from which it can be concluded that a firm with a higher market share in the first-period will be better off in the second-period. An example of this situation might be for example those banks, which offer customers under 25 years of age free banking services to induce them to open accounts (first-period) and get them used to electronic banking, and subsequently impose high bank charges to them after they fill 25 years (second-period) by which time the customers might have also other switching cost origins (study loans, bank based credit cards) besides convenience in banking.

On average, firms end up with no more market share as a result of this fiercer competition (Slade 1986) but for example in the case of a new market entrant, the aggressive first-period behaviour can be very rewarding resulting in higher profits and market share in the second-period. During the first period the entrant is clearly the challenger with zero market share but strategy management being successful, he will earn some market share e.g. by offering lower prices (and accepting the loses in profitability for the time being) and by the time of the second-period, he has become a serious threat and a very much potential competitor to the market leader and may cause many inconveniences. To be precise, Moorthy (1992) suggests that firms are hereby motivated to price promote in the first period, and charge monopoly prices in the second.

□ **Reaction Curves in an Oligopoly Market with Strategic Substitutes.** We have previously modelled the interpurchase interval in the case of substitute brands. It was concluded that a firm with a higher market share in the first-period will be better off in the second-period. Now let us examine, what happens when firm's *i* strategic variables are S_{i1} and S_{i2} and firm *j* simultaneously chooses its strategic variable S_{j2}. S_{i1}, S_{i2}, and S_{j2} can be though of as the quantities of output, amounts of advertising that the firms choose, or the inverses of prices charged[12].

If we adjust S_{i1}, S_{i2}, and S_{j2} near the Nash equilibrium according to the usual rule $S_{ij,12} = \partial\pi_{ij} / \partial S_{ij,12}$, in which π_{ij} represents the change in the marginal profitability to the firms being a bit more aggressive towards each other when the other one becomes more aggressive, we see that if marginal revenue exceeds marginal cost, the corresponding strategic variable should be raised. Thus if $\partial^2\pi_j / \partial S_{j2}\partial S_{i2} < 0$, firm *j* regards its product as a strategic substitute to *i*'s, and if $\partial^2\pi_j / \partial S_{j2}\partial S_{i2} > 0$, firm *j* regards the products as strategic complements.

[12] Because low prices are a sign of aggressive play, S_{i1}, S_{i2}, and S_{j2} , and can be thought of as the inverses of prices charged.

Figure 4.2 illustrates the strategy of firm i in market 2 as a function of firm's j strategy (S_{i2} (S_{j2})) and the strategy of firm j as a function of firm's i strategy (S_{j2} (S_{i2})). The Nash equilibrium is at point N. If S_{i2} is reduced, firm's j marginal profitability is increased and S_{j2} will be raised, and vice versa. If $\partial\pi_j$ / $\partial_{i2} < 0$, firm j earns less total profits if firm i adopts a more aggressive strategy. This is the case with substitutes. Similarly, with complements if $\partial\pi_j$ / $\partial_{i2} > 0$.

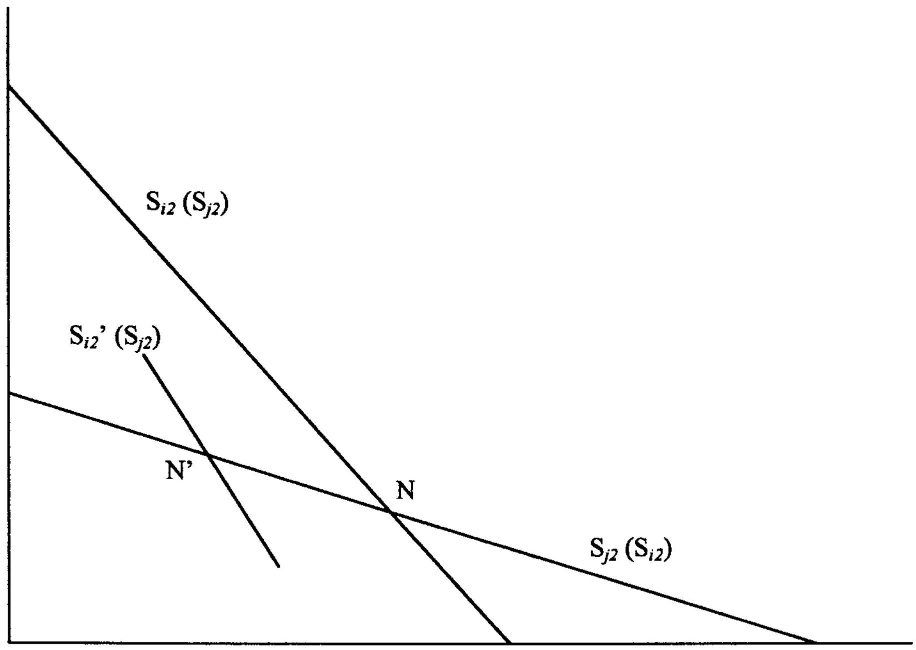

Figure 4.2 Reaction Curves in an Oligopoly Market with Strategic Substitutes
(adapted from Bulow et al. 1985)

Even if costs were unrelated across markets, $\partial^2\pi_i$ / $\partial S_{i1}\partial S_{i2}$ would generally be nonzero if demands in the two markets were interrelated (Banker et al. 1998).

Kadiyali (1996) has verified that colluding on both prices and advertising produced higher profits than a game in which only on advertising has been colluded. Therefore the firm's would be better off with the noncooperative equilibrium already in the first-period. This could mean, for example, splitting the fixed costs of quality improvement equally or preferring cooperation to competing but this being the case, the relative price responsive strategies should be conducted with caution.

6 Conclusion

This paper examined the variations in competitive and cooperative positions the market leader finds itself in the follower's position, and vice versa. In the multimarket oligopoly, the pioneer's adoptation of follower/leader role with respect to a marketing mix variable raises competitive reactions. A game-theoretic approach was used to model the characteristics of this ever on going competition. If the two markets exhibit joint economies and the products are regarded as strategic substitutes or complements, changes in competitors' strategies will raise or lower profits. To cope with these situation, firm's can use substitutability and complementary strategies.

We have gained insights into why and how firms retaliate and accommodate. In markets with significant switching costs, a noncooperative equilibrium looks the same as the collusive solution in an otherwise identical market with no switching costs. Therefore if the switching costs are noticable, it will be easier for the pioneer in the market to ignore the late mover's strategic moves in competition while in the case of no switching costs a nondominant incumbent is adviced to accommodate. However, it is not in this paper's spirit to take a stand, what are the optimal ways of creating switching costs.

We were interested in the firms' strategic substitutes and complements in terms of marginal profits. It was concluded that if the firm i reduces its strategies, firm's j marginal profitability and strategies will be increased, and vice versa. With strategies we meant mainly advertising, and pricing decisions. Moreover, as the reaction curves of firms are downward sloping, in the case of substitutes (complements) firm j earns less (more) total profits if firm i adopts a more aggressive strategy.

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CHAPTER 5. PAPER #2:

CAN *YOU* SPARE A DIME? PRICE WARS IN AN OLIGOPOLISTIC MARKET[13]

Abstract It has been claimed that firms use price wars to learn about changed conditions in the market so that they can calculate the new stationary Nash equilibrium. Supergame[14] models of tacit collusion show that supportable price-cost margins increase with expected future collusive profits, ceteris paribus. One would assume, that this is the state of art in markets, where symmetric oligopolists produce quite a homogenous product and use prices as a strategic variable. The prices are carefully observed by all but still seemingly unrational price wars occur. In this paper we analyze the dynamic pricing in such a market and an attempt to model a price war behaviour as an equilibrium strategy of a repeated game will be made.

(Price Wars; Repeated Game; Supergame Models)

1 Introduction

There has been a long tradition of static and dynamic models aimed at analysing the more complicated price-setting behaviour in collusive and noncollusive situations (Deligönül et al. 1996). In theory, when the strategies that underlie tacit collusion are

[13] International Atlantic Economic Society IAES Conference, 14.-21.3.2000 Münich.

[14] A supergame is a game that is built up out of repetitions of some simple component game (Martin 1993, 592).

credible, a stationary-equilibrium price/quantity vector is observed in every period. In practice, price war behaviour (disequilibrium) is frequently observed. For example Borenstein et al. (1996) has suggested that departure from single-period Nash behaviour may be more common than is usually suggested by studies focusing on tight oligopolies.

In oligopolistic markets, the micro theory no longer supports the use of a supply curve, and deterministic market solutions based on costs and demand alone are not possible. The reason is that the members of an oligopolistic industry are not price-takers but price-setters (Mulhern et al. 1995). Particularly short-run variable costs are normally seen to provide a reasonably solid lower bound to pricing behaviour. However, in the oligopolistic markets other factors such as explicit/implicit behaviour rules developed by the oligopoly itself, can contribute to pricing strategies well above marginal cost.(Hartman 1982).

While collusive monopolistic pricing is clearly more desirable to the oligopoly, the ability of the oligopoly to impose any of these strategies depends upon market conditions and, in some markets, government intervention (Gabor 1977, 103-106). The empirical literature supports the notion that prices are more stable in oligopolies. Whether the oligopolies with customers or customers, hedgers, and speculators are more stablized in their pricing, is still being debated. However, because both horizontal concentration and vertical integration have declined in many markets, recycling has grown, extent of both international integration and government participation has risen, price volatility has increased.(Slade 1991).

