Incentive Delegation and Collusion

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In an infinitely repeated duopoly we show the implications of strategic incentive delegation. Whether incentive delegation makes consumers or producers better-off depends on the nature of competition. We explain that the presence or absence of incentive delegation may affect the interests of the consumers and the producers in a similar way. (*JEL* Classification: D21, L13, L20)

I. Introduction

In oligopoly industries, the competing firms take various actions to increase their profits. Industry-wide merger is a simple way to increase profits. But, anti-trust laws often do not allow the merger of competing firms. However, the firms can still increase their profits through tacit collusion (see, e.g. Tirole 1988). The possibility of retaliation by the competitor in future periods helps the firms to sustain tacit collusion.

Often licensing may act as a facilitating device. Eswaran (1993) and Lin (1996) show that the possibility of tacit collusion induces licensing among competing firms. Licensing (or, cross-licensing) reduce the per-period non-cooperative profits of the concerned firms. Thus, in an infinitely repeated game, deviation from a tacit

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device. Therefore, though these strategies can be a dominated strategy in a static game, the possibility of infinite interactions makes these strategies useful. However, while the producers benefit from these strategies, the consumers suffer from higher market prices.

This paper re-examines this issue in a symmetric duopoly with strategic incentive delegation. We ask whether the possibility of strategic incentive delegation may help firms to increase their profits when the firms engage in tacit collusion.[1] The answer depends on the nature of competition and is different from earlier results (e.g. Fershtman and Judd 1987). Further, we show that the possibility of technology choice may affect the interests of the producers and the consumers in a similar way.

With the separation of ownership, management and workers, various incentive structures exist within a modern corporation. The works by Vickers (1985), Fershtman and Judd (1987), Sklivas (1987), Fershtman *et al.* (1991), Basu (1995), Basu *et al.* (1997), Das (1997), etc., show the importance of strategic incentive delegation in an oligopoly market. Strategic incentive delegation refers to design of an incentive scheme for the managers to deal with oligopolistic rivalry in the market, independent of considerations such as moral hazard or adverse selection. Thus, the profit maximizing firms may use incentive delegation as a commitment device for getting advantages in the product markets. In fact, the profit maximizing owners will tell their managers not to maximize the profits when each firm's managers are aware of other manager's incentives since each manager will react to the incentives given to competing managers.[2] Hence, strategic incentive delegation helps a firm to play more aggressively or less aggressively in the product market depending on the nature of the competition. Therefore, outputs and prices will be different between the case of incentive delegation and of no incentive delegation. However, the hiring of a manager may be a costly device and so may not benefit the firms (see Basu 1995). If hiring a manager is not too costly then

[1]Fershtman *et al.* (1991) have shown the possibility of collusion through delegation by letting the agents' strategies to be conditional on the compensation scheme.

[2]Here the terms 'owners' and 'managers' will refer to 'principals' and 'agents'. The 'principals' delegate incentive scheme to the 'agents' and 'agents' maximize the delegated objective functions.

incentive delegation becomes a preferred option.

In what follows, Section II considers an infinitely repeated game with two symmetric firms. We show that if these firms choose quantities in the product market then these firms will be able to sustain a lower industry output under incentive delegation. Here, in a stage game, incentive delegation is a dominant strategy to these firms. However, when both firms use the incentive delegation strategy, each firm ends with a profit which is lower than the profit when neither firm uses incentive delegation strategy. Therefore, in the case of a deviation from a tacit agreement, the loss of profits in the future periods are higher under incentive delegation than no incentive delegation. So, the possibility of incentive delegation makes deviation more costly to these firms and helps to sustain tacit collusion. Further, it shows that the consumers are better-off under no incentive delegation compared to incentive delegation.

In this paper the argument for a higher possibility of tacit collusion is different from Eswaran (1993) and Lin (1996). While in their works cross-licensing and licensing are dominated strategies in a stage game, in this paper incentive delegation is a dominant strategy in a stage game. In Eswaran (1993) and Lin (1996), the use of dominated strategies increases the losses from deviation and helps to sustain tacit collusion. But, in this paper incentive delegation is a dominant strategy to these firms. However, when both firms use this dominant strategy then the losses from deviation are higher compared to a situation with no incentive delegation. Thus, incentive delegation helps to sustain tacit collusion though this is a dominant strategy to these firms.

