3 Effects of Capacity Constraints and Concentration on the Pricing Behavior in Oligopolistic Industries with Demand Fluctuations

3.1 Introduction

In this chapter we shall consider the relationship between firms' pricing behavior and business conditions. Industrial organization studies around 1930 have found that in some industries prices move <u>pro-cyclically</u> with respect to the business cycle and <u>counter-cyclically</u> in some other industries. Researchers have since then faced the following two questions.

1. Why do prices move counter-cyclically?

2. In which industries do prices move counter-cyclically?

A great deal of papers in industrial organization have studied the latter question through empirical analyses. By studying the relationship between price movements and concentration, Wachtel and Adelsheim (1977) found one of probable facts. Using U.S. data, they showed that prices are likely to move counter-cyclically when concentration is high whereas prices move pro-cyclically when concentration is medium or low.[15]

Rotemberg and Saloner (1986) provided an explicable answer to the former question. In their model it is supposed that firms play an infinitely repeated price-setting game under demand fluctuations, such that in each stage firms set the price after observing the state of demand. If the discount factor is sufficiently high, firms can collusively charge the monopoly price regardless of the state of demand. But if the discount factor becomes low to some extent, the monopoly price at high demand cannot be sustained because the incentive to cut price is greater at high demand than at low demand. Thus they have to make their collusive price lower at high demand. Moreover, Rotemberg and Saloner emphasized that the collusive price at high demand can be lower than the price at low demand when the discount factor stays within some region.

[15] Domowitz, Hubbard and Petersen (1987) obtain a result similar to the one found by Wachtel and Adelsheim. Cowling (1983) also found the same pattern using U.K. data. On the other hand, Odagiri and Yamashita (1987) show that such pattern is not observed in Japan.

Rotemberg and Saloner's explanation, however, would not apply to the latter question if what Wachtel and Adelsheim found was correct. In Rotemberg and Saloner's model, prices move pro-cyclically when concentration is either high or low, while prices move counter-cyclically when concentration is in the middle range. This is because they assume that firms' cost functions obey constant returns to scale. As a result, firms can adjust the output level freely without incurring extra costs and each firm can get the whole demand by cutting its price slightly. Thus the gain from deviation is $(n-1)/n$ times the collusive profit of the whole industry where n is the number of the firms in the industry. In case that the collusive price at high demand is greater than or equal to one at low demand, the collusive profit of the whole industry at high demand is greater than that at low demand. Thus the difference of the gain from deviation between high demand and low demand is greater, as n is larger. Accordingly, under the condition that firms collude, the possibility that prices move counter-cyclically is greater, the lower is the degree of concentration. But in reality it may not be easy to increase outputs for a short period and firms may incur extra costs in increasing outputs for various reasons. Thus some modification on the difficulty of adjusting the output level in Rotemberg and Saloner's model is needed to provide some explanation to the latter question.

This chapter considers a modification of this point 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. Staiger and Wolak (1992) also analyze, using the model in which two firms compete, the effect of capacity constraints on firms' pricing behavior under demand fluctuations. They show that whether prices move pro-cyclically or counter-cyclically depends on the level of capacity which firms hold. In their model prices are more likely to move counter-cyclically as the level of capacity is higher. We derive a similar conclusion on this point. Because capacity constraints are more likely to be relaxant at low demand than at high demand, the short-run gain from deviation at low demand is bigger than that at high demand when the level of capacity is low.

The difference from Staiger and Wolak is that our work stresses the relationship between concentration and price movement. We show in this respect that countercyclical movements of prices are more likely to occur as concentration is higher. In other words, our work supports the fact observed by

Wachtel and Adelsheim.[16] This is because the minimum level of excess capacity that the industry holds to bring about counter-cyclical movements in prices must be bigger as concentration is lower.

