Transparency and Competition

Arvid Nilsson*
Stockholm School of Economics†

December 10, 1999

Abstract

This paper examines the effects of search costs on prices in a Bertrand duopoly. It is shown that if the search cost is lowered, the expected price goes down in a single play of the stage game. However, if the game is repeated it may be easier to sustain collusion the lower the search cost. In other words increased transparency can facilitate collusion even if the sellers' information is unaffected. A transitory improvement of price transparency unambiguously leads to lower prices. Hence, the model provides theoretical support for the price publication practices of consumers' councils.

Keywords: Bertrand Oligopoly, Collusion, Competition Policy, Imperfect Information, Transparency

JEL Classification: C 72, C 73, L 13, L 41

---

*I thank my supervisor Tore Ellingsen. I have also benefited from the comments of Niklas Arvidsson, Rickard Eriksson, Jonas Häckner, Giancarlo Spagnolo and seminar participants at the Stockholm School of Economics, the 1998 EARIE conference in Copenhagen, the 1998 EEA conference in Berlin and the 1999 ESEM conference in Santiago de Compostela. Financial support from Tore Browald's Foundation is gratefully acknowledged. All remaining errors are mine.

†Department of Economics, Box 6501, SE-113 83 Stockholm, SWEDEN, E-mail: arvid.nilsson@hhs.se, Tel: +46 8 736 96 48

1. Introduction

What is the relationship between transparency and competition? Or more specifically, if price information improves, does that lead to higher or lower prices? The question is relevant for the design of competition policy. Should competition authorities promote price transparency or not? The traditional view has been that there is a trade off between the positive effects of improved price information for consumers; they can more easily shop at the cheapest store, and the negative effects of improved price information for producers; it may help firms collude. Consumers' councils and organizations working for the protection of consumers have stressed the importance of transparent prices and have engaged in publication of comparative price lists. Economists and competition authorities on the other hand have generally paid attention to information sharing agreements between firms and disregarded the issue of transparent prices. This paper considers price transparency for consumers, with firms being completely informed, and shows that there is still a trade off. On the one hand, lower search costs tend to reduce the static equilibrium price; on the other hand, it is easier for the sellers to sustain collusion when consumers are better informed.

1.1. Framework

The paper's starting point is a simple search model, essentially due to Burdett and Judd[9], with heterogeneous consumers and a homogeneous goods duopoly. Some consumers have a search cost of zero, whereas the others have a positive search cost. The search cost measures the difficulty of getting information on prices; the more transparent prices are the lower the search cost. How transparent the market is can be thought of as determined by the competition authority. By publishing price lists, the competition authority can lower the search cost and hence make the market more transparent. In other words policy discussions about transparency can be linked to search costs, something that has previously not been done.

The stage game is then repeated and the question of collusion in search markets is studied. If a firm cheats on the collusive agreement and lowers its price, only the consumers with zero search cost, who always search, will notice this and the gain from deviating will be lower than in the standard case. The price cutting firm will gain all the informed consumers, but as the uninformed consumers do not know the prices before deciding which store to enter, one half of them will still go to the high price firm. A firm can always secure itself a positive profit by only serving half of the uninformed consumers at a high price. There are thus two countervailing effects of imperfect price information on the ability to sustain collusion. It reduces the incentives to deviate from a collusive agreement, but it also reduces the severity of the punishment.

1.2. Competition Policy

Transparency is not mentioned in the US competition law, but the effects of transparent prices are sometimes touched on. The US government has in several cases argued that price pre-announcements are in violation of the Sherman Act, but the US Courts have argued that the violation does not lie in the price announcements per se, but rather in the way they are used. Kühn and Vives[20] find a distinction, in the ruling of the Courts, between price pre-announcements that act as commitments to consumers and those which can easily be withdrawn by the firms. The first ones imply greater transparency for consumers, and has therefore been viewed as positive. The latter act as coordination mechanisms for the firms.

The EU view on price transparency is mixed. Examining several cases, Kühn and Vives[20] come to the conclusion that the Commission has regarded increased price transparency through price pre-announcements as harmful to competition. In the Wood Pulp Case[26] the Commission found that firms in the European wood pulp industry violated Article 85(1) both by colluding on prices and by exchanging prices between firms. The fact that prices were published in advance made the market "artificially transparent" according to the Commission. The potential benefits for consumers, by being able to compare prices before purchase were not discussed.

