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Collusion and Durability

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Abstract

We develop a model to show that cartels that produce goods with lower durability are easier to sustain implicitly. This observation generates the following results: 1) implicit cartels have an incentive to produce goods with an inefficiently low level of durability; 2) a monopoly or explicit cartel is welfare superior to an implicit cartel; 3) welfare is non–monotonic in the number of firms; 4) a regulator may demand inefficiently high levels of durability to prevent collusion.

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1 Introduction

On December 24th, 1924 the so–called "Phoebus" cartel was formed to control the manufacture and sale of incandescent lamps. From the mid-1920s to the Second World War the cartel together with General Electric controlled about three–quarters of the world's output in electric lamps.[1] Apart from allocating market shares and fixing prices, the cartel also limited the lifetime of light bulbs:

The cartel sought to regularize bulbs, setting up a central laboratory in Switzerland to which all members had to submit their goods. Few objected to the policy, as standardization lowered production costs as well as confusion among consumers. Another initiative, however, did not earn such universal praise. Phoebus (and in the United States, GE) systematically changed bulbs to allow them to produce more light per unit of electricity. This also cut the average life span of bulbs by about 20 percent, forcing consumers to purchase more of them. The cartel did not advertise the change, but when called to account, managers pointed out that the new bulbs provided more light per unit of power and so benefited customers. It was not clear, however, why consumers could not have chosen for themselves between the new, brighter bulbs and the old, longer-lasting ones. — Wells (p. 21, 2002).[2]

At first sight, the rationale behind reducing a light bulb's lifetime seems obvious: it forces customers to buy more light bulbs and, hence, increases sales. On closer inspection, however, it is unclear whether this commercial strategy raises profits, because, quite naturally, customers will not be willing to pay as much for a less durable product. Indeed, Swan (1970) demonstrates that this price effect neutralizes the sales effect. As a consequence, a monopolist does not have an incentive to distort the durability of its products. Schmalensee (1979) confirms the robustness of Swan's result. Bulow (1982, 1986) points out, however, that when the monopolist's pricing decision is viewed more dynamically, then the durable–goods–monopoly problem

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[1]Reich (1992) relates the economic conditions under which General Electric initiated and organized the international Phoebus cartel without entering the cartel itself.

[2]Stocking and Watkins (p. 353–356, 1946) provide numerous internal memo's that attest Phoebus' drive to limit lifetime at inefficiently low levels.

identified by Coase (1972) arises. He shows that, in order to mitigate this problem, a monopolist of durable goods selects an inefficiently low level of durability. Yet, Gul (1987) demonstrates that an oligopoly can circumvent the monopolist's durable goods problem by colluding with appropriate trigger strategies. Hence, the question remains why the colluding firms in the Phoebus cartel reduced the durability of light bulbs.

We provide a rather straightforward explanation why colluding firms may want to reduce durability: reduced durability makes collusion easier to sustain. Our argument is that reduced durability raises the frequency of interactions between the firms and thereby raises the speed at which cartel members can retaliate against deviators. This makes deviations less attractive. We illustrate this idea in a minimal setup which enables us to identify three further implications: 1) a monopoly or explicit cartel is welfare superior to a cartel that enforces collusion implicitly; 2) welfare is non–monotonic in the number of firms; 3) a regulator may demand inefficiently high levels of durability to prevent collusion.

2   Setup

Consider a good that may be produced in three variants; it lasts for one ($d = 1$), two, ($d = 2$), or three, ($d = 3$), discrete periods. Consumers need one functioning unit of the good per period. Their utility from consumption is $v = 1$ per period. Hence, consumers' willingness to pay for a good with durability d is

$$v_d = \sum_{i=0}^{d-1} \delta^i,$$

where $\delta \in (0, 1)$ represents a common discount factor.

A good of durability d is produced with a constant marginal cost of c_d. It is convenient to introduce the "average present value" production cost per period, $\hat{c}_d$. In particular, $\hat{c}_1 = c_1$, $\hat{c}_2 = c_2/(1 + \delta)$ and $\hat{c}_3 = c_3/(1 + \delta + \delta^2)$.

An infinite stream of goods d generates a discounted welfare

$$W_d = \sum_{t=0}^{\infty} (\delta^d)^t (v_d - c_d) = \frac{1 - \hat{c}_d}{1 + \delta}.$$

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Consequently, welfare is maximized for

$$d^* = \arg\min_d \hat{c}_d.$$

In our setup with inelastic demand a monopolist will set a price $p^m = v_d$ in order to appropriate the entire surplus W_d. Consequently, a monopolist has no incentive to distort durability; the monopolist chooses efficient durability $d^m = d^*$ and achieves a profit $\Pi^m = W_{d^*}$.[3]

The following assumption suffices to illustrate the more salient points:

Assumption: The intermediate level of durability, $d = 2$, is (strictly) socially optimal, i.e., $\hat{c}_{d^*} = \hat{c}_2 < min\{\hat{c}_1, \hat{c}_3\}$.

3 Collusion

We consider an oligopoly of $n \geq 2$ firms who initially, in an R&D joint venture, decide cooperatively which good d to develop. This is a long term decision that, once taken, remains fixed. After the firms have opted for some technology $d \in \{1, 2, 3\}$, they try to collude tacitly at some price p^c and share profits equally. We determine the critical discount factor $\bar{\delta}$ for which tacit collusion is sustainable. That is, we examine the sustainability of collusion at some price p^c supported by trigger strategies that threaten to return to the zero–profit Betrand equilibrium with $p = c_d$ as soon as some firm deviates from the collusive agreement.