3.2 Model

In this chapter we consider a situation in which there are $n (n \geq 2)$ firms in a market playing an infinitely repeated game. The demand curve which firms face at each period takes a linear form for simplicity given as follows: $P(\alpha; x) = D^{-1}(\alpha; x) = \alpha - x$ in the inverse demand form. Suppose α is determined stochastically and the value of α is $\underline{\alpha}$ with probability β and $\overline{\alpha}$ with probability $1 - \beta$ where $\overline{\alpha} > \underline{\alpha} > 0$. At each period firms choose their prices simultaneously after they observe the state of demand. Every firm has a fixed capacity K, a value that is unchanged over time. Each firm can produce up to K units of the product at zero marginal cost but cannot

[16] Matsushima and Yanagawa (1994) describe with a repeated game that firms collusively deter other firms' entries. Under such setting they also try to analyze the relationship between concentration and price movements. Their conclusion about this relationship is similar to our work.

produce more than K. We suppose $\overline{\alpha} \geq K \geq 0$.[17]

Now suppose the following efficient-rationing rule, that is, if l firms choose prices strictly below p and m firms choose exactly p, then the demand firm i faces when it chooses p is given by:

$$D(p|\alpha; p_1, \cdots, p_{i-1}, p_{i+1}, \cdots, p_n) = max \left\{0, (\alpha - p - lK)/m\right\},$$

where $n \geq l + m$.[18]

Under the above settings, they engage in an infinitely repeated game of price competition. All firms are assumed to maximize their expected collusive profits subject to the incentive constraints of both states. Let $\underline{p}^c$ and $\overline{p^c}$ denote the collusive price at low and high demand respectively. We consider the following strategy: at some period t, each firm chooses $\underline{p}^c$ at low demand and $\overline{p^c}$ at high demand as long as all firms have obeyed this rule in every period preceding t. Otherwise, firms play one of some punishment strategies thereafter.[19] And the per-period expected payoff is denoted by V on the

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[17] If $K > \overline{\alpha}$, $K - \overline{\alpha}$ is of no use.

[18] See, e.g., Tirole (1988).

[19] Kreps and Scheinkman (1983) show that if firms can play mixed strategy, then the capacity constrained game such as the period game in this model has an equilibrium and an unique expected payoff in equilibrium. A candidate of "some punishment strategies"

punishment path. Note that V is *ex-ante* common to both states. Let $\pi^c(\cdot)$ denote the per-period collusive profit. Let $\pi^{ch}(\cdot)$ denote the profit earned in one period by a deviating firm, which optimally deviates from collusive prices. Then firms' problem is as follows:

$$\max_{(\overline{p}^c, \underline{p}^c)} \beta\pi^c(\underline{\alpha}, n, K; \underline{p}^c) + (1-\beta)\pi^c(\overline{\alpha}, n, K; \overline{p}^c),$$

subject to, for high demand state,

$$\pi^{ch}(\overline{\alpha}, n, K; \overline{p}^c) - \pi^c(\overline{\alpha}, n, K; \overline{p}^c)$$

$$\leq \frac{\delta}{1-\delta}\{\beta\pi^c(\underline{\alpha}, n, K; \underline{p}^c) + (1-\beta)\pi^c(\overline{\alpha}, n, K; \overline{p}^c) - V\}, \tag{3.1}$$

for low demand state,

$$\pi^{ch}(\underline{\alpha}, n, K; \underline{p}^c) - \pi^c(\underline{\alpha}, n, K; \underline{p}^c)$$

$$\leq \frac{\delta}{1-\delta}\{\beta\pi^c(\underline{\alpha}, n, K; \underline{p}^c) + (1-\beta)\pi^c(\overline{\alpha}, n, K; \overline{p}^c) - V\}, \tag{3.2}$$

where $\delta \in [0, 1)$ is the discount factor. The left-hand sides of the inequalities (3.1) and (3.2) are the short-run gains by deviating from the collusion and the right-hand sides are the long-run losses. From now on, we call the solution of the above problem as equilibrium.

is one that firms continue to play one of such equilibria at each period forever.

We can calculate $\pi^c(\alpha, n, K; p)$ and $\pi^{ch}(\alpha, n, K; p)$ concretely and they play a central role in the following analysis. Thus we shall describe them here. $\pi^c(\alpha, n, K; p)$ is as follows:

$$\pi^c(\alpha, n, K; p) = \begin{cases} pK & \text{if } \alpha - nK > 0 \text{ and } p \in [0, \alpha - nK] \\ \frac{1}{n} pD(\alpha; p) & \text{if } p \geq \max\{\alpha - nK, 0\}. \end{cases}$$