In contrast to the Commission's negative view on transparency in these cases there are examples where only the positive aspects are discussed. In the Council Directive on Consumer Protection 79/581/EEC[10], it is argued that increased market transparency ensures greater protection for consumers. Further, the argument that the move to a single European currency will increase price transparency and hence competition has been raised numerous times by several EU institutions[1]. In a speech in Copenhagen 1997 the EU Commissioner responsible for Competition Policy, Karel Van Miert[35], stated: "For the first time real price transparency across borders will exist. Consumers will be able to source their purchases from anywhere in the Community free from the uncertainties, costs and complexities of exchange rate fluctuations. This can only bring benefits to

[1] See e.g. the Declaration by the Council (Ecofin) and the Ministers Meeting in that Council in the Official Journal of the European Communities L 139 [28].

consumers."

The Commission has even taken actions in order to increase the price transparency between the Member States. By bi-annually publishing lists of car prices the Commission hopes "...that greater price transparency will release market forces which will reduce price differentials."[27]

Maybe the most positive opinion on the competitiveness of transparency is held by the competition authorities in the Scandinavian countries. In a report by the Swedish Competition Committee[24] it is stated as one of the objectives of the competition policy to decrease the search cost for consumers. In the Norwegian Competition Act of 1993[25] it is stated as a duty of the competition authorities to "implement measures to increase the markets' transparency." In Denmark, the Danish Competition Council argues that transparency could be an instrument against anti-competitive behaviour. The argument is that improved information would push the market more towards perfect competition. This view has recently been criticised by Albæk, Møllgaard and Overgaard[4] and Kofmann Christensen[19], who argue that the principle of transparency is counterproductive. It helps firms coordinate on a collusive price.

1.3. Related Literature

Changes in the price information available to consumers have been studied in the price advertising literature. The difference is that this paper considers an exogenous change in the transparency, whereas in the price advertising literature firms decide to make their prices public or not. A common feature in this literature is that price advertising leads to lower price[2]. As in the search market literature, the issue of collusion has not been studied in the framework of a price advertising model.

In repeated games, the theoretical research on the relationship between price information and price levels has completely ignored the effect on buyers' search behaviour. It is conventionally assumed that even if firms cannot observe each others prices, the consumers can do so costlessly. Under this somewhat peculiar

[2]Bester and Petrakis[7] consider price advertising as a means to attract customers from other locations and find that sellers will advertise a low price with positive probability. Salonen[30] analyses a duopoly where firms can make binding price announcements and finds two Perfect Bayesian Equilibria. If firms announce prices, they both commit to marginal cost pricing, if they do not, both charge the monopoly price. Baye and Morgan [6] consider a medium in which firms may advertise and consumers can get the advertised information. They find that advertised prices are lower than unadvertised prices.

assumption, the literature has focused on sellers' information about each others' prices. Several authors have concluded that better and faster price information facilitates collusion[3]. In a repeated game with perfect monitoring, it is generally easier to sustain collusion the sooner any cheating is discovered. On the other hand, Abreu, Milgrom and Pearce[3] show that, under imperfect monitoring, faster reporting may destroy the ability to sustain collusion. In an experiment, Faminov and Benson[14] find weak support for the hypothesis that reporting past prices leads to higher prices. Since the only information aspects that has been studied are those affecting producers, the case in favour of transparency has never been theoretically evaluated. The objective of the present paper is to fill this gap.

The evidence from empirical studies of increased price information is mixed. Albæk, Møllgaard and Overgaard[5] examines the effect of the Danish Competition Council publishing list prices on ready-mixed concrete. Prices went up and no other explanation than facilitation of collusion is found. Numerous authors have studied the effects of advertising bans in the American optometry market[4]. In the states where price advertising is legal, and where optometrists advertise their price, the prices are lower. Several studies of the effect of Canadian retail food price reporting systems have been conducted, all with the conclusion that prices go down during the reporting[5]. The present model might explain the differing results without assuming any change in the information available to sellers.

Section 2 sets up the model and derives the stage game equilibrium. The analysis of the dynamic game is found in section 3, section 4 outlines some empirical implications and final remarks are found in section 5.

2. The Model

2.1. Setup

Consider a price-setting duopoly with identical firms and a constant marginal cost normalised to zero. There is a continuum of consumers, normalised to one, each observing only one firm's price. The model is a slight modification of the nonsequential search model in Burdett and Judd [9]. The difference is the presence of a share $\alpha \in (0, 1)$ of the consumers that have zero search cost and search even if

[3]E.g. Phlips[29], Scherer and Ross[31], Stigler[33] and Tirole [34].

