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Intertemporal Bundling and Collusion

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Abstract

This paper considers the effect of intertemporal bundling of products and services on tacit price collusion in oligopoly. In a setting of overlapping generations, it is shown that such bundling may facilitate price collusion in a variety of circumstances.

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1 Introduction

This paper shows that intertemporal bundling of products and services can facilitate tacit price collusion. Such bundling can take the form of physically extending a product's serviceable lifetime, or, equivalently, selling multiple period, rather than single period, service subscriptions[1]. I shall refer to both forms of bundling as increased "durability".

The reasoning here is closely related to Ausubel and Deneckere (1987) and Gul (1987). They compare the profitability of an oligopoly to that of a monopoly when products are (infinitely) durable. They showed that the Coase conjecture - which argues that in a dynamic setting, a monopoly selling a durable good to heterogenous consumers may be less profitable than one selling a non durable good - need not apply to an implicitly collusive oligopoly. In particular, the Coasian argument is that in the case of a durable good, high valuation customers may be unwilling to pay a monopoly a price reflecting their valuation as they anticipate that prices will eventually decrease to accommodate low valuation buyers. Ausubel and Deneckere and Gul showed that the same reasoning need not apply to a dynamic collusive oligopoly. Unlike monopoly, an oligopoly can credibly deter future price reductions by the trigger strategy of reversion to marginal cost pricing following deviation. Thus, a durable good oligopoly can avoid the deleterious effects of Coasian dynamics which might plague a monopoly and can thus be more profitable than monopoly under the same conditions.

While the focus of those authors is to compare a durable good oligopoly with a durable good monopoly, here, by contrast, I compare a durable good oligopoly with a non durable good oligopoly and show that the former may be able to collude on prices when the latter cannot. Thus increasing product durability can facilitate collusion and lead to higher prices and profits for firms and lower consumer surplus.

[1] This implies that in oligopoly, the practice of deliberately shortening a product's serviceable lifetime, normally thought to work against consumers' interests (e.g. Bulow (1986)), may actually lead to lower prices and higher consumer welfare.

2 Model

The time horizon is infinite and time periods are discrete. There are N identical firms which produce a homogenous product and compete in prices. The firms' discount factor is δ. We consider two alternative production technologies. Under the non durable (ND) technology a unit of the product provides service for only one period and must then be replaced. Under the durable (D) technology a unit provides perfect service for two periods. The cost of producing a non durable unit is c, the cost of producing a durable unit is $2c$. Thus there are no returns to scale in production and thus product durability may matter only for strategic reasons. Alternatively, and analytically equivalently, the product in question is a subscription for a service, where a service contract may be for either one period (ND), or for two periods (D).

There are overlapping generations of consumers, where measure 1 of identical consumers, each of whom lives two periods, is born each period. Thus at every period measure 1 of young consumers and measure 1 of old consumers are in the market. A consumer's utility from a unit of the product at each period of life is $v, v > c$. The consumers' discount factor is λ. Thus young consumers are willing to pay up to v for a non durable unit and up to $(1+\lambda)v$ for a durable unit, while old consumers are willing to pay up to v for a unit, durable or not. Note that since consumers are identical, product durability has no effect on monopoly profits[2] but, as shall be seen, may have a large effect on oligopoly profit.

In the following subsection I assume that the technology is exogenously determined and then in section 3 consider the case in which firms can choose the technology.

2.1 Equilibrium under non durable technology

Under the ND technology firms can produce only non durable products and the unit monopoly price is v. If the oligopoly colludes at the monopoly price, a firm's discounted profit is

$$\pi_{ND}^{m} = \frac{v-c}{N(1-\delta)} \tag{1}$$

[2] Coasian dynamics for monopoly only apply when consumers have heterogenous valuations.

(where the superscript m indicates the monopoly price). This outcome is enforced by the trigger strategy of reversion to marginal cost pricing following deviation. Thus the maximum profit from undercutting the collusive price is $v - c$, and thus the collusive equilibrium exists iff $\pi_{ND}^m \geq v - c$, i.e., iff $\delta \geq 1 - \frac{1}{N}$. Denoting the lowest discount factor at which a collusive equilibrium exists under the ND technology (i.e., the discount factor at which the preceding inequality is an equality) as δ_{ND} gives the familiar formula (e.g., Tirole 1988):

$$\delta_{ND} = 1 - \frac{1}{N}. \tag{2}$$

2.2 Equilibrium under durable technology

Under the D technology each consumer buys a unit at her first period which serves her at both periods of life. Thus the monopoly price of a durable unit is $(1+\lambda)v$. Let δ_D denote the lowest value of δ at which a collusive equilibrium with the monopoly price $(1+\lambda)v$ exists under the D technology.