And $\pi^{ch}(\alpha, n, K; p)$ is as follows:

$$\pi^{ch}(\alpha, n, K; p) = \begin{cases} pK & \text{if } \alpha - K > 0 \text{ and } p \in [0, \alpha - K] \\ pD(\alpha; p) & \text{if } \frac{1}{2}\alpha \geq \alpha - K \\ & \quad \text{and } p \in [\max\{\alpha - K, 0\}, \frac{1}{2}\alpha] \\ \frac{1}{4}\alpha^2 & \text{if } p > \frac{1}{2}\alpha \geq \alpha - K \\ K(\alpha - K) & \text{if } p \geq \alpha - K > \frac{1}{2}\alpha. \end{cases}$$

3.3 Proposition

In this section we characterize the range of a fixed capacity K where countercyclical movements of prices occur. Our analysis depends heavily on the short-run gains. Now we denote the short-run gains by $G(\alpha, n, K; p)$. That is,

$$G(\alpha, n, K; p) \equiv \pi^{ch}(\alpha, n, K; p) - \pi^c(\alpha, n, K; p).$$

We can get the following characteristic about $G(\alpha, n, K; p)$ as follows.

Lemma 1: *$G(\alpha, n, K; p)$ is non-decreasing with respect to $p \in [0, \frac{1}{2}\alpha]$.*

This lemma means that firms make their collusive price lower so that firms can make the short-run gain lower. The proof of this lemma is straightforward from the following calculation:

$$G(\alpha, n, K; p) =$$

$$\begin{cases} 0 & \text{if } \alpha - nK > 0 \text{ and } p \in [0, \alpha - nK] \\ p\{K - \frac{1}{n}D(\alpha; p)\} & \text{if } \alpha - K > 0 \\ & \quad \text{and } p \in [\max\{\alpha - nK, 0\}, \alpha - K] \\ p\{\frac{n-1}{n}D(\alpha; p)\} & \text{if } \frac{1}{2}\alpha \geq \alpha - K \\ & \quad \text{and } p \in [\max\{\alpha - K, 0\}, \frac{1}{2}\alpha] \\ \frac{1}{4}\alpha^2 - \frac{1}{n}pD(\alpha; p) & \text{if } p > \frac{1}{2}\alpha \geq \alpha - K \\ K(\alpha - K) - \frac{1}{n}pD(\alpha; p) & \text{if } p \geq \alpha - K > \frac{1}{2}\alpha. \end{cases}$$

Next we consider what characteristics the pair $(\overline{p}^c, \underline{p}^c)$ has. If δ is sufficiently large, firms can charge the monopoly price at both states. However the monopoly price cannot be sustained as their collusive price when δ is sufficiently small. Then firms make their collusive price lower than the monopoly price to sustain their collusion. The short-run gain at high demand is different from one at low demand while the long-run losses are common to both states. Thus we only consider the short-run gain at both states in order to consider whether the collusive price at high demand or at low demand is larger.

Rotemberg and Saloner claim that the collusive price at high demand is lower than at low demand when the discount factor is sufficiently small. In their model the short-run gain is always bigger at high demand than at low demand if firms set the same price in both states of demand. Thus there always exists a range of the discount factor in which the collusive price at high demand is lower than at low demand.

However this is not necessarily true for our model, because the extra demand which a deviating firm gets is more likely to be capacity constrained when demand is high. In order that countercyclical movements of prices occur, it is necessary that the short-run gain is bigger at high demand than at low demand and the collusive price at high demand is lower than at low demand. This condition is more formally described as follows:[20]

[20] Note that this condition is not sufficient for the existence of the equilibrium with counter-cyclical movements of prices because whether prices move counter-cyclically or not also depends on the discount factor.

Countercyclicity Condition (CC): a pair $(\overline{p}, \underline{p})$ satisfies the following two inequalities:

$$\frac{1}{2}\underline{\alpha} \geq \underline{p} > \overline{p}$$

and

$$G(\overline{\alpha}, n, K; \overline{p}) > G(\underline{\alpha}, n, K; \underline{p}),$$

where $\underline{p}$ (respectively, $\overline{p}$) is denoted by the price which all firms collusively charge at low (respectively, high) demand.

The reason why $\underline{p} \leq \frac{1}{2}\underline{\alpha}$ in the first part of this condition is as follows. If firms charge $\underline{p} > \frac{1}{2}\underline{\alpha}$ in equilibrium, then $\frac{1}{2}\overline{\alpha} \geq \frac{1}{2}\underline{\alpha} > nK$. Thus the equilibrium collusive prices at low and high demand are $\underline{\alpha} - nK$ and $\overline{\alpha} - nK$ respectively. Hence the latter is always greater than or equal to the former.

