

# 1 Introduction

## 1.1 An Overview of the Study of Collusion

In many industries the market structures are characterized by oligopoly. In oligopolistic markets, a few firms are likely to interact with their rivals repeatedly for a long time. It is well known that such repeated interactions often facilitate collusion.

Forms of collusion between firms are classified into two classes, overt (or direct) and tacit collusion. The typical example of overt collusion is a cartel. A cartel is the conduct that firms fix prices at high level and enforce penalties against members who violate the binding agreement, such as OPEC in the world oil market. Overt collusion weakens competition among firms so that it may distort efficiency, put back innovation, and cause unfairness in distribution. Now in many countries overt collusion is against the antitrust laws.

On the other hands, firms can cooperate in a milder form, which, unlike a cartel, is not accompanied with the binding agreement. We call it tacit collusion. The typical example is price leadership. Owing to legal prohibitions on overt collusion, firms being up to maximize joint profit in a market

are more likely to form tacit collusion. Like overt collusion tacit one weakens competition and has a bad influence on efficiency and fairness. And lately researchers have been more interested in tacit collusion than overt one.

Chamberlin (1929) suggested the possibility of tacit collusion. Chamberlin conjectured that a small number of identical firms producing a homogeneous product would charge the monopoly price without a cartel or overt collusion. However in those days there were not the theories to support this suggestion and it took a lot of time to find and develop them. To do so we need the tool to analyze the dynamics of price behavior, i.e., the theory of dynamic games.<sup>1</sup> In the late 1970's or the early 1980's the game theory was gaining ground in the industrial organization literature so that various kinds of theoretical approaches to explain firms' collusive behaviors were developed.

These approaches are classified into three groups: the repeated games

---

<sup>1</sup> Before developing the dynamic game theory, there were considerable literatures that attempt to formalize the dynamic aspects in a static context. The major examples are the kinked-demand curve story and the story of conjectural variations. Now many economists think of these approaches as theoretically unsatisfactory to analyze dynamic competition. For more detailed discussions, see, e.g., Tirole (1988).

(or supergames), price rigidities, and reputation. These three literatures are similar to one another on the point that price-cutting yields short-run gains to the under-cutting firm but triggers a price war. The difference among three is the reason that collusion is sustained. In the repeated games if a firm cuts a collusive price, i.e., deviates from collusion, it gets short-run gains. When a price-cutting is found out, the rivals provoke a price war and continue it to punish it. Thus a deviating firm suffers long-run losses. Therefore if the long-run losses are bigger than the short-run gains, firms have no incentive to deviate. In other words the punishment sustains collusion. In price rigidities literature we assume that once a firm cuts its price, it cannot change the price for a while. On the other hand, as the rivals are able to change their prices while the firm originally undercutting its price fixes new price, they optimally react to it and cut their prices. Next, on the contrary, as the rivals must fix their prices for the time being and the original firm comes to change its price, it retaliated with a further cut. Like this a firm's price-cutting leads to a price war. In this story the cost suffered from a price war sustains collusion. <sup>2</sup> In reputation literatures each firm sacrifices short-run profit

---

<sup>2</sup> For literatures of price rigidities, see Maskin and Tirole (1988) and Eaton and Engers (1987).

by raising its price in order to build a reputation for charging high prices.<sup>3</sup> Though these literatures should be thought of as describing complementary aspects, the approach using repeated games is the most simple and is fit for applications. We adopt it in this thesis.

From the late 1980's to now a great deal of researchers have devoted much time to study the repeated game. While the researchers put their interests chiefly to the theoretical aspects of repeated games, there have been a few researches of applications of the repeated game.<sup>4</sup> In particular, there are a few researches of applications to the theory of oligopoly. However many phenomena which are considered as collusive behaviors between firms remain to be explained theoretically. The aim of this thesis is to provide further contributions to this line of literature.

Though using the repeated game is common to the following 4 chapters, the topic which each chapter deals with is independent one another. Therefore in the next subsection we shall summarize the background and the contributions which the study of each chapter has.