Proposition 1 *$\delta_{ND} > \delta_D$ iff $v > 2c$.*

Proof. In a collusive equilibrium in which the price is $(1+\lambda)v$ a firm's discounted profit is

$$\pi_D^m = \frac{(1+\lambda)v - 2c}{N(1-\delta)}. \tag{3}$$

The collusive equilibrium is enforced by the trigger strategy that following deviation the common price reverts to the marginal cost of $2c$ (the cost of producing a durable unit). Let $\overline{p}$ be the highest price which young consumers accept from a deviant firm. A young consumer who buys from the deviant at price $\overline{p}$ gets lifetime utility of $(1+\lambda)v - \overline{p}$. If, instead, she delays her purchase to her second period when the unit price is expected to be $2c$, her discounted utility is $\lambda(v - 2c)$. Thus $\overline{p}$ satisfies: $(1+\lambda)v - \overline{p} = \lambda(v - 2c)$, i.e., $\overline{p} = v + 2\lambda c$. Thus the maximum profit from deviation is $\pi(\overline{p}) = \overline{p} - 2c = v - 2(1-\lambda)c$. Thus the collusive equilibrium exists iff: $\pi_D^m \geq \pi(\overline{p})$, i.e., iff:

$$\frac{(1+\lambda)v - 2c}{N(1-\delta)} \geq v - 2(1-\lambda)c \rightarrow \delta \geq 1 - \frac{(1+\lambda)v - 2c}{[v - 2(1-\lambda)c]N} \tag{4}$$

and thus

$$\delta_D \text{ D æ}- \frac{\text{bæ³ } \lambda \text{9} v - \text{O}c}{\text{¤} v - \text{Cbæ}- \lambda\text{9}c\text{´}N}. \tag{5}$$

Thus, by (2) and (5), $\delta_{ND} > \delta_D$ iff $\frac{\text{bæ³ } \lambda\text{9} v - \text{O}c}{v - \text{Cbæ}- \lambda\text{9}c} > \text{æ}$, i.e. iff:

$$v > \text{O}c. \tag{6}$$

■

Thus if $\delta_D < \delta < \delta_{ND}$, tacit price collusion is feasible only if the product is durable. For example, if $N \text{ D O}$ and $\lambda \text{ D æ}$ then $\delta_{ND} \text{ D } \frac{\text{æ}}{\text{O}}$ while $\delta_D \to \text{¨}$ as $c \to \text{¨}$. Thus in oligopoly shortening a product's useful lifetime or the duration of a service subscription can lead to lower prices, lower firm profit and greater consumer surplus.

As described in the proof of the preceding proposition, the reason is that consumers anticipate that a price cut will lead to marginal cost pricing at the following period. Thus, if the product is durable and a firm deviates, its customers may delay consumption to their second period, substituting cheaper future consumption for more expensive present consumption. Thus consumers will only buy from a deviant if its price cut is substantial enough, which makes deviation less attractive. By contrast if the product is not durable, second period consumption is independent of the price paid at the first period and hence consumers will accept even an arbitrarily small price cut from a deviant, which makes deviation more attractive.

3 Endogenous Technology

In the preceding section it was assumed that the technology is exogenously determined. In this section we reexamine the preceding analysis when firms may choose the technology. Specifically, we now assume that at every period a firm may choose either the D or the ND technology (and may switch technologies from period to period). If it chooses the D technology all its products at that period are durable and if it chooses the ND technology all its products at that period are non durable. All other assumptions are as above.

Proposition 2 *Suppose that at every period a firm can choose whether to make its* *product durable or non durable and consider a collusive equilibrium in which all firms produce only durable products at every period. Then* $\delta_{ND} > \delta_D$ *iff* $v > \dfrac{c}{\lambda}$.