[4]See e.g. Bond, Kwoka Jr, Phelan and Taylor Whitten[8], Feldman and Begun[15] and Kwoka Jr[21].

[5]See e.g. Devine and Hawkins[11], Devine and Marion[12] and McCracken, Boynton and Blake[23].

the expected gain is zero. One can think of these consumers as people who enjoy the act of shopping, an enjoyment that outweighs the search cost so that the net search cost is zero. Another interpretation of α could be that a share α of the consumers have free access to a superior information technology like the internet. Instead of searching for prices in the traditional way, these consumers can by a few mouse-clicks obtain lists of prices for an increasing number of products. As in Stahl[32], we will call these consumers "shoppers". The other consumers have a positive search cost s. They maximize expected utility, comparing the expected gain from searching with the search cost. In equilibrium a fraction $\beta \in [\alpha, 1]$ of the consumers search and obtain perfect price information. These consumers purchase at the store with the lowest price, whereas the others go to either store with equal probability. When firms are colluding on a fixed price the expected gain from searching is zero, and only the shoppers will search. The share of informed consumers β will in that case coincide with the share of shoppers α.

All consumers have an individual demand of one unit of the good, with a reservation price of p^r. Confining attention to the case where $\min\{p_i, p_j\} \leqslant p^r$, the β fully informed consumers have a total demand of

$$E_i(p_i, p_j) = \begin{cases} \beta, & \text{if } p_i < p_j; \\ \frac{\beta}{2}, & \text{if } p_i = p_j; \\ 0, & \text{if } p_i > p_j; \end{cases}$$

for firm i:s products. We are interested in the aggregate demand facing firm i, which simplifies to

$$D_i(p_i, p_j, \beta) = \begin{cases} \frac{1+\beta}{2}, & \text{if } p_i < p_j; \\ \frac{1}{2}, & \text{if } p_i = p_j; \\ \frac{1-\beta}{2}, & \text{if } p_i > p_j. \end{cases}$$

Whether firms can or can not observe each others prices does not matter in this setup since they can infer each others actions from their observed demand.

2.2. Stage Game Equilibria

We first look at equilibria in the stage game. Each firm wants to undercut the other firm's price as long as the profit from doing so is greater than the profit from charging the reservation price. If one firm sets p^*, where p^* solves the equation

$$\frac{1+\beta}{2}p^* = \frac{1-\beta}{2}p^r,$$

the other firm wants to set the reservation price and serve half of the uninformed consumers. First note that $\beta = \alpha = 0$ implies reservation price as the unique equilibrium like the Diamond[13] result, where a positive search cost for all consumers inevitably leads to monopoly pricing. With $\beta = 1$ we are back in the standard Bertrand equilibrium with price equals marginal cost. For $0 < \beta < 1$ we have the following results:

Lemma 2.1. *In any equilibrium no price is set with positive probability.*

Proof. No price lower than p^* or higher than p^r can be part of any equilibrium. Profits could then be increased by increasing or decreasing price respectively. If firm i sets a price p_i with positive probability and firm j plays according to some arbitrary strategy, firm j could increase profit by assigning probability mass on $p_j = p_i - \varepsilon$.$\blacksquare$

Proposition 2.2. *For any β, there is a unique symmetric mixed strategy equilibrium. In this equilibrium each firm randomize according to the cumulative distribution function*

$$F(p_i) = \begin{cases} 0, & \text{if} \quad p_i \leqslant p^*; \\ 1 - \dfrac{1-\beta}{2\beta}\left(\dfrac{p^r}{p_i} - 1\right), & \text{if} \quad p^* < p_i < p^r; \\ 1, & \text{if} \quad p_i \geqslant p^r. \end{cases}$$