---

<sup>3</sup> For a literature of reputation, see Kreps et al. (1982).

<sup>4</sup> For the survey of the theory of the repeated game, see Fudenberg and Tirole (1991) or Pearce (1992).

## 1.2 Summary on the Following Chapters

For studies about tacit collusion among firms we often use the framework of infinitely repeated games. The main assertion of the repeated game's theory is summarized by folk theorems. Folk theorems for infinitely repeated games, e.g., Friedman (1971), Rubinstein (1979), and Fudenberg and Maskin (1986), assert that if the players are sufficiently patient, then any feasible, individually rational payoffs can be enforced by equilibrium. In infinitely repeated games we often assume that players discount future payoffs using discount factor  $\delta < 1$ . Then "sufficiently patient" means that the discount factor is sufficiently high. When we interpret the theorems in the context of collusion among firms, they may assert that firms are likely to collude when firms' discount factor is sufficiently high. This is because long-run losses become bigger than short-run gains as the discount factor is higher.

However actual firms not so easily collude and keep their collusion. Because in reality there exist many factors to prevent them from colluding. However firms grope for various ways of keeping their collusion under such situations. Therefore the phenomena which are thought as firms' collusive behavior sometimes look complex. Concrete examples of the phenomena

are counter-cyclically moves of prices, price leadership, and gradual trust building.<sup>5</sup> In this thesis we shall give theoretical explanations to such phenomena using models of the repeated game. We shall deal with counter-cyclically moves of prices in chapter 3, price leadership in chapter 4, and gradual trust building in chapter 5.

In chapter 2 we consider collusion between financially constrained firms. This chapter is different from the another three chapters on the point not explaining the complex collusive behavior which are observed in reality. Here we argue the relationship between collusion and predation. The word of “predation” or “predatory pricing” means a reduction of price in the short run so as to drive competing firms out of the market or discourage entry of new firms.

The reason why we need to examine the relationship between collusion and predation is searched for the experience in the U.S. airline industry after deregulation. The deregulation began in 1977. Right after it fares were cut sharply. For a while a violent price war continued and many firms exited from the market or were merged. We can interpret that predatory behaviors

---

<sup>5</sup> We shall give another example, such as multimarket contact. For this literature, see Bernheim and Whinston (1986).

swept over the industry at the time. However, in 1984, the concentration rate and fares began to rise. At last, by 1986, the industry have had even higher concentration than had existed before deregulation and collusive behaviors (e.g. high price and Hub System) have obserbed.<sup>6</sup>

A series of events in the industry show that collusion and predation, which are incompatible with each other, occurs in the same market and besides in a short period. However this two phenomena have been studied separately in the industrial organization literature. Therefore in order to explore the experience of the industry we need the model in which we can consider both of them at the same time.

The studies for predatory behaviors go back to Bain (1949). Bain pointed out that a low price the established firms set conveys bad news to potential entrants about their profitability in the market, i.e., a low price could deter entry. Since then there have been many arguments for Bain's view, because it was not clear how a low price could deter new entry. The focus of the discussions was the rationality behind predation.

Researchers in Chicago School protested against Bain's view. McGee

---

<sup>6</sup> For a more detailed review of the U.S. airline industry after deregulation, see, e.g., Shepherd (1990) or Dempsy and Goetz (1992).

(1958, 1980), Telser (1966), and Bork (1978) have asserted that it cannot be rational to engage in predatory pricing in order to induce exit since merging with the rival is a superior way to realize monopoly power.

Using the model introducing asymmetric information to Selten's (1978) chain-store game, Milgrom and Roberts (1982) and Kreps and Wilson (1982) suggested that the rationality of predation may be reasonable. Concretely, if an established firm faces several potential entrants, then predation which is costly in the short run may be rational because it yields a reputation that deters another entrants. Benoit (1984) also suggest that even though an established firm competes with only one entrant, predation occurs if the entrant faces a financial constraint. These game theoretic explanation assert that when the discount factor is sufficiently high, then established firms have incentives to predation. This claim conflicts with that of folk theorem. In other words, each claim respectively says that collusion and predation occur under the common condition that the discount is sufficiently high. Then which claim on earth is correct?