In order to consider the above condition, we use the following lemma.

Lemma 2: *For given $\overline{\alpha}$, $\underline{\alpha}$, n, and K, there exists a pair $(\overline{p}, \underline{p})$ satisfying CC if and only if the following inequality is satisfied:*

$$G(\overline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) > G(\underline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}). \tag{3.3}$$

Proof. Suppose that there exists a pair $(\overline{p}, \underline{p})$ satisfying CC, then

$$G(\overline{\alpha}, n, K; \overline{p}) - G(\underline{\alpha}, n, K; \underline{p}) > 0.$$

From the lemma 1

$$G(\overline{\alpha}, n, K; \underline{p}) - G(\underline{\alpha}, n, K; \underline{p}) \geq G(\overline{\alpha}, n, K; \overline{p}) - G(\underline{\alpha}, n, K; \underline{p}).$$

Thus we get

$$G(\overline{\alpha}, n, K; \underline{p}) - G(\underline{\alpha}, n, K; \underline{p}) > 0. \tag{3.4}$$

Investigation of property of function $G(\cdot)$ shows that if $G(\overline{\alpha}, n, K; p)$ and $G(\underline{\alpha}, n, K; p)$ cross at a certain point $p = \hat{p}$ ($\in [\max\{\underline{\alpha} - nK, 0\}, \frac{1}{2}\underline{\alpha}]$), then

$$G(\overline{\alpha}, n, K; p) - G(\underline{\alpha}, n, K; p) \begin{cases} = 0 & \text{if } \underline{\alpha} - nK > 0 \text{ and } p \in [0, \underline{\alpha} - nK] \\ < 0 & \text{if } p \in (\max\{\underline{\alpha} - nK, 0\}, \hat{p}) \\ = 0 & \text{if } p = \hat{p} \\ > 0 & \text{if } p \in (\hat{p}, \frac{1}{2}\underline{\alpha}]. \end{cases}$$

Using this fact and the assumption, if the inequality (3.4) is satisfied, then there exists $\hat{p}$ such that

$$\hat{p} < \underline{p} \leq \frac{1}{2}\underline{\alpha}.$$

Hence

$$G(\overline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) - G(\underline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) > 0.$$

Suppose, conversely, that the inequality (3.3) is satisfied. Then it suffices to check that there exists a pair $(\overline{p}, \underline{p})$ such that $(\overline{p}, \underline{p}) = (\frac{1}{2}\overline{\alpha} - \epsilon, \frac{1}{2}\underline{\alpha})$ and the inequality

$$G(\overline{\alpha}, n, K; \overline{p}) > G(\underline{\alpha}, n, K; \underline{p})$$

is satisfied. Note that $G(\overline{\alpha}, n, K; \overline{p})$ is continuous with respect to $\overline{p}$, then it is clear that there exits a pair $(\overline{p}, \underline{p})$ satisfying the above condition. □

From this lemma we can say that in order to confirm whether there exists a pair $(\overline{p}^c, \underline{p}^c)$ satisfying CC, we need only consider the inequality (3.3). Then we will get the next proposition.

Proposition 1: *Prices can move counter-cyclically when $K \in (\hat{K}, \overline{\alpha}]$, while prices move pro-cyclically when $K \leq \hat{K}$, where*

$$\hat{K} = \frac{1}{n}(\overline{\alpha} + \frac{n-2}{2}\underline{\alpha}).$$

Proof. From lemma 2 we need only compare $G(\underline{\alpha}, n, K; \frac{1}{2}\underline{\alpha})$ and $G(\overline{\alpha}, n, K; \frac{1}{2}\underline{\alpha})$. To do it let us consider $G(\overline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) - G(\underline{\alpha}, n, K; \frac{1}{2}\underline{\alpha})$. It follows from the property of $G(\cdot)$ that $G(\overline{\alpha}, n, K; p) = 0$ if $p \leq \overline{\alpha} - nK$. Hence if $\overline{\alpha} - nK \geq \frac{1}{2}\underline{\alpha}$, $G(\overline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) - G(\underline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) \leq 0$. In other words, there exist no pairs $(\overline{p}^c, \underline{p}^c)$ satisfying CC. Hence we only consider the range such as $\overline{\alpha} - nK < \frac{1}{2}\underline{\alpha}$. Then there are two cases to be considered. If $D(\underline{\alpha}; \frac{1}{2}\underline{\alpha}) \geq \frac{1}{n}D(\overline{\alpha}; \frac{1}{2}\underline{\alpha})$, then