Proof. The unique symmetric equilibrium is characterised by a cumulative distribution function $F(p)$ on $[p^*, p^r]$. All prices in the interval $[p^*, p^r]$ must yield the same expected payoff, in particular setting p_i or p^r when the other plays $F(p)$ should be equivalent. We have the profit from charging p_i when the other firm randomizes according to $F(p)$,

$$E\Pi_i\left(p_i, F\right) = \left(\beta\left(1 - F(p_i)\right) + \frac{1-\beta}{2}\right)p_i, \tag{2.1}$$

where the first component is the probability that the price p_i is lower than p_j, times the share of informed consumers. The second component is firm i:s share of the consumers who do not search. Equating this expression with the profit from charging the reservation price

$$E\Pi_i\left(p^r, F\right) = \frac{1-\beta}{2} p^r, \tag{2.2}$$

we get

$$\left(\beta\left(1 - F(p_i)\right) + \frac{1-\beta}{2}\right) p_i = \frac{1-\beta}{2} p^r,$$

which gives the unique distribution function

$$F(p_i) = 1 - \frac{1-\beta}{2\beta}\left(\frac{p^r}{p_i} - 1\right), \text{ if } p^* < p_i < p^r. \blacksquare$$

Corollary 2.3. *The higher the β the lower the expected price.*

Proof. This follows from p^* being decreasing in β,

$$\frac{dp^*}{d\beta} = \frac{-2p^r}{\left(1+\beta\right)^2} < 0,$$

and the density function $f\left(p_i\right)$ being decreasing in β. The corresponding density function $f\left(p_i\right)$ to the distribution function $F(p_i)$ is

$$f\left(p_i\right) = \frac{1-\beta}{2\beta}\frac{p^r}{p_i^2},$$

which is indeed decreasing in the share of searchers,

$$\frac{df\left(p_i\right)}{d\beta} = \frac{-p^r}{2\beta^2 p_i^2} < 0. \blacksquare$$

Lemma 2.1, Proposition 2.2 and Corollary 2.3 are similar to related propositions in Burdett and Judd[9], Guimarães[17], Stahl[32] and Varian[36].

2.3. Search Behaviour

The consumers' search behaviour will depend on their search cost. Both α and β depend on s. The share of shoppers α can rise when the search cost s is reduced, because some consumers that were formerly not shoppers start enjoying shopping. This will typically happen when the competition authority encourages search by publishing comparative price lists. Formally one can write $\alpha_t = \alpha_{t-1} + \varepsilon(s)$, where $\varepsilon(s)$ is an unknown function with $\varepsilon'(s) \leqslant 0$.

The $1-\alpha$ consumers with search cost s maximize expected utility, comparing the expected gain from searching with s. The expected gain from searching v is the difference between the expected price $\overline{p}$ and the expected minimal price $\overline{p}_{\min}$, $v = \overline{p} - \overline{p}_{\min}$. A searcher faces the expected minimal price $\overline{p}_{\min}$ and a consumer that abstains from searching expects the price $\overline{p}$. The distribution of the minimal price $p_{\min}$ is

$$F(p_{\min}) = \begin{cases} 0, & \text{if } p_{\min} \leqslant p^*; \\ 1 - \dfrac{(1-\beta)^2}{4\beta^2}\left(\dfrac{p^r}{p_i} - 1\right)^2, & \text{if } p^* < p_{\min} < p^r; \\ 1, & \text{if } p_{\min} \geqslant p^r. \end{cases}$$

Proposition 2.4. *Depending on the search cost s two cases may arise, first that only the shoppers search and second that a share β of the consumers search.*

Proof. When $s > v(\alpha)$, the search cost is higher than the gain from searching when only the shoppers search, there exists always an equilibrium where only the shoppers search. It is not profitable for the first consumer to search, so no one will start. Furthermore when $s > v(\beta)$ for all β, it is never profitable for the consumers with positive search cost to search, so only the shoppers search. In the second case the $1-\alpha$ consumers with search cost s are indifferent between searching and not. The share β is such that $s = v$ where both $\overline{p}$ and $\overline{p}_{\min}$ depend on β. The equilibrium condition is

$$\begin{aligned} s &= v = \overline{p} - \overline{p}_{\min} \\ &= \int_{p^*}^{p^r} p\,dF(p_i) - \int_{p^*}^{p^r} p\,dF(p_{\min}) \\ &= \int_{p^*}^{p^r} p\frac{1-\beta}{2\beta}\frac{p^r}{p^2}dp - \int_{p^*}^{p^r} p_{\min}\frac{(1-\beta)^2}{2\beta^2}\frac{p^r}{p_{\min}^2}\left(\frac{p^r}{p_{\min}} - 1\right)dp_{\min} \\ &= p^r\left(\frac{1-\beta}{2\beta}\ln\frac{1+\beta}{1-\beta} - \frac{(1-\beta)^2}{2\beta^2}\left(\frac{2\beta}{1-\beta} - \ln\frac{1+\beta}{1-\beta}\right)\right) \\ &= p^r\frac{1-\beta}{2\beta}\left(\frac{1}{\beta}\ln\frac{1+\beta}{1-\beta} - 2\right). \blacksquare \end{aligned}$$