The purpose of chapter 2 is to put this apparent contradiction in order. We assume that all firms in the market face some financial constraints and



they play the repeated “prisoner’s dilemma” game.<sup>7</sup> In this framework we consider the possibility of collusion and find that financially constrained firms cannot collude when the discount factor is sufficiently close to one but collusion emerges at lower discount factors.

It is of course that we do not intend to claim that this model perfectly explains the U.S. airline industry after deregulation. But many researchers consider that the experience in the industry is important and notable. In order to advance the theoretical exploration about it in the future we would need various types of model to consider the relationship between predation and collusion.

In chapter 3 we shall consider the relationship between firms’ pricing behavior and business conditions in oligopolistic industries. It has been found that prices move pro-cyclically in some industries and counter-cyclically in others. In the industrial organization literature empirical research have stud-

---

<sup>7</sup> One problem in this chapter is whether firms faces financial constraints. As we wander from the subject, we do not argue it in this thesis. We introduce the related articles instead. Fudenberg and Tirole (1985,1986) argue that imperfections in the capital market make firms face financial constraints. Bolton and Scharfstein (1990) make the same assertion from a point of view of incomplete contract.

ied what kind of character the industries in which prices move counter-cyclically have. <sup>8</sup> Some researchers noticed that price movements relate with concentration of the industry.

Wachtel and Adelsheim (1977) showed that prices in the industry are likely to move counter-cyclically when concentration is high whereas prices tend to move pro-cyclically when concentration is low. Domowitz, Hubbard and Petersen (1987) and Cowling (1983) obtained a result similar to the one found by Wachtel and Adelsheim. On the other hand, Odagiri and Yamashita (1987) showed that such pattern is not observed in Japan.

Rotemberg and Saloner (1986) provided an answer to the question why prices move counter-cyclically. They analyze the model in which firms play an infinitely repeated price-setting game under demand fluctuations. And they showed that if the discount factor stays within some region and besides is not near one, the most collusive equilibrium path has the character that

---

<sup>8</sup> This counter-cyclical price movements attract Macro-economists' interests. Under perfectly competitive models of the neoclassical theory the real wage must move counter-cyclically. But such patterns are not observed in reality. This embarrassment has been noted. However counter-cyclical price movements in product market can be consistent with pro-cyclical movement of the real wage. For more detailed discussions, see Rotemberg and Woodford (1992).

the collusive price at high demand is lower than the collusive price at low demand.

Rotemberg and Saloner's explanation, however, is not consistent with Wachtel and Adelsheim's findings. In their model, prices move pro-cyclically when concentration is either high or low, while prices move counter-cyclically when concentration is in the middle range. In chapter 3 we attempt a modification of the model and theoretically explains the fact uncovered by Wachtel and Adelsheim. Our modification is based on the introduction of a capacity constraint, something already mentioned by Wachtel and Adelsheim and Cowling as an important factor to decide price movements. This modification leads the conclusion that countercyclical movements of prices are more likely to occur as concentration is higher. This supports the fact observed by Wachel and Adelsheim.

In chapter 4 we consider price leadership. Quoting from Scherer and Ross (1990), "price leadership implies a set of industry practices or customs under which list price changes are normally announced by a specific firm accepted as the leader by others, who follow the leader's initiatives" and "economists commonly distinguish three main types of price leadership: dominant firm, collusive, and barometric."