$$G(\overline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) - G(\underline{\alpha}, n, K; \frac{1}{2}\underline{\alpha}) =$$

$$\begin{cases} \frac{1}{2n}\underline{\alpha}(\underline{\alpha}-\overline{\alpha}) & \text{if } D(\underline{\alpha};\frac{1}{2}\underline{\alpha}) \geq K \geq \frac{1}{n}D(\overline{\alpha};\frac{1}{2}\underline{\alpha}); \\ \frac{1}{2}\underline{\alpha}[\{K-\frac{1}{n}(\overline{\alpha}-\frac{1}{2}\underline{\alpha})\} - \frac{n-1}{n}(\underline{\alpha}-\frac{1}{2}\underline{\alpha})] & \text{if } D(\overline{\alpha};\frac{1}{2}\underline{\alpha}) \geq K \geq D(\underline{\alpha};\frac{1}{2}\underline{\alpha}); \\ \frac{n-1}{2n}\underline{\alpha}(\overline{\alpha}-\underline{\alpha}) & \text{if } K \geq D(\overline{\alpha};\frac{1}{2}\underline{\alpha}). \end{cases}$$

If $D(\underline{\alpha};\frac{1}{2}\underline{\alpha}) \leq \frac{1}{n}D(\overline{\alpha};\frac{1}{2}\underline{\alpha})$, then

$$G(\overline{\alpha},n,K;\frac{1}{2}\underline{\alpha}) - G(\underline{\alpha},n,K;\frac{1}{2}\underline{\alpha}) =$$

$$\begin{cases} \frac{1}{2}\underline{\alpha}[\{K-\frac{1}{n}(\overline{\alpha}-\frac{1}{2}\underline{\alpha})\} - \frac{n-1}{n}(\underline{\alpha}-\frac{1}{2}\underline{\alpha})] & \text{if } D(\overline{\alpha};\frac{1}{2}\underline{\alpha}) \geq K \geq \frac{1}{n}D(\overline{\alpha};\frac{1}{2}\underline{\alpha}); \\ \frac{n-1}{2n}\underline{\alpha}(\overline{\alpha}-\underline{\alpha}) & \text{if } K \geq D(\overline{\alpha};\frac{1}{2}\underline{\alpha}). \end{cases}$$

In both cases $G(\overline{\alpha},n,K;\frac{1}{2}\underline{\alpha}) - G(\underline{\alpha},n,K;\frac{1}{2}\underline{\alpha})$ is increasing on K. And it is negative when K is small, while it is positive when K is large. Thus we calculate the value of $\hat{K}$ from the equality

$$G(\overline{\alpha},n,\hat{K};\frac{1}{2}\underline{\alpha}) - G(\underline{\alpha},n,\hat{K};\frac{1}{2}\underline{\alpha}) = 0.$$

Therefore there is $\hat{K}$ such that for every K such that $K > \hat{K}$

$$G(\overline{\alpha},n,K;\frac{1}{2}\underline{\alpha}) > G(\underline{\alpha},n,K;\frac{1}{2}\underline{\alpha}),$$

and for every K such that $K \leq \hat{K}$

$$G(\overline{\alpha},n,K;\frac{1}{2}\underline{\alpha}) \leq G(\underline{\alpha},n,K;\frac{1}{2}\underline{\alpha}),$$

where

$$\hat{K} = \frac{1}{n}(\overline{\alpha} + \frac{n-2}{2}\underline{\alpha}). \qquad \square$$

This proposition provides a necessary condition when the phenomenon that the collusive price at high demand is lower than at low demand happens. In this proposition we characterize the lower bound $\hat{K}$ of the range of capacity constraints where counter-cyclical movements of prices may occur. Then this proposition has the following implications.

1. Counter-cyclical movements of prices can occur if firms set up sufficiently larger capacities. On the other hand, pro-cyclical movements of prices always occur if firms set up sufficiently smaller capacities.

2. When concentration decreases, $n\hat{K}$ (that is, the minimum level of total capacity of the industry which is needed in order for prices to move counter-cyclically) increases. Hence if total capacity of the industry does not change so much regardless of its concentration, then each firm cannot have capacity above $\hat{K}$ as concentration is lower. In other words, the movements of prices will be pro-cyclical as n increases.