The graph of the function $v(p^r, \beta)$ is illustrated in Figure 2.1. Note that $v(p^r, \beta)$ attains a unique maximum at some β^*, is strictly increasing for $\beta \in (0, \beta^*)$

and strictly decreasing for $\beta \in (\beta^*, 1)$.[6] Given the reservation price p^r, there exists a unique $s^* > 0$ satisfying $v(p^r, \beta^*) = s^*$. As in Burdett and Judd[9] there are several equilibria to be analysed. If s is larger than s^*, only shoppers will search. If $s = s^*$, we have a unique equilibrium with $\beta = \beta^*$, and if $s < s^*$, there are two equilibria corresponding to β_1 and β_2 in Figure 2.1. As Fershtman and Fishman[16] have shown, only one of the equilibria when $s < s^*$ is stable. Consider the neighbourhood of β_1 in Figure 2.1. If $\beta < \beta_1$, the gain from searching is less than the search cost, thus, β will always decrease away from β_1. If $\beta > \beta_1$, the gain from searching is larger than the search cost, so β will always increase away from β_1. The equilibrium with the share of searchers β_2 is, on the other hand, stable. When $\beta_1 < \beta < \beta_2$, then $v > s$, and β will increase to β_2. If $\beta > \beta_2$, then $v < s$, and β will decrease to β_2. In the rest of the analysis we will restrict attention to this stable equilibrium.

Proposition 2.5. *A reduction of s will lead to a higher or unchanged β.*

Proof. Given that we are in the stable equilibrium, the figure shows that $d\beta_2/ds < 0$, so the lower the search cost the more people search, which is a common result in the search market literature. Consider now a reduction of the search cost when the initial search cost is larger than s^*. In order to increase the number of searchers, the search cost has to be lowered significantly. β will remain at α until the search cost is lower than the gain from searching, when only α of the consumer search. So

$$\beta^*(s) = \begin{cases} \alpha, & \text{if} \quad s > v(\alpha); \\ \beta_2, & \text{if} \quad s < v(\alpha). \end{cases}$$

If $\alpha = \alpha_2$ in the figure, a reduction of the search cost to s' will induce β_2 of the consumers to search. If, on the other hand, $\alpha = \alpha_1$ in the figure, reducing the search cost to s' is not enough to raise the search activity.■

There are potentially two effects of a price publication by the competition authority. First, a reduction of the search cost which will raise β. Secondly, some consumers that did not use to search will start studying the price lists and derive enjoyment from doing so and hence raise α. Indeed, some people read price surveys for goods they are not even considering buying, just because they happen to stumble over the survey in their newspaper. Likewise, those connected to the internet are likely to look up prices of e.g. books and compact discs on

[6] For proof see Burdett and Judd[9].