If the firms choose prices in the product market, the prices under incentive delegation are higher compared to a situation with no incentive delegation. This increases the profits of these firms under incentive delegation compared to no incentive delegation. Hence, the future losses from deviation is more without incentive delegation compared to incentive delegation. Thus, in this situation, the possibility of incentive delegation makes tacit collusion difficult. Further, the possibility of incentive delegation hurts the producers and makes the consumers better-off. Therefore, a larger strategy space or the availability of more business strategies may reduce the possibility of collusion.

Section III shows that the above findings about the consumers welfare may change when these firms invest in R&D before entering

the market. The possibility of technology choice before entering the market may affect the interests of producers and consumers in a similar way. For example, if the incentive delegation makes collusion easier then the possibility of incentive delegation provides more profits to these firms. The higher profits induce firms to invest more in R&D. Hence, the firms get relatively better technology when they have the option to use the incentive delegation strategy. This better technology creates an efficiency gain. If this efficiency gain is sufficiently strong then it may outweigh the effect of collusion and can make the consumers better-off as well. Section IV concludes the paper.

II. Model

Suppose there are two firms — 1 and 2. These firms produce a homogeneous good. Each firm faces a constant marginal cost of production $c>0$ and we assume that there are no other costs of production. These firms live for infinite periods and play the same game in each period. We consider two situations: (a) Where the firms have the option to hire a manager and delegate decision-making power to the manager (called 'incentive delegation'); and (b) where the firms do not have the option to hire a manager (called 'no incentive delegation'). Following Fershtman and Judd (1987), Sklivas (1987), Basu (1995), and others, we assume that if the firms hire a manager then it picks an objective function for the manager which can only belong to the following class

$$R_i \equiv \alpha_i \pi_i + (1-\alpha_i) S_i, \qquad i = 1, 2, \tag{1}$$

where, π_i, S_i are the profits and sales functions of the ith firm.[3] Therefore, if the owner of firm i hires a manager then, at stage 1, the owner of firm i specifies the objective function for the manager

[3]Here, we have assumed that the firms live for infinite periods but the incentive scheme specified above considers only the profit of a single period. For this type of linear incentive scheme, the short term incentive or long term incentive, where incentive depends on the future periods also, will not matter. Further, we shall show (after Proposition 1) that for our analysis it is not important whether the incentive schemes are short term or long term.

given in (1) by choosing α_i which maximizes the profit of firm i. Then, at stage 2, the manager maximizes the delegated objective function by choosing output or price.[4] On the other hand, if at stage 1, the owner i does not hire a manager then, at stage 2, the owner i chooses output or price to maximize the profit of firm i.[5]

A. Quantity Competition

This section assumes that the firms compete in quantities with Cournot conjectures. For convenience, we consider the following inverse market demand function:

$$p=a-q, \quad a>c>0, \tag{2}$$

where the notations have the usual meanings. The two firms play an infinitely repeated Cournot game.

Assume that the firms want to engage in tacit collusion in the product market and if they can collude in this manner, then in each period, each will produce $x(a-c)/4$, where $x\geq 1$. For $x=1$, we have monopoly industry output, and for $x>1$, industry output is more than the monopoly industry output. However, the non-cooperative Cournot output provides an upper bound on x since there is no meaning of cooperation for an output which is more than their non-cooperative industry output.[6] Due to symmetry, x is the same for the two firms. Now consider the following (symmetric) trigger strategy. As long as both owners are producing their colluding outputs, they will continue to produce that amount in the next period. But if at any period, one of them deviates from it, then in all future periods they will play a non-cooperative game.

[4]Actually, manager i is told that his/her salary is $A_i+R_iB_i$, where A_i and B_i are constants. Hence, maximizing the expression (1) maximizes $A_i+R_iB_i$, where the constants are adjusted to satisfy the reservation value of the manager.

[5]Basu (1995) has dealt with the endogenous decision on hiring a manager. However, in a symmetric structure (like the one considered in this paper) there are only two types of equilibria: (i) Where both firms hire a manager, and (ii) where neither firm hires a manager. Further, for our purpose, any asymmetry will not add new insights but will complicate the analysis unnecessarily.