2 Price Instability

Slade (1991) sees increased price instability as a problem. Factors affecting price (in)stability on the supply side of the market include cost stability, recycling activity, and by-production. Cost is also clearly an important determinant of pricing. Fixed and variable costs might cause managers not to adjust prices continuously and fully (Berry et al. 1995). Price instability can be measured for example by using the variance of price, the coefficient of variation of price, or the variance of percent changes in price, of which the variance of percent changes in price is perhaps the best measure of instability. For example, the variance of price depends on units of measurement and is therefore inappropriate for making comparisons across commodities. The coefficient of variation, on the other hand, cannot distinguish between random price movements and systematic trends (Nooteboom 1986).

There are lots of Nash equilibria in the repeated game. The intuition is that infinitely repeated play gives players many opportunities to device creative punishments to enforce payoffs. One of the punishments used is an extremely low price for everyone immediately after a defection, after which everyone returns to the collusive price until the next episode of cheating[15] and punishment. This is considered to be discontinuous punishment behaviour (Moorthy 1992). The collusive equilibrium might also have a so-called trigger price, such that only if the market price dips below that, is punishment action taken (Mariotti 1997). The ultimate price equilibrium is less collusive than joint-profits-maximization, but more collusive than noncooperative single-period behavior (Ferson et al. 1995).

[15] With cheating we mean a deviation from common positions in the game, to which all the players on the market have silently agreed on.

Price war may be also triggered because of changes in the demand conditions or market shares e.g. because of a new entrant (Slade 1986). This kind of behaviour leads to the phenomenon of periodic price wars, which are considered to be continuous. Slade's (1989) data support a continuous-reaction-function model, in which a firm's price changes are related continuously to rivals' previous-period price changes. However, as long as the discount factor is in some intermediate range, the collusive arrangement that can be sustained has the firms charging below the monopoly price during boom times and at the monopoly price during bust times (Slade 1991).

3 Models in Price Dynamics

It has been estimated, that for a business of extracting exhaustible resources a specific discount rate is $\delta_i = r + \rho_i$[16], in which r is the risk free interest rate, and ρ_i (varies depending on the firm) is the excess return required to compensate for the particular risks that the specific *i*th firm assumes. For example for the oil industry an average discount rate is about 11%[17].(Malliaris et al., 1990).

In the constituent game, strategies for each player consist of a choice of price p_i (price charged by the *i*th firm), where $p_i \geq 0$. Payoffs are the profits π that each firm earns, which depend on all the prices chosen. Demand functions are considered to be linear and price is measured above constant marginal cost, so that $p_i = 0$ when price equals marginal cost. Therefore

[16] $\rho_i = \beta_i (r_M - r)$, in which β_i is a measure of the covariance between the market rate and the return on the particular asset in question, r_M is the expected return on a diversified portfolio of assets (market return) and r is the expected risk free rate of interest.
[17] Brealey et al. (1981) estimated, that the real risk free rate is approximately 2%, $\beta = 1.07$ for the oil industry and $r_M - r = 8.8\%$.

(1) $\pi(p_i, p_j) = p_i q_i = (a - bp_i + cp_j)$.

It can be easily seen that the Bertrand-Nash solution to the constituent game is

(2) $p = a / (2b - c)$,

(3) $q = ab / (2b - c)$, and

(4) $\pi = a^2 b / (2b - c)^2$.

If we want to capture the notion that a permanent structural change has occurred in the industry and that the old strategy is therefore no longer an equilibrium, we must assume that the dynamics inherent in the model determine behaviour until the new stationary Nash equilibrium is reached.

For the repeated game, the constituent game is repeated a countably infinite number of times (Firth 1993). It has been debated, whether in the oligopolistic markets the use of infinite game is acceptable. Some research streams consider an oligopoly to end after a certain period of time and therefore claim, that the infinite game approach is not valid (Dufwenberg 1995, 7). However, in this paper an oligopoly is seen to last for an unpredictable period of time, which means that even though it might end one day, since the date is unknown, the market resembles so much an ever going on situation and therefore an infinite game can be applied.

In the repeated game, a strategy for player *i* is a set of functions that map the history of play prior to period *t* into the chosen price p_{it} (Dufwenberg 1995, 16). Formally, strategies are sets

(5) $\{f_{it}\}$ where $f_{i0} \in I := [0, \mu p^M]$ and $f_{it} : (I \times I)^t \rightarrow I$

in which $p^M = a / 2(b-c)$ = the monopoly solution to the one-shot game

μ = positive integer.

The payoff Γ_i to each player is then its discounted stream of single-period profits

(6) $$\Gamma_i := \sum_{t=0}^{\infty} \delta_t \pi_i(p_{it}, p_{jt})$$

in which p_{it} = firm's i price at the certain time t

p_{jt} = firm's j price at time t

$\delta_t = 1 / (1 + \rho)$ = common discount factor at time t
ρ = discount rate

π_i = positive integer.

When firm i changes its price by an amount Δp_i, firm j responds next period with a price change $\Delta p_j = R\Delta p_i$. There is some probability R that a price change will be matched in the following period. Hartman (1982) has shown that if it is matched, it is matched exactly. The majority of researchers, however, tend to believe, that the matching doesn't have to be exact but with continuous strategies small (large) deviations lead to small (large) punishments (Saajo 1996, 57[18]), in which continuous-reaction functions can be Nash equilibria of supergames (Friedman 1968).

[18] Saajo (1996) has collected quite an extensive literature review, which includes price war models e.g. from Green and Porter, Rotember and Saloner, Slade, Klemperer, Maskin and Tirole, and Eaton and Engers.

4 Endemic Price War

Assume the oligopoly faces a known group demand curve and the costs and demand are given. The oligopoly prefers to develop a limited number of pricing/production strategies and to choose one in order to maintain the price discipline characteristic of a mature oligopoly. The three resulting pricing/production strategies can be observed from figure 5.1.

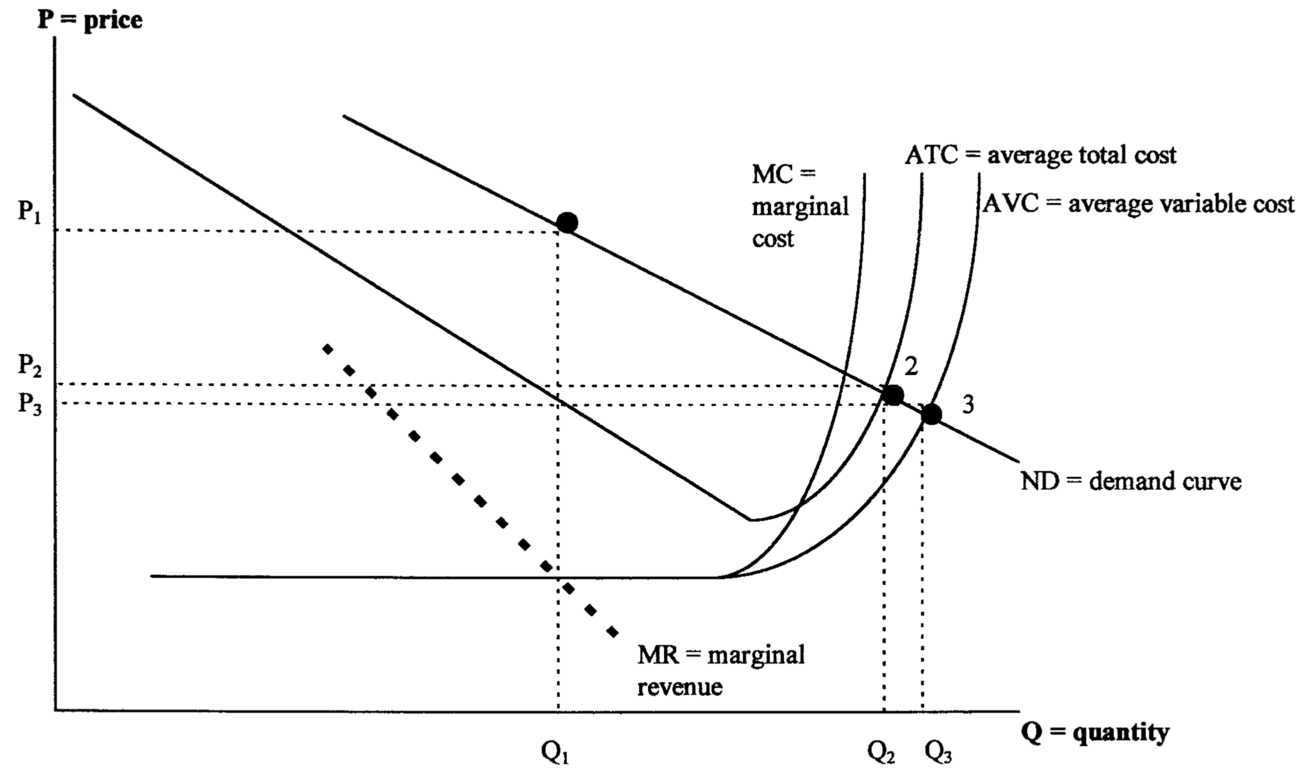

Figure 5.1 Oligopoly Pricing and Production Strategies (adapted from Hartman 1982).

The short-run, static upper-bound on price is assumed to be the collusive monopolistic strategy, in which MR = MC. This pricing/productions strategy would be desired and imposed by the oligopoly. It would involve perfect collusion and perfect profit-sharing agreements. Full-cost pricing, in which P = ATC is assumed to characterize the normal behaviour of some oligopolies. In this strategy ATC includes AVC plus average fixed costs AFC. The lower bound on price in a given period is identified as the strategy equating price and AVC, in other words in this average variable cost pricing P = AVC. While this reflects a real short-run pricing option, a firm cannot price at this lower bound for long.(Hartman 1982).