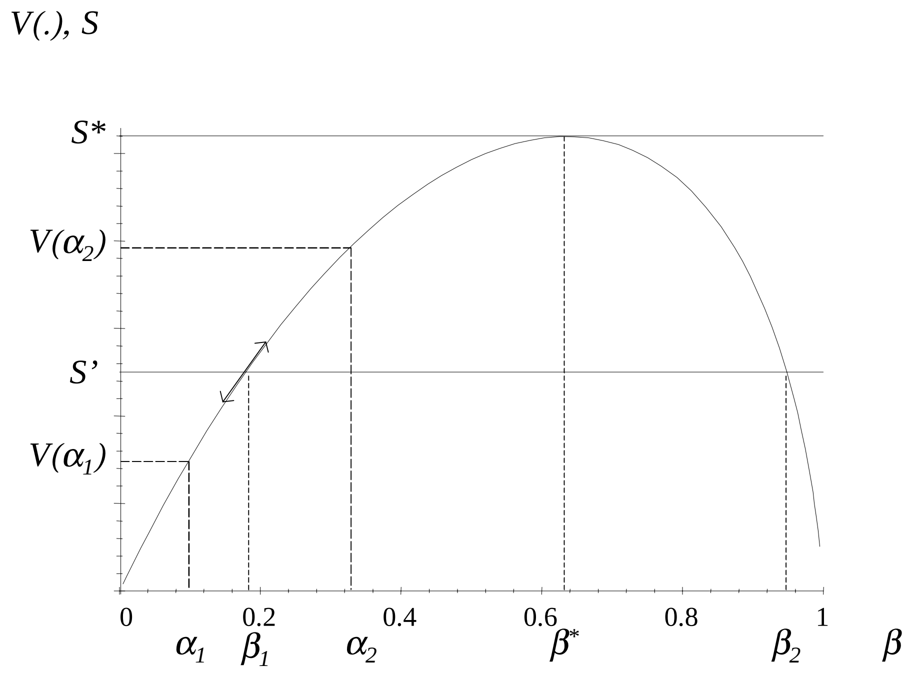

Figure 2.1: The function $v\left(p^r, \beta\right)$

the net before purchase, something they would not have done a few years ago. Promoting the use of internet would certainly induce search in these markets. The more α raises the less s has to be reduced to induce a jump to β_2. In markets where the shoppers are very responsive to changes in s we are almost guaranteed a search-intensive equilibrium and hence low prices.

3. Dynamic Game

When the game is repeated there are intuitively two countervailing effects of imperfect price information. First the profit from deviating from a collusive agreement is lower than under complete information. A deviating firm does not gain the whole market by ε-undercutting. Second, the possible punishment imposed on a deviator should be less severe, since a firm can always gain positive profit by charging the buyers' reservation price.

When the search cost is low enough for some positive search cost consumers to search, we may not have the same stage game in every period. Specifically the stage game changes after a deviation. During collusion only the shoppers search since the expected gain from searching is zero. In the punishment phase a larger fraction β of the consumers search so the stage game is different. However it is still possible to analyse the resulting dynamic game in the same way as a repeated game.

A crucial assumption is that consumers must be able to identify the shift from collusion to competition. One way this could happen would be that the consumers notice the demand, at the store they are shopping at, in the period of the deviation. If the demand is higher or lower than in the previous period, they know that the next period will be a punishment period. Another way the information could be transmitted to the consumers could be via the shoppers. Since the shoppers always know the nature of the following period, they can transfer this knowledge to the rest of the consumers. As a basis for comparison we first review the perfect information case, when all consumers observe both prices. In the imperfect information case we continue by analysing collusion supported by trigger strategies and optimal punishments[7] respectively.

[7] The simple two-phase optimal symmetric punishment suggested by Abreu[1] [2], implies a harsh punishment in one period and then a reversion to the collusive agreement. This stick and carrot setup means that it pays for the deviator to participate in its own punishment. Refraining from doing so prolongs the first stage of the punishment. Abreu originally developed it for Cournot games; Lambson[22] and Häckner[18] have later adapted it to Bertrand games

3.1. Perfect Information

In the perfect information case, trigger strategies and optimal two-phase punishments coincide, and the punishment payoff is zero. A deviation from the collusive agreement implies ε-undercutting the collusive price and gaining all consumers. Collusion on the reservation price p^r is sustainable if

$$\frac{p^r}{2(1-\delta)} \geqslant p^r + \frac{\delta}{1-\delta}0,$$

or equivalently, if

$$\delta \geqslant \frac{1}{2}.$$

As long as the discount factor is larger than one half, collusion is sustainable.[8]

3.2. Trigger Strategies

A deviation from collusion will lead more people to search since the expected gain from searching is positive in the punishment phase. This implies that the punishment payoff will be lower. Collusion supported by trigger strategies implies that a deviation from the collusive agreement is punished by an eternal reversion to the stage game equilibrium. Firms set the reservation price p^r in the collusive phase and firm i receive profit $p^r/2$. If firm i deviates, the profit is

$$\Pi_i^d = (1+\alpha)\frac{p^r}{2},$$

and in the punishment phase they revert to the stage game mixed equilibrium forever, with profit

$$\Pi_i^p = \frac{\Pi(\overline{p})}{2} = \frac{1-\beta}{2}p^r.$$

Collusion is sustainable if

$$\frac{p^r}{2(1-\delta)} \geqslant (1+\alpha)\frac{p^r}{2} + \frac{\delta}{1-\delta}\frac{(1-\beta)}{2}p^r,$$

or equivalently, if

$$\delta \geqslant \frac{\alpha}{\alpha+\beta}. \tag{3.1}$$

with capacity constraints and product differentiation respectively.

[8] Regardless of the collusive price, collusion is sustainable for discount factors larger than one half.

We see that it is now possible to sustain collusion for discount factors smaller than one half, since $\beta > \alpha$.