[6]For example, in case of no possibility of incentive delegation x will be less than 4/3.

Since, in our work, the sole role for hiring a manager comes from strategic incentive delegation, we assume that our firms will hire a manager only if it makes them better-off compared to a situation with no manager. Hence, it is easy to understand that these firms will not hire a manager if they can sustain the collusion. Further, in case of an unilateral deviation from the collusive output, the deviating firm will not hire a manager because for any specified output of the competitor, incentive delegation will not provide the deviating firm any strategic benefit. The firms will, therefore, hire a manager if they play non-cooperatively.

First, consider case (a). Here, under a non-cooperative game, hiring a manager is a dominant strategy for these firms. Therefore, each owner will hire a manager and will delegate the incentive scheme given in (1). Then the managers choose output to maximize the delegated objective function.

Denote the per-period profit of the ith firm, when both produce $x(a-c)/4$ in each period, when the jth firm produces $x(a-c)/4$ but the ith firm deviates optimally and when these firms compete non-cooperatively by hiring a manager, by π_i^m, π_i^d and $\bar{\pi}_i$, respectively (where $i, j=1, 2, i\neq j$). Therefore, we have[7]

$$\pi_i = \frac{x(2-x)(a-c)^2}{8}, \tag{3}$$

$$\pi_i^d = \frac{(4-x)^2(a-c)^2}{64}, \quad \text{and} \tag{4}$$

$$\bar{\pi} = \frac{2(a-c)^2}{25}. \tag{5}$$

Now consider the possibility of tacit collusion between these firms. Due to the symmetry we shall look at firm 1 only. Assuming a common discount factor $\delta \in (0, 1)$, we can say that tacit collusion will be sustained provided

$$\delta \geq \frac{\pi_1^d - \pi_1^m}{\pi_1^d - \bar{\pi}_1} \; (= \delta^*, \; say). \tag{6}$$

From (3)-(6) we get that

$$\delta^* = \frac{\frac{(4-x)^2}{64} - \frac{x(2-x)}{8}}{\frac{(4-x)^2}{64} - \frac{2}{25}} = \frac{25\{(4-x)^2 - 8x(2-x)\}}{25(4-x)^2 - 128}. \tag{7}$$

[7]In (5), the weights on profits and sales (i.e. α_i) are chosen optimally.

Therefore, given the possibility of incentive delegation, we can say that, given x, $\forall\, \delta \geq \delta^*$, owners will be able to sustain collusion, but they cannot sustain collusion when $\delta < \delta^*$.

Now consider case (b). Here, the owners do not have the option to hire a manager. Therefore, from the argument given above, we can say that this case will affect only the non-cooperative payoffs of these firms (i.e. $\bar{\pi}_i$ will be changed), but the values of π_i^m and π_i^d will remain unchanged. Denote the profit of the ith firm ($i=1, 2$) by π_i^c when the owners do not hire managers and the owners choose the outputs non-cooperatively to maximize the profits of their firms. Therefore, $\pi_i^c=(a-c)^2/9$. Again due to the symmetry we may look only at firm 1. Hence, in this situation, tacit collusion will be sustained provided

$$\delta \geq \frac{\pi_1^d - \pi_1^m}{\pi_1^d - \pi_1^c} (= \delta^{**},\ say). \tag{8}$$

Given the demand and cost specifications we have

$$\delta^{**} = \frac{\dfrac{(4-x)^2}{64} - \dfrac{x(2-x)}{8}}{\dfrac{(4-x)^2}{64} - \dfrac{1}{9}} = \frac{9\{(4-x)^2 - 8x(2-x)\}}{9(4-x)^2 - 64}. \tag{9}$$

From (7) and (9), we see that for any x, $\delta^* < \delta^{**}$. This implies that for any agreed upon x, it is easy for the firms to sustain tacit collusion under strategic incentive delegation compared to no strategic incentive delegation. Further, it is easy to check that $\partial\delta^{**}/\partial x<0$. This implies that as the firms want to sustain a higher industry output level, the critical value of the discount factor decreases. Now, suppose that the firms want to sustain a collusive agreement where each firm produces $x(a-c)/4$ and the value of the discount factor is, say δ_1, where $\delta_1 \in (\delta^*, \delta^{**})$. In this situation, these firms can sustain this agreement only under incentive delegation. However, without incentive delegation and with this discount factor, δ_1, these firms can sustain an output level which is greater than $x(a-c)/4$. Therefore, when $\delta < \delta^{**}$, the possibility of incentive delegation helps the owners to sustain a relatively lower level of output. So, we immediately get the following proposition.