Proof. First, note that in a collusive equilibrium in which firms sell only non durable products at every period, then, as usual $\delta_{ND} = 1 - \dfrac{1}{N}$. Consider a collusive equilibrium in which firms always sell only durable products at the collusive price $(1+\lambda)v$. Then equilibrium profit is π_D^m given by (2). Consider a firm which deviates to the ND technology. Since a young consumer's surplus from buying a durable unit from a non deviant firm at the price $(1+\lambda)v$ is zero, she is willing to pay the deviant firm up to v for a non durable unit. That is because, as the unit she buys at her first period provides service only for one period, her utility at her second period will be independent of first period consumption. Thus the profit from deviation is $v - c$ and thus the collusive equilibrium exists iff: $\pi_D^m \geq v - c \to \delta \geq 1 - \dfrac{(1+\lambda)v - 2c}{(v-c)N}$. Thus in this case $\delta_{ND} = 1 - \dfrac{(1+\lambda)v - 2c}{(v-c)N}$ and thus $\delta_{ND} > \delta_D$ iff $(1+\lambda)v - 2c > v - c$, i.e., iff:

$$v > \frac{c}{\lambda}. \tag{7}$$

■

Comparison of conditions (6) and (7) shows that, interestingly, relative to exogenously imposed product durability, endogenously chosen product durability can either facilitate or hamper collusion. Specifically, if $\lambda \geq 0.5$ then $\dfrac{c}{\lambda} \leq 2c$. In that case, if $\dfrac{c}{\lambda} \leq v < 2c$, $\delta_{ND} > \delta_D$ only if product durability is endogenously chosen but not if it is exogenous. While if $\lambda < 0.5$ then $\dfrac{c}{\lambda} > 2c$ and thus if $2c \leq v < \dfrac{c}{\lambda}$, then $\delta_{ND} > \delta_D$ only if product durability is exogenous.

4 Extensions

4.1 Heterogenous Consumers

In this subsection we consider consumers with heterogenous preferences. Specifically, suppose the fraction α of consumers (patient consumers) have the discount factor λ_1 while the fraction $1 - \alpha$ (impatient consumers) have the discount factor $\lambda_0 < \lambda_1$. To economize on notation, let $\lambda_1 = 1$ and denote $\lambda_2 \equiv \lambda < 1$. As in section 2 we assume the technology is exogenous. When the product is non durable, the collusive price is v and as usual $\delta_{ND} = 1 - \frac{1}{N}$. Now suppose the product is durable and consider the collusive equilibrium in which all young consumers buy at the collusive price $(1+\lambda)v$ (the highest price which young impatient consumers are willing to pay). The following proposition presents a sufficient condition that $\delta_{ND} > \delta_D$[3].

Proposition 3 *Suppose the proportion α of consumers (patient consumers) have the discount factor 1, and the fraction $1-\alpha$ (impatient consumers) have the discount factor $\lambda < 1$ and the product is durable. Corresponding to the collusive equilibrium with the price $(1+\lambda)v$, $\delta_{ND} > \delta_D$ if $v > \max\{2c, \frac{2c}{(1+\lambda-\alpha)}\}$.*

Proof. In the collusive equilibrium with price $(1+\lambda)v$, firm profit is π_D^m given by (2). There are two possible deviations to consider: Undercutting the collusive price in order to sell to young patient consumers only and undercutting the collusive price to sell to all young consumers. Let $\widetilde{p}_1$ and $\widetilde{p}_2$ be, respectively, the highest price at which a patient and impatient consumer is willing to buy from a deviant. Since following a deviation the price will be $2c$, then by already familiar reasoning, $\widetilde{p}_1$ satisfies:

$$2v - \widetilde{p}_1 = v - 2c \rightarrow \widetilde{p}_1 = v + 2c$$

and $\widetilde{p}_2$ satisfies:

$$(1+\lambda)v - \widetilde{p}_2 = \lambda(v - 2c) \rightarrow \widetilde{p}_2 = v + 2\lambda c.$$

The profit from deviation to $\widetilde{p}_1$ is:

$$\pi(\widetilde{p}_1) = \alpha(v + 2c - 2c) = \alpha v$$

[3] The model does not include a second hand market. Since each old consumer derives utility v from a durable unit at her second period, no old consumer would sell for less than v. A young consumer who buys a second hand unit at the price v gets utility v at her first period but, since a second hand unit serves her only at her first period (as durable units last for two periods only), to consumer at her second period she must buy a new unit at the market price $(1+\lambda)v$, from which she will only derive utility v. Thus neither type of consumer would benefit from the existence of a second hand market and thus there does not appear to be a clear role for such a market in this setting.