In a longer run pricing on the level P $\leq$ AVC may be considered as price war pricing. The period of time how long a firm can go on with this strategy, depends on many things among market and company structure, and what is the margin between price and the average variable costs. If P - AVC is large, the losses in profits are also large, and a firm can continue pricing on price war level P $\leq$ AVC only for so long.

Let's work on a bit more with the equation (6). As you recall, the strategy for the *i*th player in the repeated game is a choice of price to play in every period and can depend on the history of the play. During wars firms are said to aim at the expected values of their Bertrand-Nash prices for the new one-shot game. Expectations about the new demand conditions are updated in each period as new price-quantity combinations are observed (Slade 1987). Behaviour during wars is thus described by

(7) $$\Delta p_{it} = \Delta E\,(p_{in} \mid \Omega_t) + \eta_{it}, \qquad i = 1,\ldots,M$$

in which Δ denotes a first difference,

E is the expectation operator,

Ω_t is the information available at time t, and

η is a random disturbance.

Contemporaneus price changes will be correlated as players use the same information to update their expectations. Players may thus appear to be moving in tandem.

According to Slade (1987) firms will not react to rival previous-period price changes and yet according to the very basic ideas of game-theory, firms have a memory of an elephant and e.g. past reputation is said to affect their future decisions. I believe that firms in fact do react also on a psychological level to rival previous-period price changes. I base my opinion on several interviews that were conducted in one homogenous oligopoly, and according to those results at least in that specific market, all the firms said that they do take into account the rival previous-period price changes once in price war towards each other and try to exploit that for the best of their knowledge.

If we insert the price war behaviour previously modelled in to the figure 5.1, which was about pricing and production strategy option in general in an oligopoly, we get the following kind of interpretation presented in figure 5.2. In the figure 5.2, P_{wi} is the average price charged by player i during a price war and P_{ri} is the price that the same firm will charge when the war is over. There is a unique fixed point for equation (7), which is a stationary Nash equilibrium for the supergame with payoffs given in equation (6). In figure 5.2 this Nash equilibrium can be found in point N, in which P = MR = MC, which is collusive monopolistic pricing. During the price war period, when prices are below the production costs, firms move along their reaction functions in tandems up and down learning from the changed market situation and trying to locate the Nash equilibrium, after which they start charging higher prices and recouperating from the profit losses.

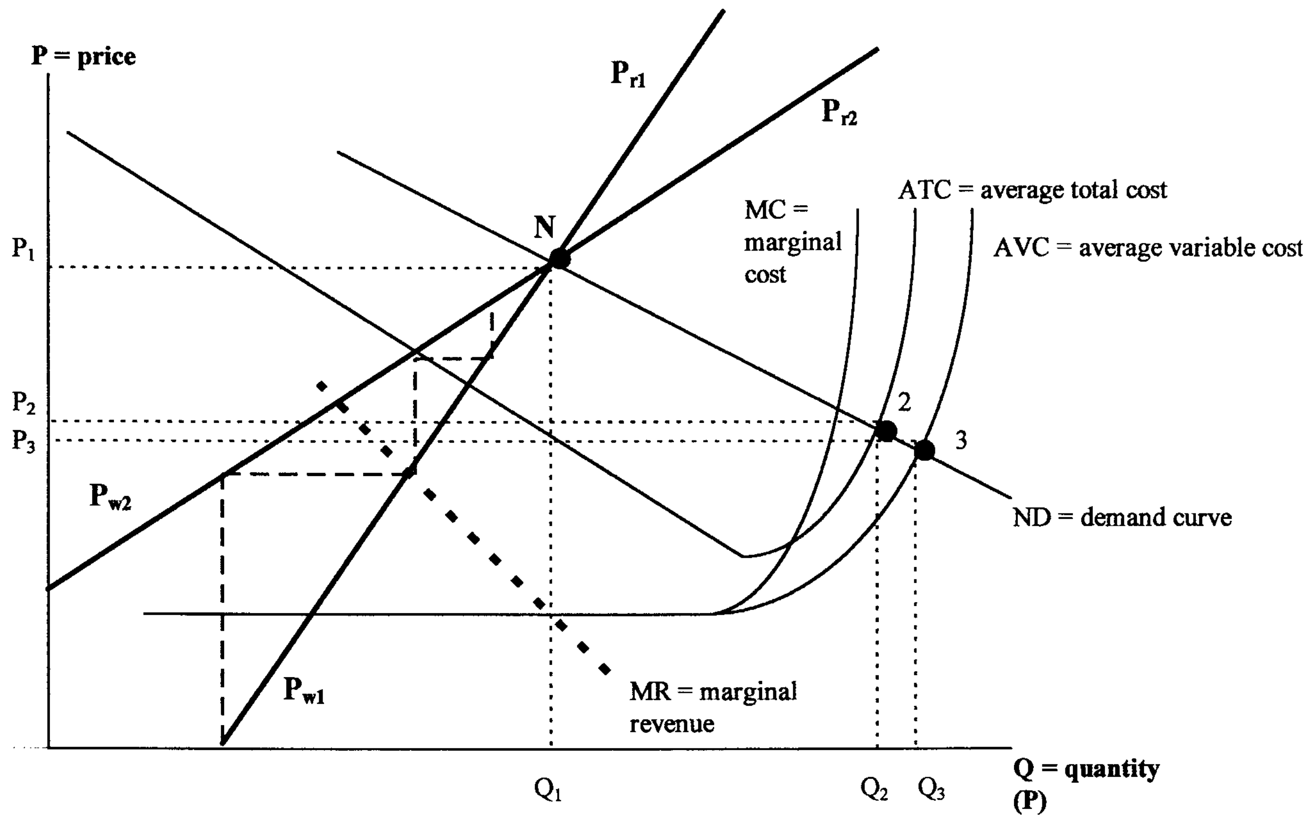

Figure 5.2 Intertemporal Reaction Functions Reflected to Oligopoly Pricing and Production Strategies

5 Conclusion

In this paper the dynamic pricing of one oligopoly was analyzed and the pricing behaviour during price wars was modelled in comparison to the regular oligopolistic pricing and production strategies. In oligopolistic markets different kinds of behavioural rules may contribute to pricing strategies well above marginal cots. While collusive monopolistic pricing was shown to be clearly the most desirable choice to the oligopoly, price wars tend to occur from time to time. The debate, whether they can be modelled as infinite games, will probably go on also after this paper, but we saw it as a reasonable approach, and so the constituent game of *N*-players played repeatedly was used as the basis of the analyses.

There are several reasons why price war occur. Among them, for example, demand shocks, the new distribution of market shares after an entry, learning about your fellow competitors, and method of punishment. Usually while punished, the starter of the punishment also gets it, but how badly, depends on his cost structure, resources, and so on. Surely in a long-run, price war can never been seen as constructing or profitable bur rather destructive and demolishing behaviour, which leads to many profit losses before the Nash equilibrium is reached.

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CHAPTER 6. PAPER #3:

TOWARDS A BETTER UNDERSTANDING OF COMPETITIVE BEHAVIOUR[19]

Abstract It has been argued that managers should react to changes in marketing activities for other brands only if those changes have nonzero effects on their own brands' market shares. Theory and limited empirical evidence suggest that a firm with a reputation for being a credible defender of its markets should deter competitive attacks against it. We study the relationship between competitive effects and firm's market position. We are also interested in modelling competition appearing in cycles; what happens when manager's competitive cognition about his opponents' leads to under/overreactions. This study will shed light into the competitive behaviour of firms and perhaps help managers to avoid an unproductive competition and to find more optimal competitive responses.

(Under/Overreactions; Optimal Competitive Responses; Market Share Equations)

1 Introduction

It has been argued that the competitive environment becomes increasingly dynamic. Due to that managers need fresh perspectives and a sharply tuned understanding of the true nature of competition. Managers find themselves haunted by the interactions between their decision and other people's decision: in order to decide what you should do, you must reason through how they are going to act or react. Knowledge about competitive reaction effects allows management to determine whether the net effect of a promotion or other competitive tool is expected to be positive.

Firms constantly undertake offensive and defensive actions in pursuit of competitive advantage and tend to respond to rivals' adjustments of their marketing mix (Chen et at. 1992). The firms' marketing instruments may also depend on the predicted values of the competitors' marketing instruments. A reduction in sales for one brand may be offset if another brand retaliates. Thus the actual benefit due to the increased marketing activities depends crucially on the nature of competitive reactions.(Mattila et al. 1999).

It has been found that the market shares tend to be stationary, but sales are evolving (Kaul et al. 1992). In this paper we will focus on examining market share equilibrium in the context of competitive interactions. Kaul et al. (1992) has claimed that the maintenance of market share equilibrium in response to short-run deviations of competitive variables from competitors' equilibrium levels does not require offsetting responses if the effects of variations of the marketing variables die out over time. However, it is possible when competitive variables influence an evolving series for temporary changes in a competitive variable to have long-run or even permanent effects.

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[19] Academy of Marketing Science AMS Conference, 24.-27.5.2000, Montreal.

2 Competitive Cognition

Firms know the future values of their own marketing instruments but the competitors' marketing instruments are unknown and must be predicted (figure 6.1) either by using a naïve or sophisticated models (Alsem et al. 1989). The standard game theoretic rationality and knowledge assumptions (common knowledge of rationality CKR) assume that the players are rational in the sense that they always seek to maximize their own individual expected utilities, and that this is common knowledge in the game. The specification of the game, including the rules, the players' strategy sets, and the payoff functions, and every proposition that can be proved about the game by logical reasoning, are assumed to be common knowledge in the game as well.(Colman 1997).