***Proposition* 1**

Suppose the firms compete in quantities. Then, for any δ, the lowest output sustainable with incentive delegation is smaller than the lowest output sustainable without it.[8]

Under a non-cooperative game, the possibility of strategic incentive delegation helps the firms to play more aggressively against its competitor. Therefore, when these firms play non-cooperatively, the industry outputs are more under incentive delegation compared to no incentive delegation. Hence, the firms get lower profits under incentive delegation compared to no incentive delegation. Thus, the possibility of incentive delegation makes deviation from a collusive agreement more costly. As a result, the incentive for sustaining a collusive agreement is greater under incentive delegation relative to no incentive delegation.

How the firms behave with the possibility of strategic incentive delegation is important for our result. Since the quantities are 'strategic substitutes' (see Bulow *et al.* 1985), a firm will get the strategic benefit if it can commit to a higher output level. Strategic incentive delegation helps these firms to do this job. Therefore, for our result, it is not important whether the incentive scheme is dependent on the profit from a single period or whether it depends also on future profits. If the incentive scheme that depends on future profits gives better strategic advantage then it will make the result stronger and will affect the result quantitatively. However, whether a long term incentive scheme will provide more strategic advantage or not is beyond the scope of this paper.

Further, one should note that in our analysis we did not allow the possibility of tacit collusion by the managers. It is clear from the critical values of the discount factors that if the managers face the same discount factors then there will be no possibility of tacit collusion between the managers whenever it is not possible for the firms. Further, one may think that there always exists the possibility that the managers will quit the firm due to better job opportunities, while the new entrants in the job market maintain the competitive wage for the managers; or, alternatively, while the firms live for infinite periods, the managers live for single period

[8]Note that if the firms can sustain monopoly industry output without incentive delegation then these firms will sustain the same output under incentive delegation.

(or, finite periods). Therefore, it rules out the possibility of collusion between the managers. In fact, these assumptions may also help to justify why the incentive schemes are short term.

B. Price Competition in a Differentiated Product Duopoly

This section considers an infinitely repeated game similar to the previous section with two exceptions. First, the choice variable in the product market is price rather than quantity. Secondly, the firms produce differentiated goods rather than homogeneous goods. We assume that the ith firm faces the following inverse market demand function[9]

$$p_i = a - q_i - \theta q_j, \quad i, j = 1, 2, i \neq j, \tag{10}$$

where θ shows the degree of product differentiation, with $0 < \theta < 1$.

To avoid duplication of analysis, we shall be brief in discussing the results of this section. First, consider the case (a), i.e. where each owner hires a manager and delegates decision-making power to that manager. Due to similar reasons of the previous section, the owners will hire a manager only when these firms act non-cooperatively. Assume that the firms want to sustain a price level which lies between their non-cooperative price level and their joint profit maximizing price level. Then, tacit collusion will be sustained (due to the symmetry we again concentrate on firm 1 only) provided

$$\delta \geq \frac{\pi_1^d - \pi_1^m}{\pi_1^d - \bar{\pi}_1} (= \delta', \text{ say}), \tag{11}$$

where the meanings of the symbols are the same to those of the previous section. Again, it is easy to understand that δ' is a function of the agreed upon price level. It is known that $\pi_1^d > \pi_1^m > \bar{\pi}_1$. This implies that $\delta' < 1$.

Now consider case (b), i.e. where the owners do not have the option to hire a manager. Then tacit collusion can be sustained provided we have

$$\delta \geq \frac{\pi_1^d - \pi_1^m}{\pi_1^d - \pi_1^c} (= \delta'', \text{ say}). \tag{12}$$

[9]This demand system can be generated if the typical consumer maximizes a quadratic utility function.