A special case arise when the search cost s is larger than the gain from searching in the stage game. In this case we have a repeated game where $\beta = \alpha$, and the condition for collusion to be sustainable is $\delta \geqslant 1/2$, the same as in the perfect information case. The intuition is straightforward, the small gain from deviating is perfectly outweighed by the weaker punishment. It is the same fraction of consumers that the deviator gains when deviating and loses in the punishment phase.

An interesting feature of the model is that collusion is easier to sustain the higher the collusive price. Under collusion on p^c, we have

$$\frac{d\delta}{dp^c} = \frac{-\alpha\left(1-\beta\right)p^r}{\left(\left(1+\alpha\right)p^c - \left(1-\beta\right)p^r\right)^2} < 0,$$

for $p^c < p^r$, so if firms collude they do it on the reservation price p^r. In the perfect information case, the collusive price does not affect the ability to sustain collusion, and in most other models higher collusive price makes it harder to sustain collusion. The reason for the opposite result in this model is that the value of sticking to the collusive agreement changes more than the gain from deviating, when the collusive price changes.

3.3. Optimal Punishments

While trigger strategies have several appealing features (they are simple and do not involve negative prices), they are not always optimal. Abreu[2] demonstrated that in the search for optimal penal codes, attention can be restricted to simple two-phase penal codes. Lambson[22] proved that in Bertrand game with capacity constraints, which is similar to the setting in this paper, optimal penal codes are characterised by security level punishments. The present value of the punishment is equal to the present value of the profits a firm can guarantee itself, here by setting the reservation price and serving half of the uninformed consumers. Theorem 3.8 in Lambson[22] which proves the existence of an optimal penal code carries, after some definitions, over to the model in this paper. First note that the search market model in this paper is equivalent to a model with a capacity constraint

$$k = \frac{1+\beta_o}{2},$$

where β_o is the share of searchers in the punishment phase under optimal punishments. Replacing Assumption H7 in Lambson[22] with the following assumption H7' lets us refer to the proof of Theorem 3.8 in Lambson [22], for the proof of existence.

Assumption H7'. For all p_i, p_j, i, j if $p_j < p_i$ and $s_j(p_i, p_j) < k$ then $s_i(p_i, p_j) = \frac{1-\beta_o}{2}$.

Given existence, it remains to characterise the optimal punishment. To check if collusion on the reservation price p^r is possible to sustain with two-phase punishments amounts to check that the penal code is sustainable and credible. A penal code is sustainable if a deviation from the collusive agreement is not optimal and credible if a deviation from the punishment phase is not optimal. In a collusive period each firm gets $p^r/2$ whereas a deviation yields $(1+\alpha)p^r/2$. The punishment consists of two stages; first one period of very low prices, followed by a reversion to collusive pricing. In the punishment period the punisher will set price equal to marginal cost and the punished must set a lower price p^p. In this model marginal cost is normalised to zero, so p^p is negative. The payoff is Π^p for the punished and zero for the punisher, and a deviation from the punishment period yields $(1-\beta_o)p^r/2$ which is the profit from charging the reservation price. The condition for sustainability is thus

$$\frac{(1+\alpha)p^r}{2} - \frac{p^r}{2} \leqslant \delta\left(\frac{p^r}{2} - \Pi^p\right), \tag{3.2}$$

the punished's condition for credibility is

$$\frac{(1-\beta_o)p^r}{2} - \Pi^p \leqslant \delta\left(\frac{p^r}{2} - \Pi^p\right), \tag{3.3}$$

and the credibility constraint for the punisher is

$$\frac{(1-\beta_o)p^r}{2} - 0 \leqslant \delta\left(\frac{p^r}{2} - \Pi^p\right).$$

It is easy to see that the credibility constraint for the punisher is never binding, since the credibility constraint for the punished is always tighter. To find the optimal punishment is then equivalent to minimizing the present value of the punishment

$$PV^p = \Pi^p + \frac{\delta}{2(1-\delta)}p^r,$$

subject to (3.2) and (3.3). We find that the punishment profit must be

$$\Pi^p = \frac{1 - \beta_o - \delta}{2(1-\delta)} p^r,$$

and that the present value of the punishment PV^p is indeed the same as the profit from charging the reservation price,

$$PV^p = \frac{1 - \beta_o}{2(1-\delta)} p^r.$$

It is thus a security level penal code and therefore optimal. It is easy to see that with this type of punishments the condition for collusion to be sustainable becomes