Dominant firm price leadership means that there exists a single dominant firm which sets a price as the price leader. This type of price leadership is likely to occur when the leader has a large market share and other firms being too small to have a perceptible influence on price. Hence this can not be explained as a form of collusion between firms but by a sufficient cost advantage of the leader firm over rivals. <sup>9</sup>

Collusive price leadership is one form that tacit collusion may take. The terminology loosely implies the phenomenon that a leader firm leads a price change and the other firms follow it cooperatively. The difference from dominant price leadership is that collusive one is formed by firms being similar sizes. During 1890-1940, many concentrated industries in U.S.A. did seem to display collusive price leadership. Barometric price leadership means that the price leader does no more than act as a barometer of market conditions, setting prices approximating those that would emerge in any event under competition. Collusive and barometric price leadership are hard to be distinguished in actual cases. <sup>10</sup>

---

<sup>9</sup> For studies of dominant firm price leadership, see, e.g., Nichol (1930) or Deneckere and Kovenock (1992).

<sup>10</sup> For concrete case studies of price leadership, see, e.g., Scherer and Ross (1990).

As we described in the previous subsection, collusive price leadership is the typical example of tacit collusion. However there are a few models to explain it. Macleod (1985) showed particular supergame strategies in a repeated game as reflecting price leadership. Albaek (1989) and Rotemberg and Saloner (1990) analyzed price leadership as a device to reveal information.

In chapter 4 we provide a model to explain collusive price leadership in the framework of the repeated game. In each component game of our model, the order of firms in choosing standard strategic variables will be assumed to be endogenous. Assuming the identical technology (cost function) and symmetric information among firms, we will show that collusion can be sustained by means of price leadership even under the situation where their collusion cannot be sustained when firms simultaneously choose their standard strategies.

In this chapter there remains some problems. The most important one is the following. The result is with a proviso that the allocation to be sustained is one such that the followers are more profitable than the leader. Hence it may be difficult to justify why a particular firm would willingly take the position of the leader. One way to enable price leadership equilibrium plau-

sible is that all firms become the leader in turns (rotating price leadership) or different firms become the leader in different markets (divided price leadership). However in our model there is still nothing that would generate a particular firm price leadership. We need to carry out further investigation about it.

In chapter 5 we consider the phenomenon which is called “slow trust building” or “gradual trust building.” Gradual trust building means that any long-term relationship involves a low initial level of cooperation, which increases to a higher level when the initial phase is successfully passed without termination of the relationship. This phenomenon is often observed in reality. Good friendship rarely starts as soon as two persons meet. Typically, people take time to nurture their friendship. Credit relations or employer-employee relationships often involves gradual trust building.

Datta (1993), Ghosh and Ray (1996), and Kranton (1996) formalize this idea under the setting of matching game. Common to their model is that if matching is not completely random and each party has the option of continuing to play the partner, cooperation has to be gradual to make a defection, which leads to building a new relationship from scratch, unattractive.

In oligopolistic industries, gradual trust building is often observed. The

U.S. turbogenerator industry is the most famous example. From 1960 to 1963, sharp competition prevailed in the industry. Then collusion emerged after the announcement of General Electric about pricing in May 1963.<sup>11</sup>

We must not apply the previous works for gradual trust building to the cases of oligopolistic industries because firms cannot change the competitors. Therefore we need to construct the model that cooperation gradually deepens even if partners are fixed.

In chapter 5 we consider the model in which two fixed firms play an infinitely price-setting repeated game in the product market. And we derive the most-cooperative, self-enforcing collusion path. Each of two firms has private information whether its R&D cost is high or low. The higher R&D cost is prohibitively high so that the firm will not engage in R&D. But a firm with the lower R&D cost may undertake risky R&D whose success will decrease the unit cost drastically and drive out the other firm. As time goes by without a success of R&D, each firm puts more belief on that the other firm has the high R&D cost. The two price-setting firms cannot reach full collusion from the beginning if the original belief that the other firm has the

---

<sup>11</sup> For more detailed discussions, see, e.g., Shepherd (1990).

high R&D is low. In that case, collusion level must go up gradually as the belief is updated.

Finally we shall describe the problem common to the following four chapters. All of the four chapters attempt only to provide theoretical explanation to the actual phenomena. We have no policy implication from the analyses. Though it may be difficult to propose the policy through the game theoretic approach, we hope to contribute to it by further investigations in the future.