The value of δ'' is also the function of the agreed upon price level. We have $\bar{\pi}_1 > \pi_1^c$ (see Sklivas 1987 and Fershtman and Judd 1987). Therefore, $\delta'' < 1$ and $\delta' > \delta''$. Hence, we have the following result.

Proposition 2

Suppose the firms compete in prices. Then for any δ, the lowest output sustainable without incentive delegation is smaller than the lowest output sustainable under incentive delegation.

The prices act as strategic complements. So, each owner knows that any credible increase in its own price will be followed by an increase in its rival's price. This induces each owner to design an incentive scheme that motivates its manager to be less aggressive in the product market. Therefore, by penalizing managers on sales at the margin, the owners can induce the managers to price less aggressively than under the regular profit-maximizing hypothesis. Hence, when the owners hire a manager and delegate incentive schemes to the managers, both the owners put negative weight to the sales. Thus, the equilibrium prices under incentive delegation are higher than the equilibrium prices without incentive delegation (i.e. under profit-maximization hypothesis). As a result, the profits of these firms are higher under incentive delegation relative to no incentive delegation. Therefore, a punishment strategy is less effective when the owners have the option to hire a manager compared to a situation with no possibility of hiring a manager. As a result, the possibility of incentive delegation makes it difficult to sustain a collusive agreement compared to a situation without incentive delegation. Thus, in the case of price competition, the existence of more options hurt the firms and benefit the consumers. Again, as mentioned for the quantity competition, the possibility of long term incentive schemes will not affect the qualitative result.

However, unlike prices, quantities act as strategic substitutes. Therefore, if a firm increases its output then it reduces the output of its competitor. This fact encourages one firm to design an incentive scheme in a way that motivates its manager to become more aggressive in the product market. As a result, both owners will twist their managers incentives away from profit-maximization towards sales-maximization. This, in turn, increases total outputs under incentive delegation relative to no incentive delegation. Hence, the

profits of these firms are less under incentive delegation compared to no incentive delegation. So, under quantity competition, the punishment strategy is more severe with incentive delegation than without incentive delegation. Therefore, under quantity competition, a better collusive agreement can be sustained under incentive delegation compared to no incentive delegation.

Comparing Propositions 1 and 2, we see that whether the possibility of incentive delegation helps to sustain tacit collusion depends on the nature of the competition, i.e. whether firms choose outputs or prices.

III. Technology Choice

So far we have considered that firms operate with a technology corresponding to a constant marginal cost of production c. This section examines how the results are affected with the possibility of R&D by firms before entering the market. This factor shows the importance of the choice of technology to our results.[10] A lower marginal cost, however, comes with greater expenses on improved technology. Thus, we consider the following game. First, the firms decide which technology to use in the project where the innovation of better technology requires higher cost to incur. After the choice of the technology level, the firms operate infinitely with those technologies. We shall show that this choice of technology can alter our conclusions of the previous section about consumers welfare. Hence, whether the firms have the option to choose a technology level is also an important factor.

A. Quantity Competition

Assume that the firms compete in quantities. Consider that δ is less than δ^{**}. Therefore, the analysis of Section II, *A* shows that for these discount factors, the firms can sustain a lower industry output level under incentive delegation compared to no incentive delegation. Therefore, the profits of these firms are higher under incentive delegation compared to no incentive delegation.

First, consider the situation with incentive delegation. Due to

[10]In this paper, marginal cost of production shows the technology level. Better technology implies lower marginal cost of production.

symmetry, we consider only the problem of firm 1. Suppose, the firms are able to sustain an collusive agreement where each firm produces an output $y_1(a-c)/4$. Hence, in this situation the discounted life-time payoff of firm 1 will be $\pi_1^m(y_1)/(1-\delta)=y_1(2-y_1)(a-c)^2/8$. Now, examine the optimal technology choice by the firm. The problem of firm 1 is:

$$\underset{c}{\text{Max}} \ \frac{\pi_1^m(y_1)}{1-\delta} - f(c), \tag{13}$$

where $f(c)$ is the cost of getting a technology corresponding to the marginal cost c with $f'<0$ and $f''>0$. Maximization of (13) gives

$$-\frac{y_1(2-y_1)(a-c)}{4} - f'(c)=0. \tag{14}$$

Assume that the second order condition for maximization is satisfied.