and the profit from deviation to $\widetilde{p}_2$ is:

$$\pi(\widetilde{p}_2) = v + 2\lambda c - 2c = v - 2c(1-\lambda).$$

Suppose that $\pi(\widetilde{p}_2) > \pi(\widetilde{p}_1) \Leftrightarrow v - 2c(1-\lambda) > \alpha v$. Then the most profitable deviation is to $\widetilde{p}_2$ and hence the collusive equilibrium exists iff $\pi_D^m \geq \pi(\widetilde{p}_2) \Leftrightarrow \dfrac{(1+\lambda)v - 2c}{(1-\delta)N} \geq v - 2(1-\lambda)c$. The preceding inequality is the same as (4) in the case of homogenous consumers and hence implies (5). Thus if $v - 2c(1-\lambda) > \alpha v$, then $\delta_{ND} > \delta_D$ iff $v > 2c$. Combining these two conditions gives that $\delta_{ND} > \delta_D$ if $v > \max\{2c, \dfrac{(1-\lambda)2c}{(1-\alpha)}\}$. ■

4.2 Linear demand

Suppose consumers have a per period linear demand function,

$$q = 1 - p \tag{8}$$

where q is the quantity demanded per period and p is the period price. Then a consumer's period surplus when the period price is p is $S(p) = \dfrac{(1-p)^2}{2}$. To simplify, let consumers' discount factor be $\lambda = 1$. As in section 2 we assume the technology is exogenous. The production cost of a non durable unit is $c < 1$ and of a durable unit is $2c$. Then under the ND technology the one period monopoly price and quantity are respectively $p^m = \dfrac{1+c}{2}$ and $q^m = \dfrac{1-c}{2}$ and the per period consumer surplus is then $S^m(p) = \dfrac{(1-p)^2}{2}$. As usual, under the ND technology, $\delta_{ND} = 1 - \dfrac{1}{N}$.

Consistent with the case of unit demand, we assume that when the product is durable a young consumer's *per period* willingness to pay is determined by half the price - that is, if the price of a durable unit is p then her demand per period is given by $q(\frac{p}{2})$. Then the collusive equilibrium price of a durable product is $2p^m$ and thus collusive profit is:

$$\widehat{\pi}^m = \frac{2[(p^m - c)q(p^m)]}{(1-\delta)N} = \frac{(1-c)^2}{2(1-\delta)N}. \tag{9}$$

Proposition 4 *There is $\widetilde{c} < 1$ such that under the linear demand function (8), $\delta_{ND} > \delta_D$ if $c > \widetilde{c}$.*

Proof. Let $\widehat{p}$ be the highest price a young consumer is willing to pay a deviant *per period*. That is, the highest price she is willing to pay a deviant for a durable good is $2\widehat{p}$. Her surplus from buying at this price is $2\frac{(1-\widehat{p})^2}{2}$ while her surplus from delaying her purchase to her second period when the price will be $2c$ is $\frac{(1-2c)^2}{2}$ (since then she only consumes at one period*).* Thus $\widehat{p}$ satisfies: $2\frac{(1-\widehat{p})^2}{2} = \frac{(1-2c)^2}{2} \rightarrow$

$$\widehat{p} = 1 - \frac{1-2c}{\sqrt{2}}.$$

The deviant's profit is

$$\pi(\widehat{p}) = 2(\widehat{p} - c)q(\widehat{p}).$$

Thus the collusive equilibrium exists if : $\widehat{\pi}^m \geq \pi(\widehat{p}) \rightarrow \frac{(1-c)^2}{4(1-\delta)N} \geq 2(\widehat{p} - c)q(\widehat{p}) \rightarrow$

$\delta \geq 1 - \frac{(1-c)^2}{8(\widehat{p} - \widehat{p}^2 - c + c\widehat{p})N}$. Thus $\delta_{ND} > \delta_D$ if

$$\frac{(1-c)^2}{8(\widehat{p} - \widehat{p}^2 - c + c\widehat{p})} > 1$$

A simple calculation reveals that the preceding inequality obtains (approximately) for $c > 0.2$ ■

5 References

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