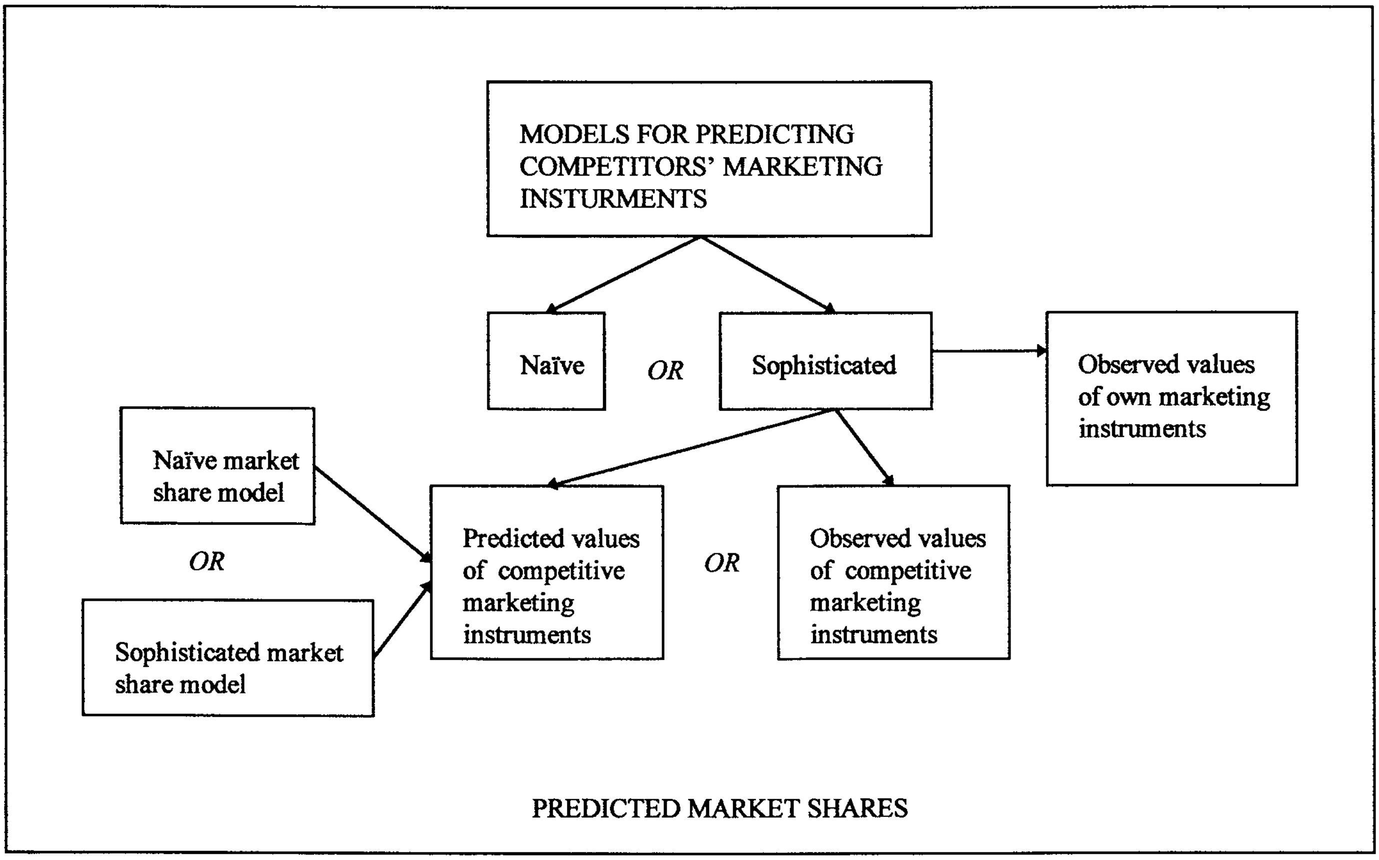

Figure 6.1 Forecasting Competitive Behaviour and Market Shares (modified from Alsem et al. 1989)

An understanding of competitive reaction effects as well as of consumer response effects is required to determine whether a marketing initiative will or will not increase expected performance (Poulsen 1990). A firm's performance can be enhanced through meaningful differentiation with marketing activities consumers care about. The long-term opportunity for differentiation depends, however, on competitors' abilities and willingness to react (Leeflang et al. 1997).

A firm can gain a reputation for strongly defending its markets that then deters rivals from engaging that firm in its markets. The psychological aspects of how a decision maker might form an impression of his or her rivals relate to a given rival's perceived willingness and ability to fight (Stenbacka 1987). While the theory of deterrence seems compelling, empirical evidence is considerably more mixed. According to Clark et al. (1998) deterrence occurs only if the following two conditions are met:

- the attacker must believe that the defender is willing and able to fight (credible defender)
- the cost to the attacker due to fighting must exceed the value of the prize the attacker is fighting for.

Mathematical psychologists have attempted to examine the reputation and deterrence effects postulated in game theory through exploring predatory pricing, and sequential equilibria (Coombs et al. 1970, 168-175). Clark et al. (1998) list several cases, how firms perceive each other as competitors. Against the main stream of theory on the area, they found that a hypothesis "The more a firm is seen as a credible defender of its markets, the less likely it is to be attacked." to be true only for minor competitors and not at all supported for main competitors. However, hypothesis "The more successful a firm is, the more the firm will be perceived as a credible defender." was supported.

□ **Competitive Reaction Effects.** With competitive *action* (CA) we mean a change in a component of a marketing mix or in that components dimension, with competitive *reaction* (CR) we mean a change in a component of a marketing mix, which was provoked by the rival's decisions and aimed at compensating its alledged influence. Reaction can be defined as *response* as well. Managers should use the competitive reactions when aiming to maintain their brands' market shares. Competitive *effect* (CE) is referred as the total influence of the actions and reactions on the competing brands. That is,

(1) $$CA + CR = CE$$

If brand *j* reacts to *i*'s marketing activity, the total effect of brand *i*'s change in marketing tool *h* on brand *j*'s market share is

(2) $$\frac{\delta ms_j^T}{\delta u_{hi}} = \frac{\delta ms_j}{\delta u_{hi}} + \left[\sum_{l=1}^{kj} \frac{\delta ms_j}{\delta u_{li}} \frac{\delta u_{li}}{\delta u_{hi}} \right]$$ (Leeflang et al. 1996)

To decide, which one/s of the changes in marketing tools are worth responding to, and what tools should the respondant to use, a closer analysis of the situation is needed.

When an intense competition can be identified, all the competitive effects (cross market share, own market share, and competitive reaction effects) are nonzero. This means that brand *i* uses marketing tool *h* to restore its market share, which is affected by brand's *j* use of variable *l*.

No competitive reaction effects can be identified if $\eta_{ulj,\ uhi} = 0$, even though brand *j* should defend its market share by using effective marketing tool *l*. This is called underreaction. Underreaction may occure also when brand *j* hasn't reacted to recover the initial loss of market share with an efficient marketing tool.(Mattila et al. 1999).

In case of a zero cross market share effect (the market shares are stable even though some brand/s are introducing competitive actions, that is $\eta_{ulj,\ uhi} \neq 0$, competititive reactions effects should be absent. Underreaction becomes overreaction if brand *j* has reacted to recover the initial loss of a market share with an ineffective marketing tool. Overreacting is present also in a case, in which brand *j* sees the brand's *i* change in a marketing tool *h* as a part of the competition even though it wouldn't have cross market share effect nor own market share effect what comes to brand *j*.(Mattila et al. 1999). The above line of reasoning is illustrated in figure 6.2 modified from Leeflang et al. (1996).

□ **Reasons for Under/Overreaction.** Leeflang et al. (1996) have identified two main arguments why underreaction can be found. They say, that an underreaction happens, when managers have incomplete understanding of the competitive structure of a market or when managers have general rules of thumb about the relevance of promotional activities for each brand which do no depend on the specific type of the promotional instrument.

CROSS MARKET SHARE EFFECT
i = Attacker, j = Defender

	YES $\frac{\delta ms_j}{\delta u_{hi}} \neq 0$		**NO** $\frac{\delta ms_j}{\delta u_{hi}} = 0$	
	Competitive Reaction Effect		**Competitive Reaction Effect**	
OWN MARKET SHARE EFFECT	**YES** $\frac{\delta u_{lj}}{\delta u_{hi}} \neq 0$	**NO** $\frac{\delta u_{lj}}{\delta u_{hi}} = 0$	**YES** $\frac{\delta u_{lj}}{\delta u_{hi}} \neq 0$	**NO** $\frac{\delta u_{lj}}{\delta u_{hi}} = 0$
YES $\frac{\delta ms_j}{\delta u_{lj}} \neq 0$	Intense competition	UNDERREACTION: Brand j should defend its market share but does not react, even though instrument l is effective	Reaction occurs with an instrument that has an own effect, but no cross market share effect	No competition
NO $\frac{\delta ms_j}{\delta u_{lj}} = 0$	Unnecessary reaction with an instrument that is ineffective	No reaction effects and the own market share elasticities are equal to zero	OVERREACTION: Unnecessary reaction with an instrument that is ineffective	No competition

Figure 6.2 A Categorization of Combinations of Cross Market Share-, Competitive Reaction-, and Own Market Share Effects

About overreaction Leeflang et al. (1999) continues, that an overreaction takes more often place when managers have competitor-oriented objectives for their brands or firms. Managers, who overestimate the extent to which consumers compare alternative brands and managers who know more about the changes in competitive activities than about the effects of those changes on their own brand's market share, tend to also overreact more often. According to naïve reasoning it is believed, that it is more costly for the manager not to react when a reaction should have occurred than it is to react when a reaction was not necessary. This line of reasoning has led to a quite an extensive habit of overreacting among managers.