We shall discuss about these economic implications in the next section.

3.4 Concentration and Price Movements

The implication 1 is similar to Staiger and Wolak. Because capacity constraints are more likely to be relaxant at low demand than at high demand, the short-run gain from deviation at low demand is bigger than one at high demand when the level of capacity is low.

Our main contribution is the implication 2. The reason why the first sentence of the implication 2 issues is the following. From the lemma 2, we only take note of the case when firms charge $\frac{1}{2}\underline{\alpha}$ at both states and examine whether the short-run gain at high demand is greater than at low demand (in other words, whether the inequality (3.3) is satisfied). Let $\underline{p}^c$ fixed as $\underline{p}^c$ is equal to $\frac{1}{2}\underline{\alpha}$. At high demand firms must have excess capacities so that firms can charge $\overline{p}^c$ lower than $\frac{1}{2}\underline{\alpha}$ (in other words, they can charge their collusive price counter-cyclically). How large excess capacities do they need for charging $\overline{p}^c$ lower than $\frac{1}{2}\underline{\alpha}$ at that time? Excess capacities at high demand are smaller than or equal to ones at low demand in charging the same price at both demand. If each firm has less capacity than $\frac{1}{2}\underline{\alpha}$, it is capacity constrained even at low demand when it undercuts its price slightly. As a result, for any n and $K \leq \frac{1}{2}\underline{\alpha}$ the incentive of the deviation at low demand is greater than at high demand if firms charges $\frac{1}{2}\underline{\alpha}$ at both states. Thus there is no possibility that $\overline{p}^c$ is greater than $\underline{p}^c$. Hence all firms have more capacities than $\frac{1}{2}\underline{\alpha}$ so that $\overline{p}^c$ can be lower than $\frac{1}{2}\underline{\alpha}$. Then each firm always gets an extra demand of almost $\frac{n-1}{n}(\frac{1}{2}\underline{\alpha})$ if it deviates at low demand. For the above reasons firms can charge $\overline{p}^c$ lower than $\frac{1}{2}\underline{\alpha}$ if they have excess capacities more than $\frac{n-1}{n}(\frac{1}{2}\underline{\alpha})$ when they hypothetically charge $\frac{1}{2}\underline{\alpha}$ at high demand.[21] That is, the minimum capacity level of one firm when they can charge their collusive price counter-cyclically is as follows:

$$\underbrace{\frac{1}{n}(\overline{\alpha} - \frac{1}{2}\underline{\alpha})}_{\text{active capacity}} \quad + \quad \underbrace{\frac{n-1}{n}(\frac{1}{2}\underline{\alpha})}_{\text{excess capacity}} \quad .$$

Hence the minimum capacity level in the whole industry is as follows:

$$\underbrace{\overline{\alpha} - \frac{1}{2}\underline{\alpha}}_{\text{active capacity}} \quad + \quad \underbrace{(n-1)\frac{1}{2}\underline{\alpha}}_{\text{excess capacity}} \quad .$$

While the term of the active capacity is constant, the term of the excess capacity increases with increasing number of firms.

[21] In this sentence we use the words "can" because whether $\overline{p}^c$ is greater than $\underline{p}^c$ also depends on the value of δ. If δ is sufficiently large, firms can collude without decreasing their collusive prices.

3.5 Concluding Remarks

In this chapter we consider the relationship between concentration and price movements by means of introducing capacity constraints to Rotemberg and Saloner's model. We characterize the lower bound of the range of capacity constraints where counter-cyclical movements of prices may occur. Then we have shown that the minimum level of capacity each firm holds to bring about counter-cyclical movements of prices must be bigger as concentration is lower. From this argument we may suggest that counter-cyclical movements of prices are more likely to occur as concentration is higher.

However we do not investigate about what happens above the the minimum level of capacity to bring about counter-cyclical movements of prices. Thus we should not overestimate our conclusion. We also do not investigate about how large capacity each firm decides to set up. To keep our argument exactly we have to consider the relationship between concentration and the level of capacity each firm sets up. Staiger and Wolak's model includes firms' decisions about the level of capacity which they hold. However their model, as we state before, is a two firm model. Thus Staiger and Wolak cannot answer the question about the relationship. It is delicate that firms decide to set up more capacity as concentration is higher. If the fact reverses the above, then our argument in this chapter may be wrong. We have to carry out further investigation about this point.