Next, consider that incentive delegation is not a credible option to these firms. Here, if each firm wants to produce the output $y_1(a-c)/4$ these firms cannot sustain this agreement. But these firms can sustain an agreement where each firm produces output level, say $y_2(a-c)/4$, where $y_2>y_1$. Therefore, the discounted life-time payoff of firm 1 will be $\pi_1^m(y_2)/(1-\delta)=y_2(2-y_2)(a-c)^2/8$, where $\pi_1^m(y_2)<\pi_1^m(y_1)$. Here, the problem of firm 1 is:

$$\underset{c}{\text{Max}} \ \frac{\pi_1^m(y_2)}{1-\delta} - f(c). \tag{15}$$

Maximization of (15) gives

$$-\frac{y_2(2-y_2)(a-c)}{4} - f'(c)=0. \tag{16}$$

Assume that the second order condition for maximization holds. From (14) and (16) we see that $y_1(2-y_1)>y_2(2-y_2)$, since at least $y_1\geq 1$ and $f''>0$. Therefore, these firms will choose better technology under incentive delegation compared to no incentive delegation. The possibility of incentive delegation helps firms to get larger payoffs compared to a situation with no incentive delegation. The larger profit under incentive delegation induces the firms to invent better technology and this creates an efficiency gain. Therefore, the possibility of R&D creates a trade-off between technological gain

and a gain from incentive delegation. *Ex post* R&D, the possibility of incentive delegation helps the firms to collude over a relatively lower output level. This fact encourages the firms to invest more under incentive delegation relative to a situation with no incentive delegation. Therefore, while the possibility of incentive delegation tends to reduce the industry output through collusion, the higher profit from collusion helps to increase industry output by encouraging more investment in R&D. On the balance, if the technological effect is more than the effect of incentive delegation then the presence or absence of incentive delegation affects the interests of the producers and consumers in a similar fashion. Whether, technological effect will be more or less than the incentive delegation effect depends on the cost function associated with R&D, i.e. $f(c)$. So, with sufficient technological gain, the presence or absence of incentive delegation makes both the producers and consumers better-off or worse-off, respectively. We summarize the above findings in the following proposition.

***Proposition* 3**
Suppose the firms do R&D before entering the market. If the technological gain can outweigh the collusive effect of incentive delegation, then consumers and producers will not be worse-off (better-off) with (without) the possibility of incentive delegation compared to no incentive delegation.

B. Price Competition

To avoid duplication, we will not carry out the analysis for price competition in detail. Following similar logic of the previous subsection we can arrive at the following proposition.

***Proposition* 4**
Suppose the firms do R&D before entering the market. If the technological gain can outweigh the collusive effect then consumers and producers will not be better-off (worse-off) with (without) the possibility of incentive delegation compared to no incentive delegation.

Under price competition, the possibility of incentive delegation makes collusion difficult. Hence, the firms get lower profits under incentive delegation compared to no incentive delegation. Therefore,

the firms invent relatively better technology without incentive delegation than under incentive delegation. Thus, this loss from the technological point of view may dominate the effect of collusion and may make the consumers worse-off under incentive delegation compared to no incentive delegation. Further, lower possibility of collusion under incentive delegation also makes the producers worse-off.

IV. Conclusion

Earlier studies have shown that the availability of more business strategies can help the firm by acting as facilitating devices. This paper re-examines this issue in an infinitely repeated duopoly game with or without the possibility of strategic incentive delegation. We find that the nature of competition and the possibility of technology choice have important implications in this respect.

Without the possibility of technology choice, the possibility of incentive delegation hurts (benefits) the consumers (producers) when the firms compete in quantities, but incentive delegation benefits (hurts) the consumers (producers) when the firms compete in prices. However, with the possibility of technology choice by these firms, the presence or absence of incentive delegation affects the interests of the consumers and the producers in a similar way provided the technological effect is stronger than the effect of incentive delegation.

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