3 Modelling Competitive Behaviour and Firm's Market Position

The strategic gains and costs of commitments depend crucially on the nature of optimal reactions by the other players (Kirzner 1997). Capacity (Cournot) competition is an example of strategic substitutes where a higher strategy - larger capacity or output - by one player is matched with lower reactions by others, and vice versa. Price (Bertrand) competition is an example of strategic substitutes, where higher strategy - higher price - is met with higher reactions, and vice versa. In the Cournot case, lower strategies by rival players increase the principal's payoffs, while the opposite is true for the Bertrand competition.(Stenborg 1996). Thus the countervailing effects through simultaneous contracts by multiple players may more than offset the private benefits or costs of unilateral commitments (Epstein 1998).

In international business simulations it has been detected, that firms tend to get engaged with their behavioural patterns in a cyclical repeated game, in which the periods of demand, sales, and competitive effects follow each other in a certain order (Mattila et al. 1999). If e.g. a firm's competitive action raises only a demand or sales effect, a firm should retaliate from competitive response. Only the ones with competitive effect should be reacted to.

Suppose that brand *i* changes marketing tool *h* with an effect on its own market share (Leeflang et al., 1996):

$$\frac{\delta ms_i}{\delta u_{hi}} \neq 0 \qquad (3)$$

If there is a competitive effect present, the balance in market share balance will be affected. Managers ofter strive to preserve market share and therefore additional competitive reactions will occure. However, not alone the nonzero effect reveals the true nature of a situation. It might mean either one of the gain or the loss of a market share. To emphize more clearly the possible competitive nature of the changes in the marketing tools three more equations are needed.[20] We suggest that the marketing tool effect equations are valuable in describing the marketing tools in relation to the market shares and firm's sales.

Sum $\sum mt_i$ is allowed to vary depending on the amount of the marketing tools that will be included in the observation. That is on the other hand a subjective choice of the researcher. But the fewer of the changing marketing tools are incorporated, the more one needs to examine the true correlation coefficient between these marketing tools and market share. The correlation efficient can be used to explain how much of the variations in the market share can be explained with the selected marketing tool's change.

If the use of a certain marketing tool mix has a **primary demand effect** only, the following equations are valid:

$$\text{(4)} \qquad \frac{\delta Q_i}{\delta(\sum mt_i)} > 0 \qquad \frac{\delta m_i}{\delta(\sum mt_i)} = 0 \qquad \frac{\delta Q}{\delta(\sum mt_i)} > 0$$

$$\frac{\delta Q_j}{\delta(\sum mt_i)} > 0 \qquad \frac{\delta m_j}{\delta(\sum mt_i)} = 0$$

in which	the total industry sales is	$Q = Q_i + Q_j$
	firm's *i* marketing tools present[21]	$\sum mt_i$[22] $=$ Adv. + Price + … n
	firm's *j* marketing tools present[23]	$\sum mt_j$
	firm's *i* market share	m_i

[20] The marketing tools formulation was derived in details in Mattila et el. (1999).

[21] This includes *all* the possible variable in a certain firm's marketing mix, not just the ones that are changing but also the seemingly stable ones. The distiction between the including only the marketing variables that are changing to all the marketing variables will be done in a later phase in the evaluation of the competitive market situation.

[22] $\sum mt_i$ and $\sum mt_j$ are pure numbers representing the monetary value of the marketing tools and therefore they can't be to used to express solely the total number of the variables.

firm's j market share m_j

and assume $\frac{\delta Q_i}{\delta(\sum mt_i)} > 0$, $\frac{\delta Q_j}{\delta(\sum mt_j)} > 0$

If the use of a certain marketing tool mix has a **primary sales effect** only, the following equations are valid:

$$(5) \qquad \frac{\delta Q_i}{\delta(\sum mt_i)} > 0 \qquad \frac{\delta m_i}{\delta(\sum mt_i)} > 0 \qquad \frac{\delta Q}{\delta(\sum mt_i)} > 0$$

$$\frac{\delta Q_j}{\delta(\sum mt_i)} = 0 \qquad \frac{\delta m_j}{\delta(\sum mt_i)} < 0$$

If the use of a certain marketing tool mix has a **competitive effect**, the following equations are valid:

$$(6) \qquad \frac{\delta Q_i}{\delta(\sum mt_i)} > 0 \qquad \frac{\delta m_i}{\delta(\sum mt_i)} > 0 \qquad \frac{\delta Q}{\delta(\sum mt_i)} = 0$$

$$\frac{\delta Q_j}{\delta(\sum mt_i)} < 0 \qquad \frac{\delta m_j}{\delta(\sum mt_i)} < 0$$

Notice, that in the case mentioned last, both the market share and sales of a firm j will be diminishing as the monetary value of the marketing mix tools raises. So only and only this type of an effect can be referred to as competitive.

The equation clearly demonstrate that reacting to the change in one's market share is straightforwarded only so much. It wouldn't lead to a very productive reaction, if the reaction would occur solely based on the observed change in the market share equilibrium. The change might be resulting from something else than a competitive effect of the competitors marketing tools. Therefore it would be simplistic to claim, that every change in brand's j market share resulting from the change in brand's *i* marketing activity for instrument *h* should raise a reaction in *j*'s marketing activity to avoid market share loss. If and when the reaction is needed, it should be carefully assessed that the appropriate reason for the market share loss will be confronted with the appropriate tool.

The marketing tool effect equations are valuable in describing the marketing tools in relation to the market shares and firm's sales. They can be used to reveal the competitive nature of a market: brand *i* sales and market share are being dropped due to the successful competition strategy implemented by the brand *j* in its marketing decisions even though the equations don't suggest any reaction strategy, not to mention optimal reaction strategy.

The best-response function documents the firm's best response for each possible strategy combination of its competitors (Smith et al. 1989). The firm's best-response function for each of its strategic variables can be computed and the intersection of these functions represent the Nash equilibrium. In practice, this means computing the first-order conditions for each firm, and then solving these equations simultaneously.(Moorthy 1992).

The optimal response e.g. to firm's *j* use of advertising as the competitive tool, is not necessarely the use of firm's *i* advertising as the competitive tool as well but instead it should be determined depending on the case in hand, what in fact is the optimal reaction tool or method. The competitive tools need not to be corresponding and therefore we chose to use a notion of $\sum mt_i$ in the marketing tool effect equations instead of specifying it in one special marketing tool such as marketing, pricing, or product differentation. It may be said that firms would be better off acknowledging first by which competitors' actions their market shares actually are affected and then responsing only to those ones.

4 Conclusion

Firms constantly undertake offensive and defensive actions in pursuit of competitive advantage and tend to respond to rivals' adjustments of their marketing mix. In this paper an attempt was made to shed light into the complex competitive behaviour of managers. It was found that managers should react to only those competitive actions, that actually have an impact on their market shares. It is a false belief, that an overreaction wouldn't come costly on business when in fact it is just as harmful as underreaction can be. Whether the competitive actions can be avoided with larger organization or reputation of credible defender, is still being discussed.

Firms (should) know their own marketing instruments but in estimating the ones of their competitors, mistakes are common and lead to an unproductive competition. The strategic gains and costs in competition depend crucially on the nature of optimal reactions by the other players. What might be the Nash equilibrium for another player, might seem a competitive action to another.

We formed three sets of marketing tool effect equations to describe the competition in relation to firm's position on markets. They can be presented also in figures using real values from business, and in this way they can be used by managers to observe, whether some use of an marketing tool has only a demand or sales effect distributed equally on all the firms on the market or is their a competitive effect and diminishing market shares to be detected, which requires immediate actions.

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CHAPTER 7. PAPER #4:

TACIT COLLUSION IN OLIGOPOLY: YOU'RE DAMNED IF YOU DO AND DAMNED IF YOU DON'T[24]

Abstract Empirical findings suggest that players who meet daily to compete are better off in terms of profits if they cooperate rather than if they'd play their noncooperative strategies in every period. Those firms who are not playing the tacit collusion game on the market, face often a tremendous pressure from their fellow competitors. On the other hand, a governmental intervention in a explicit cartel -like tacit collusion is a constant threat hanging over the players. The prices are thought to be obvious to all the customers, competitors, dealers, and other observers. Preliminary results suggest that the optimal result is achieved if firms collude on both price and advertising.

(Collusive Models; Cooperative Behaviour; Game Theory)

1 Introduction

Competition is a driving force behind the dynamics of today's markets and the pressures on marketing managers to devise strategies that can cope effectively with changing market conditions. A few empirical papers have attempted to test for tacit

[24] International Atlantic Economic Society IAES Conference, 7.-10.10.1999 Montreal.

collusion. This line of research deals with the wealth of equilibria provided by game theory (Leeflang 1999a). So far the papers have focused on one particular specification of collusive behaviour, appealing in particular to the simplicity of some strategies such as trigger strategies, or the continuity of reaction functions (Gasmi et al. 1992).