Collusion at a price $p^c \leq v_d$ yields each firm a discounted profit of

$$\Pi^c(p^c, d) = \sum_{t=0}^{\infty} (\delta^d)^t (p^c - c_d)/n = \frac{p^c - c_d}{n(1 - \delta^d)}.$$

By slightly undercutting the price p^c a firm captures the entire market and obtains a profit of

$$\Pi^d(p^c, d) = p^c - c_d.$$

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[3]Swan (1970) shows that there is also no incentive to distort durability when demand is elastic.

Appealing to the single deviation principle, collusion at price p^c is sustainable if and only if

$$\Pi^c(p^c, d) \geq \Pi^d(p^c, d).$$

This leads to our main observation:

Proposition 1 *Tacit collusion with durability d at price $p^c \leq v_d$ is sustainable if and only if*

$$\delta \geq \bar{\delta}_d = \left(\frac{n-1}{n}\right)^{1/d}.$$

Our main insight is that the critical discount factor $\bar{\delta}_d$ is decreasing in durability d; it is harder to sustain collusion when durability is larger. Intuitively, higher durability implies that the firms interact less often. Consequently, firms can retaliate less quickly against deviations. This makes collusion harder to sustain. The observation yields the following result.

Proposition 2 *For $\delta \in [\bar{\delta}_2, 1)$ the equilibrium that maximizes firms' total profits is one in which the n colluding firms choose durability $d^* = 2$ and achieve a total profits of $\Pi_2 = W_2$.*

For $\delta \in [\bar{\delta}_1, \bar{\delta}_2)$ collusion is only sustainable for the lower durability level $d = 1 < d^*$. The equilibrium that maximizes firms' total profits is one in which the n colluding firms choose an inefficiently low level of durability $d = 1 < d^*$ and achieve aggregate profits of $\Pi_1 \equiv (1 - c_1)/(1 - \delta) < \Pi_2$.

For $\delta < \bar{\delta}_1$ collusion is not sustainable for any level of durability.

4   Implications

This section lists the, in our view, most interesting implications of our setup.

Implication 1: Firms have an interest in reducing durability to facilitate collusion.

Implication 1 is a corollary of Proposition 2 for the case $\delta \in [\bar{\delta}_1, \bar{\delta}_2)$.

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Implication 2: A monopoly or explicit cartel is welfare superior to a cartel that enforces collusion implicitly.

If firms are able to coordinate on their most preferred equilibrium and if $\delta \in [\bar{\delta}_1, \bar{\delta}_2]$ then tacit collusion leads to the lower welfare W_1. In contrast, a monopoly chooses durability $d = 2$ and price $p^m = v_2$, resulting in a larger welfare of W_2. The point is that tacit collusion leads to a distortion in durability, which, as shown by Schmalensee (1979), does not occur under quite general conditions in a monopoly. Hence, if the regulatory instruments are limited to a choice between explicit or implicit collusion, explicit collusion is preferable.

Implication 3: The relationship between firm entry and welfare is non–monotonic.

In line with standard theory, the critical discount factor $\bar{\delta}_d$ is increasing in the number of firms n. Now suppose that for a duopoly ($n = 2$) the actual discount factor δ exceeds $\bar{\delta}_2$ so that the duopoly profits most from colluding at the efficient durability level d^*. This results in a welfare level W_2. As the number of firms rises, the critical discount factor $\bar{\delta}_2$ also rises. For some number of firms, say n_2, the critical discount factor $\bar{\delta}_2$ will exceed the actual discount factor δ; collusion with n_2 firms requires the inefficiently low level of durability $d = 1$. Hence, an increase from $n_2 - 1$ operating firms to n_2 reduces welfare from W_2 to W_1. As the number of firms rises even further, the critical discount factor $\bar{\delta}_1$ will, say at n_1, exceed the discount factor δ. Hence, whenever the number of firms exceeds $n_1 - 1$ collusion is not sustainable for any level of durability and the competitive outcome with its associated higher social welfare results.

Implication 4: Excessive durability may prevent collusion.

Whenever $\delta \in [\delta_2, \delta_3)$ collusion is sustainable for durability levels $d = 1$ and $d = 2$, but not for excessive durability $d = 3$. Hence, a regulator who is concerned about the possibility of collusion may prevent collusion by demanding the excessively high level of durability $d = 3$.

Indeed, in practice regulators do regulate the choice of durability indirectly by imposing minimum warranty standards. For instance, in the year

2002 the European Union extended the minimum warranty of products to two years. This move may be understood as a way to increase the durability of products and, according to our theory, may result in less collusion between producers.

5   Concluding Remarks

In order to make the intuition as clearly as possible, we derived our results in a minimalistic setup. We stress, however, the generality of the underlying idea that durability affects the discount factor and thereby influences the sustainability of collusion. For instance, it also obtains when durability is stochastic or when firms can change durability across the different stage games. In the latter case, firms collude in both price and durability and the sustainability of collusion requires that firms also do not defect from the collusive durability level. This yields an additional sustainability condition that complicates the analysis somewhat, but does not change our main point that collusion is easier to sustain at lower durability. Finally, we assumed that the consumers buy their goods all at the same time. This assumption is not crucial. As long as consumers' demand fluctuates over the different periods, reduced durability facilitates collusion.

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