Recent game theoretic work as well as experimental evidence has suggested that cooperation among players could emerge in repeated games context, even under the assumption of noncooperative Nash behaviour. Such a cooperation can be referred to as tacit collusion (Gaijsbrechts 1993). The noncooperative equilibrium in an oligopoly with switching costs may be the same as the collusive outcome in an otherwise identical market without switching costs (Leeflang et al. 1996). Repeated play enables firms to enhance their profits position vis-à-vis the noncooperative outcome of the one-shot game Nevertheless, industry profit is far from the monopoly level (Jacquemin and Slade, 1989).

In this paper the game described is noncooperative. Explicit collusion is rule out because in most of the industrialized countries binding agreements on price or output are illegal. However, when a game is repeated many times, solutions that have a collusive flavour can emerge (Cho et al. 1987). Cooperative periods in this kind of industry are characterized by identical prices for all the firms which are constant over time (Leeflang et al. 1985).

2 Managerial Rationality and Profit Maximization

Whereas the assumption of profit maximization may lead to accurate predictions of behaviour where competition is vigorous, it is not clear that this assumption should be carried over uncritically to firms for which the conditions of competition are weak. The treating of profit maximization as being the entire objective of the firm without regard for the conditions of competition in which firm operates, have been also a subject to repeated criticism. Indeed, a broader framework than profit maximization is needed to understand the performance of firms sheltered from the rigors of competition. However, the profit maximization hypothesis can be supported on grounds of self-interest seeking. The profit maximization hypothesis has continued to play a dominant role in economics both for the class of firms for which its *a priori* claims are clear and for the firms where its claims are less certain.(Cyert et al. 1963, 238-244).

A state of vigorous competition will prevent a management from manipulating the activities of the firm to conform to personal objectives. The absence of such competitive conditions will permit managers to pursue their own goals (Kannan et al. 1991). The first proposed line of behaviour requires that managers choose to operate the firm in a stewardship sense of attending to the stockholders' best interest by maximizing profits (Willner 1984). As the conditions of the environment become increasingly more severe, the firm will converge to profit maximization behaviour independent of the constraint (Slade 1988).

It has been found that the more farther apart on the affective scale the decision options that a manager has to take are, the shorter will be the judgement time in making a comparative judgement. Guilford (1954) has concluded that confidence and judgement time are functionally related, but the relationship is not a highly dependable one. He goes on describing their relationship by means of the hyperbolic equation

$$(1) \qquad T = a + \frac{b}{2C - 1}$$

in which T = judgement time

C = measured degree of confidence

a & b = constants.

The same relationship can also been described by an exponential relationship

(2) $$T = a\ (10)^{b(1-C)}.$$

In view of the mathematical equations proposed above, we may say that either variable, judgement time or confidence, changes more rapidly at lower levels of the other. The task now becomes one of selecting a set of variables that permits us to translate management's objective function into mathematical terms. The profit maximization relationships are here taken as given in Cyert et al. (1963, 246):

(3) $$\frac{\partial R}{\partial X} = \frac{\partial C}{\partial X}\ ,$$

in which P = price

X = output

R = revenue = P * X

C = C(X) = production cost.

The model preserves the results of the profit maximizing hypothesis under conditions of pure competition. Furthermore, it suggests that the production and pricing decisions are being made along lines consistent with profit maximization while the staff decision is not. But for firms that find themselves sheltered from the rigors of competition, a model drawn more closely along the lines of the aspects of managerial motivation neglected by the profit maximization hypothesis than along the lines of the profit maximization hypothesis may be appropriate.

3 Cooperative Behaviour

Recall that the collusive output is always a local optimum for each firm, even if the switching cost is not large enough for it to be a global optimum. If there are customers with switching costs arbitrarily close to zero, firms still have some incentive to chisel on the collusive agreement by slightly increasing their outputs. In case of no switching costs, this incentive is even more reduced, and the forces for collusion are correspondingly strengthened.(Klemperer 1987).

Since competition policy in modern economies typically makes it impossible for collusive agreements to be enforced in courts of law, it is tacit (noncooperative) collusion which attracts firms' attention. Tacit collusion is a joint restriction of output in which firms willingly engage because the losses that any single firm expects to follow defection from collusive behaviour exceed the gains from collusive behaviour (Kim et al. 1999). If collusive agreements cannot be enforced, then a cartel is internally (externally) stable only if every firm in (outside) the cartel earns a greater profit by staying in the cartel (fringe) than by joining the fringe (cartel), taking into account the way other firms would adjust their behaviour after its defection (Martin 1993, 98-99). The stability of a cartel is illustrated in figure 7.1.

Once rivals realize that the collusive agreement is being violated - or in other words cheating is taking place - it is implausible to expect that they will continue to produce their cartel outputs. In this case the firms are most likely to react with their prices, which are being dropped down one by one (Cavero et al. 1998). Once the collusive agreement breaks down either because of cheating or a third party intervention, all the firms, including the firm which initiated cheating, suffer lost profits (Shaffer et al. 1994).

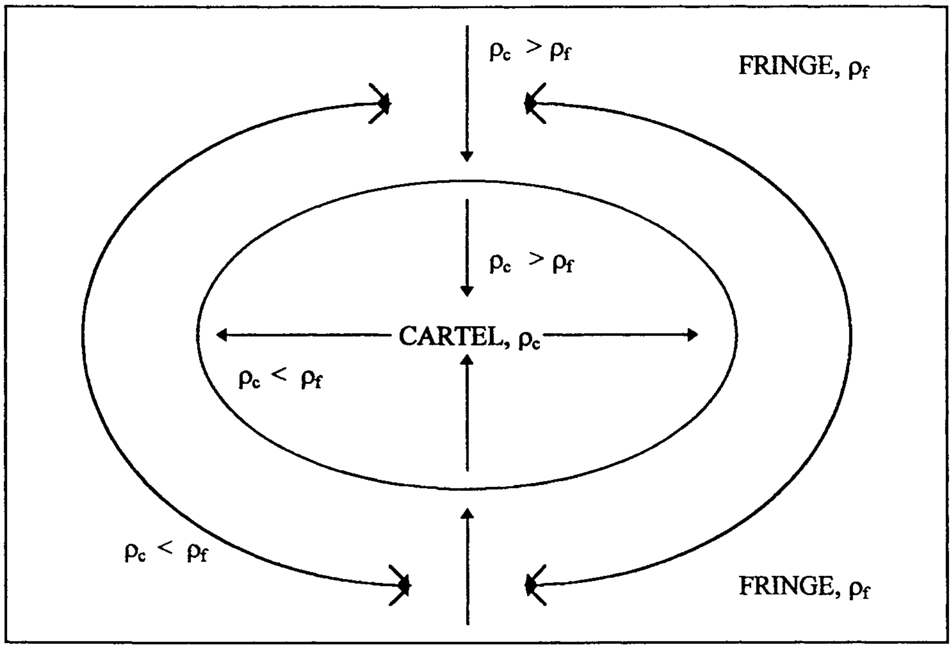

Figure 7.1 The Stability of a Cartel

Tacit collusion can be implemented as a Nash equilibrium of a dynamic game. Any individually rational outcome of the constituent game can be implemented as the Nash equilibrium of an associated repeated game (Slade 1987). The firms have many options in their collusion. In the case of total collusion without compensatory transfers amounts to maximazing a weighted average of both firms' profits with respect to prices and advertising expenditures. The alternative option is that firms first collude on advertising (pricing) knowing that they will later compete on prices (advertising).(Erickson 1995).[25]

[25] Kadiyali (1996) proved, that firms are better off colluding on both prices and advertising already in the first-period of the game.

4 Existence of Collusion

Adam Smith (1776, 144) wrote that

> "People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices."

In the case of a successful collusion it is not a totally strange phenomenon that the governmental authorities decide to step in. With collusion, identical firms could each supply their part[26] of the monopoly quantity, and together they would obtain the monopoly profits. But this isn't an equilibrium. If one side provides half the monopoly quantity, the other side has the incentive to supply more. It is necessary in any collusive arrangement that each side is able to monitor the actions of others. The requisite costs of monitoring and punishment increase with the number of participants, hence collusion is more difficult to achieve the more firms there are in the industry.

Strategies for the constituent game consist of the choice of prices (p_i) on for each group. The payoff for each firm is its profit ($\pi_i(p)$). If marginal cost is constant, the profit for a firm from group i can be written as

$$\text{(4)} \qquad \pi_i(p) = (p_i - mc_i)q_i(p), \qquad i = 1, \ldots, M.$$

in which π_i = profit earned by a representative firm from group i

mc_i = representative firm's marginal cost

p_i = price charged by a firm in group i

p = vector of M prices

q_i = quantity sold by a firm from group i.

[26] E.g. in case of a four firm oligopoly, each of the firms supply one fourth of the monopoly quantity.

Each firm's objective is to choose price so as to maximize profit, in other words

(5) $$\max_{p_i} \pi_i(p).$$

According to Slade (1987) the first-order conditions for this maximization can now be written as

(6) $$d\pi_i / dp_i = (p_i - mc_i)dq_i / dp_i + q_i = 0, \qquad i = 1, \ldots, M.$$

Suppose, that instead of each firm maximizing its own profit, given rival reactions on which dq_i / dp_i is dependent, the firms in the market collude to maximize joint profit. Joint profit can be expressed as

(7) $$\Pi(p) = \sum_{t=1}^{M} M_t(p_t - mc_t)q_t(p), \qquad t = 1, \ldots, M.$$

The terms are as presented with equation (4). First-order conditions for the maximization are $\partial\Pi / \partial p_i$, from which by differentiating the demand equation[27], substituting into equation (7) and rearranging, we have

(8) $$M_i \{(2p_i - mc_i)(b_i + c_i) + a_i + g_i(z)\} + \sum_{\substack{t=1 \\ t \neq 1}}^{M} M_t M_i \{(d_{ti} + d_{it})p_t - d_{it}mc_t\} = 0$$

[27] The needed demand equation is derived and presented in Slade (1987):

$$q_i = a_i + b_i p_i + c_i \sum_{\substack{j \in N_i \\ j \neq 1}} w_{ij} p_j + \sum_{\substack{t=1 \\ t \neq 1}}^{M} d_{ti} \sum_{k \in N_t} w_{tk} p_k + gi(z),$$ where terms are as in above equations but in addition we have here p_j as the price charged by another firm from group i, p_k as the price charged by a firm from a different group, w_{tk} as the vector of weights of unit norm, $t = 1, \ldots, M$, and z as the vector of exogenous variables that shift demand.

in which $i, t = 1, \ldots, M$

$a_i \ldots d_i$ = demand parameters

z = vector of exogenous variables that shift demand

other terms as in (4).

The M linear equations of the form of (8) can be solved for the unique joint-profit maximization price vector p_m which is the cooperative solution to the constituent game.

5 Conclusion

Tacit collusion emerges in repeated games context. Repeated play enables firms to enchance their profits position vis-à-vis the noncooperative of the one-shot game. In this paper explicit collusion was ruled out because binding agreements on price or output are illegal in most of the industrialized countries.

A state of vigorous competition will force managers to pursue the most profitable outcomes for their firm. As the conditions of the environment become more severe, the firm will converge to profit maximization behaviour independent of the constraint. Cooperative periods of this kind are characterized by identical prices (constant over time) for all the firms. Firms may collude either only e.g. on prices, or on both pricing and advertising, or first on prices followed by a collusion on advertising. Empirically it has been proved that collusion on more than one strategic variable is more profitable than colluding only on one strategic variable.

If the collusive agreement brakes down, all the firms suffer lost profits. Any collusive agreement is stable only, if the profits the members in it gain are higher than they would gain without colluding. This possess a severe constraint on collusion. Even though firms may choose to supply monopoly quantities, the cooperative solution by unique joint-profit maximazing price vector is not an equilibrium. Someone will always have an incentive to supply more. Therefore for a collusion to succeed, it is necessary that each side is able to monitor the actions of others.

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CHAPTER 8. DISCUSSION

This chapter ties the whole study together and the results are presented collectively. Each of the research questions (on italic in the text) outlined in chapter 1.2 will be answered separately. The conclusions for the research articles were presented at the end of each article and therefore they will be left on a less attention in this chapter. In chapter 8.1 the difficulties in the data collection procedures are being discussed. Following that the methodological limitations and theoretical contributions of this study will be taken under a closer examination, and all the academic goals of this study will be addressed. The implications of this study for marketing decision in business is the issue in chapter 8.4 and two more research questions get answered. Ideas for future research will be outlined in chapter 8.5.

8.1 About Data Collection

We attempted to gather empirical evidence about the price wars and other peculiar competitive behaviour implications taking place in an oligopolistic market. However, in the process of data collection we run into a strong opposition from some parties and finally were forced to give up hope of getting the already promised, very valuable data. Without the numerical data, also the already performed in-depth interviews in one particular industry became useless. Naturally we went on mapping our possibilities of getting a similar kind of data set from any other industry, but we run into a constant resistance and reluctance of passing on the data. We learned that the competitive behaviour, actions and reactions, are so sensitive and private that firms do not rely on other than couple of key persons inside their organization with the data related in that area.

After this very educating experience about the difficulties of data collection, we were adviced to apply meta-analysis. Meta-analysis is a methodology, in which the previously written literature is used to describe the researched phenomenon. Meta-analysis requires the literature to be of an quantitative nature, so that different kinds of statistical methods such as correlation matrices could be applied on it. First you collect all the possible literature on the subject, and then assess it, and compare your own models with it, and hopefully come up with the proper solution and support for your research hypothesis. Meta-analysis seemed like a good solution, because one must anyway go through a considerable pile of literature while conducting research, but with our study once again, it was a deadend.

In a quite an extensive literature search we came up with only two suitable articles. We learned that even though there are lots of publications available on the competition, they are not quantitative nor has the authors had a real empirical data in their use. Almost all the articles about the competitive responses used some kind of mathematical modelling instead of clear correlation matrices and interpretations based on them. I learned that there is a huge hole in the litarature at this point and a huge methodological hole as well. The articles that we run into were of a very general nature on a general level and therefore no use what so ever to our study. The articles were also very much econometrics focussed and the marketing dimension was very much absent. From our perspective, this is an issue calling for more attention in the future.

Competitive behaviour needs to be examined in the eyes of the marketing managers as well and not only from a economical perspective.

We also tried business simulations as sources of data. The final reports from all over the world (e.g. countries such as United Kingdom, United States, Spain, Peru, Australia were included) from such a games as MarktStrat, Intopia, the Business Strategy Game, the Marketing Game!, Marketer, amd Brandmaps were at our use. The author also took personally part in a world-wide business simulation organized by Globalview Organization to gather the data. We learned that no matter how real world like the game would be, its results are hard to interprete and not always reliable.

In most of the games there were tens of competitors competing in several markets with several not homogenous products. Even if we tried to separate only couple of firms (duopoly or oligopoly) from the main group of competitors, it was still impossible to see what part of their budget was used to react in the competitors' actions. For example, in the case of Globalview, which came closest to our research purposes, there were two main products (aftershave and perfume) sold in two main markets (EU and NAFTA) and over hundred of competitors. Yet the marketing budget, sales persons' salaries, quality improvement budget, and so on were informed in the firm reports as one big number meaning that it was impossible to know, which part of them were used as competitive tools either to act or react in competition.

Let's take a closer look at this particular case. If we take only five firms out of those over hundred firms, this decision already has a built-in flaw meaning that we can't know for sure if the competition is only going on between these five firms and which part of their actions depends on some other competitors actions. But let's now assume, that these five firms are the clear market leaders in every possible scale of measurement (sales volumes, profits, etc.) and therefore it can be concluded that the major competition is going on between them. Let's go on assuming that one of them is selling both products in both market areas, one is selling only the other one of the products in both market areas, and so on.

If we now try to apply the marketing tool effect equations on these five firms' dependent variable being advertising, we run into some serious troubles. As the marketing budget is informed only as an one big number, not as several smaller amounts distributed among products and market areas, it becomes impossible to conclude, which part of it was e.g. used by firm *i* in EU with perfume sales to react in a change fo firm *j*'s aftershave sales in NAFTA or whether these two issues are intercorrelated in the first place. We could use the whole marketing budget, the one number, as the dependent variable but what about the cases where the number of different brands sold and the number of market areas being served varies among the firms included in the observation? Of course the marketing budget of a firm selling two brands in two markets is larger than a firm's selling only one brand in one market and yet these two might be competitors. To compare these two cases would require too many assumptions warping the results.

In addition to all these practical calculation problems, there was a problem of missing price competition. In the case of Globalview the only price competition took place during the simulated trade shows in every simulated year altogether four times and with the other games, the price competition dimension was not present at all. Nor were the prices visible or could be observed by the other competitors immediately after they have changed which was a basic assumption in our study. The trade shows did represent a special case of game theory in the sense that in them a very strong bargaining power became apparent. When participating in the trade shows as a buyer, I had a chance to test different kinds of theories and e.g. tell the offers I had got from sellers to the other buyers and in this way educated them not to accept too high offers. I also noticed that the buyers started to form cartels and agreeing on the pricing issues. As interesting as the trade show data was, even if we'd had changed our research perspective and started analysing it, there wasn't enough data both in terms of the amount and the time period.

It came also apparent during the negotiations that some buyers were so much in a hurry, that they just wanted to reach the volume and price limits given to them by the organizor instead of trying to push the prices and volumes any further. Also the firms' representatives didn't take the simulation all the time seriously, because with simulation the firm never really exist and no matter how poorly the firm would perform, nobody looses anything in the physical world. We believe that this is a general problem with simulation data – the players need to be really connected to what they are doing or otherwise the results can't be trusted.

8.2 Methodological Limitations

Eventually we were left with only the theoretical modelling possibility. In chapter 3 the foundations for such a methodological approach were laid. What was clearly new, though, in our approach, was the application of behavioural sciences such as (mathematical) psychology and marketing to the formal modelling style. Therefore this study makes an important *methodological contribution by investigating a new, practioner-focused method for mathematical modelling in behavioural sciences* which was one of the academic goals of this study.

Altogether seven research questions to be addressed in this study were outlined in chapter 1.2 of which the primary question, *the validity of the game theoretic* *paradigms for describing the competitive behaviour,* was examined in chapters 4-7. Five of the questions were more of an academic nature, and two more practioner-oriented. First the game theoretical methodology was outlined in chapters 2.1-2.5 and later on applied in the four articles. The validity of game theoretic paradigms in general has been constantly questioned in the literature (e.g. Kreps 1990a, 1990b). There has been, for example, a debate going on whether the price wars can be modelled as infinite games. In this study, however, the game theoretical approach and mathematical modelling in general was not only appropriate but almost the only possible way of reasoning.

In our methodology the marketing instruments were combined with psychological decision making to better capture the dynamic nature of the marketing decisions. The behaviour was not forced into the numeric form but instead persuaded into a descriptive expression. Based on this study we go on suggesting that when describing marketing phenomena, more gentle ways of modelling should be applied. From a methodological stand point this would mean an inclusion of immaterial variables in the equations, which isn't against the foundation of game theory, rationality that is, but instead follows the footsteps laid by Naert (1978), who argued that both extreme ends should be avoided when modelling marketing related phenomena.

We have a reason to suspect that there are some missing variables in our examinations. Sometimes a player takes an action that the theory suggests he or she will not take and we see this as an indication of missing variables in the model. These missing variables might include e.g. environmental and corporate variables. The competitive behaviour and decisions managers make are usually guided by the corporate mission and culture. Also managers' personal competencies – their bounded rationality - have impact on their decision making. From the environmental side, sustainability and its requirements for businesses have become increasingly important factors in marketing decisions. The competitive behaviour is likely to be influenced with issues like what is said in the rules and regulations about environmentally friendly production and products, whether consumers like the environmentally friendly products better, and is there any savings available for firms from green marketing. Therefore the missing variables might have to do with issues such as environmental ethics and sustainability.

We addressed this issue in the same way as so many authors before us by posing 'complete theories' in which no action or series of actions is absolutely precluded, although those that are not part of the equilibrium are held to be very unlikely *a priori*, and then drew conclusions for the refinements we commonly use. However, the lack of variables still remains and therefore we have to take some precautions when addressing the results. If there are indeed missing variables in our models as indicated because of the players' behavioural outcomes, we have to take into account that their impact on the final results could be significant. For example, the over/underreaction matrix might get a totally different kind of appearance (see chapter 6) depending on what variables are included.

8.3 Theoretical Contributions

It was stated among the goals of this study that *the causality amongst various marketing instument effects will be more completely indicated* in this paper. This was done in chapter 6. In that chapter we formed three marketing effect equation groups, which indicated the dependence among marketing tools effect and sales and market shares. It was found that the marketing tools can be classified in having three different kinds of effects: demand, sales, or competitive, and that these effects are to appear in cycles. This model has been tested on simulation data in Mattila et al., 1999. When these differential equations are presented in figure forms, the causality amongs various marketing instrument effects comes even more apparent. For example in a case of two competing firms, the intersectional points are countable and from the slope and discontinuity points it can be seen how the competitive behaviour is proceeding.

The fourth academic goal of this study was to *demonstrate a taxonomy and framework which relates the econometric constructs describing marketing behaviour.* The theoretical foundation to accomplish this aim was laid in chapters 2.6 and 2.7 and the major applied results were presented in chapter 6, in which the competitive behaviour of the managers was modelled in econometrics terms. But also all the other research articles illustrate clearly the different dimensions of game-theoretic taxonomy by presenting their own frameworks relating the econometric constructs as well as the game-theoretic ones in describing the marketing behaviour. For example, the chapter 5 analyzed the dynamic pricing of one oligopoly and the pricing behaviour during price wars was modelled in comparison to the regular oligopolistic pricing and production strategies, which related the econometric constructs describing marketing behaviour. At the same time the fifth academic goal, *the demonstration of a more fundamentally sound scheme for the quantitative methods in marketing research,* gets fullfilled.

8.4 Implications for Marketing Decisions

The models allow the formulation of prescriptive answers to crucial marketing decisions, which was the sixth goal of this study. It was found, for example, that managers should react to only those competitive actions, that actually have an impact on their market shares. Earlier in the literature the models have been more or less purely mathematical or rules of thumb -styled, and as such haven't been much of a help in everyday decision for the marketing managers. However, this study differs from the previous ones by taking the mathematical analysis further and also showing how the models can be applied in marketing decisions. The new perspective in this study and what has been missing in the previous ones is the managerial perspective. In this study it was understood both the benefits and contraints what the mathematical modelling might possess from the managerial perspective, and the obsticles were overcame and harneshed in a convenient use for managers.

It was asked in the beginning of this Thesis *what responses do firms utilize to react, who are the players, and how is the optimal results gained.* Even though this study manages to give partial answers to these practical research questions, it remains still quite obvious that this area is open for future research. In every research article a piece to solve this puzzle was given and the voids left by the previous studies got filled. It was noted that there are generally more players than there are firms competing in the markets meaning that the number of competitors need not to be equal to the number of the players. Often third parties intervene the game and everybody wants to stir the stew so to say. This hasn't been taken into account in the previous literature.

Moreover, it was stated that the reactions of firms are based on the firms internal decision theories and company cultures. Needless to say, that the reaction might be quite different from the original action, and all these game moves taking place lead to a varying sets of responses. For example, in the multimarket oligopoly, the pioneer's adoptation of follower/leader role with respect to a marketing mix variable raises competitive reactions. If the two markets exhibit joint economies, and the products are regarded as strategic substitutes or complements, changes in competitors' strategies will raise or lower profits. To cope with these situations, firm's use substitutability and complementary strategies.

Over/underreaction seems to be happening around us frequently hampering the optimal reactions strategies from taking place. In markets with significant switching costs, a noncooperative equilibrium looks the same as the collusive solution in an otherwise identical market with no switching costs. Therefore if the switching costs are noticable, it will be easier for the pioneer in the market to ignore the late mover's strategic moves in competition while in the case of no switching costs a nondominant incumbent is adviced to accommodate. It was concluded that if the firm *i* reduces its strategies (pricing, advertising, etc.), firm's *j* marginal profitability and strategies will be increased, and vice versa. Moreover, as the reaction curves of firms are downward sloping, in the case of substitutes (complements) firm *j* earns less (more) total profits if firm *i* adopts a more aggressive strategy.

Firms (should) know their own marketing instruments but in estimating the ones of their competitors, mistakes are common and lead to an unproductive competition. The strategic gains and costs in competition depend crucially on the nature of optimal reactions by the other players. What might be the Nash equilibrium for one player, might seem a competitive action to another. The three sets of marketing tool effect equations formed in chapter 6 can be presented also in figures using real values from businesses, and in this way they can be used by managers to observe whether some use of a marketing tool has only a demand or sales effect distributed equally on all the firms on the market or is there a competitive effect and diminishing market shares to be detected, which requires immediate actions.

8.5 Future Research

As suggestions for future research, we would like to discuss a couple of issues. The testing of the models presented in this Thesis on a real-world data would be very much of our interest. No matter how theoretically sound the models would be, their empirical justification is always a very intreaging challenge. A suitable data could come for example from oligopolistic markets, in which the price wars occur from time to time. Such a market could be from airline, oil or accommodation industry.

If this kind of data is not available in the future, we would recommend next a development of a simulation game designed especially for describing competitive behaviour. The practioners from business life should be included in the designing process as well as academics from economics, marketing, and computer sciences. We believe that it would be possible and everybody's interest to play such a game, from which the results could be interpreted into the business life terms. The existing games were not useful for our purposes but now that the theoretical ground has been laid and examined, it could be used in designing such a games that would greatly contribute in to this field of science.

A more profound inclusion of psychological factors in the analysis of pricing and competitive behaviour modelling would be both academically and practically interesting. We showed the way to examine the impact of not visible decision criteria in competitive behaviour but we didn't give much of an attention to a true inclusion of psychological factors in our equations. To do this a new methodological perspective is needed, which would allow a total combination of qualitative and quantitative reseach streams. The number of immaterial variables that could be included in the models should be examined carefully and the suggestions of their nature should be made.

A new insight in economical marketing research could be also created by adding the macroeconomical perspective in the examination of marketing decisions. Previously the microeconomical perspective has been emphasized. With macroeconomical perspective we mean the better inclusion of third parties and environmental factors (including political and social) in the models. So far the models have been interfirm concentrated as was also in this paper. Only couple of statements were made about the influence of the environment of operation on competitive behaviour. It is a false believe to assume that the competitive behaviour would be solely dependent on the interfirm relationships. This could be cleared out by taking into account the environmental factors in the examinations.

Duopoly is a special case of an oligopoly. It would be interesting to test how the models presented in this study would work in a case of duopoly. And how should they be reformulated - if at all - to be suitable in the case of unlimited number of competitors. Oligopoly is quite a limited market structure and therefore it would be more of a practical benefit for the managers to get information on the competitive behaviour in highly competitive open markets.

This would not rule out the use of a game-theoretic approach but instead it would create also a new knowledge about how the game theory could be applied. The game theory is also yet to be proved empirically. It is not an easy task but this is a challenge worth pursuing for. We believe that with a suitable data set the empirical verification of game theory could be accomplished. This would naturally require that the marketing researcher would work in a close cooperation with mathematicians or be one himself.

The use of metaphores is not totally out of the question either. In this study that kind of approach was out of the research outlines, but in the future metaphores could be used to bring highly mathematical terms more down to earth -like and to ease up the interface between the theoretical models and the managers attempting to apply them. How about if the games businesses play would be desribed in terms of some daily social exchange event familiar to all for example from our family lives. Or the competitive behaviour could be reflected in terms of gambling or poker game: what if instead of Prisonner's Dilemma we would have a case of whether to raise, call or pass in a poker game. Everybody knows what it's all about without having to concern themselves with unfamiliar definitions.

POSTSCRIPT

To end this Thesis, let us return to the very beginning, and quote once more the ever so wise Rabbit from Winnie the Pooh's Most Grand Adventure:

> "Never trust your ears, your nose, your eyes. Putting faith in them is most unwise. Here's a phrase you all must memorize: in the printed word is where truth lyes. Never trust your tommies, your tails, your toes. You can't learn a thing from any of those. Here's another fact I must disclose: from the mighty pen true wisdom flows. Never trust that thing between your ears. Brains will get you nowhere fast, my dears. Haven't had a need for mine in years on the pages where the truth appears. If it says so, then it is so. If it is so, so it is."

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