$$\delta \geqslant \frac{\alpha}{\alpha + \beta_o}. \tag{3.4}$$

As long as more people search in the punishment phase under two-phase punishments than under trigger strategies, i.e. $\beta_o > \beta$, two-phase punishments are optimal. How large β_o will be is determined by the difference between the two firms' prices. Since the punisher sets price equal to marginal cost, the punished firm's price p^p must be low enough to induce enough consumers to search. It turns out that one can achieve maximal search, $\beta_o = 1$, by setting

$$p^p = \frac{-\delta p^r}{2(1-\delta)},$$

given that

$$s \leqslant \frac{\delta p^r}{4(1-\delta)}.$$

So when the search cost is not too high, it is possible to sustain collusion for

$$\delta \geqslant \frac{\alpha}{\alpha + 1},$$

which is easier than with trigger strategies.

3.4. Price Publication

The competition authority's aim with price publications is to increase the transparency and reduce the price in the market. As we noted earlier, there are potentially two effects of a price publication, both α and β may increase.

Proposition 3.1. *Improving the price information has ambiguous effects on the ability to sustain collusion with trigger strategies, and will never facilitate collusion under optimal punishments.*

Proof. The first part follows from $d\alpha/ds \leqslant 0$, $d\beta/ds \leqslant 0$, $d\delta/d\alpha > 0$ and $d\delta/d\beta < 0$, and the second part from $d\alpha/ds \leqslant 0$, $d\beta_o/ds = 0$, $d\delta/d\alpha > 0$ and $d\delta/d\beta_o = 0$.■

The mechanism is the following. By publishing prices the competition authority decreases the search cost s for the consumers. This leads more people to become shoppers, α rises, which increases the incentives to deviate from the collusive agreement. It will also lead more people to search, raise β, in the punishment phase which strengthens the punishment, and makes collusion easier. The total effect is thus ambiguous.

So it is not increased information for the firms that makes collusion easier, but the fact that consumers react to the lower search cost. Also the incentive for the firms to collude is strengthened, since the profit in the stage game is lowered by the competition authority's act of publishing prices.

In the case when firms are using optimal punishments, the only possible effect of the publication is a rise in α, which make collusion harder to sustain. Remember that β_o is equal to one, so it is not possible to increase the share of searchers any further.

Proposition 3.2. *A transitory price publication will never facilitate collusion.*

Proof. Consider the case when the search cost s is larger than the gain from searching v, and only α of the consumers search in the stage game. Suppose the competition authority starts publishing prices and declares that it will do so for a specific number of periods. The search cost is only reduced during the publication, so everyone knows that at the end of the publication only α of the consumers will search. This implies that a deviation from a collusive agreement in the last publication period is only punished with the punishment payoff $(1-\alpha)p^r/2$, as in the repeated game. Collusion is only sustainable for $\delta \geqslant 1/2$ in that period. In the next to last publication period both firms know that collusion in the next period is not possible for discount factors δ lower than one half. If the discount factor is indeed lower than one half, both firms will deviate from the collusive agreement. By backward induction it is easy to see that it is not possible to sustain collusion in any period for discount factors lower than one half, when the price publication is temporary.■

4. Empirical Implications

The model in this paper entails some empirical predictions. A reduced search cost, or a facilitation of price comparisons, should either lead to lower prices or higher prices with reduced price dispersion. The first case occurs when firms compete without collusion both before and after the reduction of the search cost. In the second case, firms start colluding after the reduction of the search cost.

In the absence of collusion the price goes down when the search cost is reduced. This is in line with the findings from the food market in Canada. All reports show a decrease in the price level, some show a decline in the dispersion of prices, while others do not. Looking at the variance of the price,

$$var\,(p) = (1-\beta)\,p^{r^2}\left(\frac{1}{1+\beta} - \frac{1-\beta}{4\beta^2}\left(\ln\frac{1+\beta}{1-\beta}\right)^2\right),$$

we find that it exhibits a non-monotonic relationship with the search cost. Recall that the price varies from marginal cost when everyone is informed to reservation price when no one is informed. In both extreme cases the variance is zero, while being positive in between. On the one hand the possible price range widens as the search cost declines, but on the other hand the distribution shifts towards lower prices, so high prices will be seen less often. The first effect dominates for small β and the second for large β. We have

$$\begin{aligned}\frac{dvar\,(p)}{ds} &= \frac{dvar\,(p)}{d\beta}\frac{d\beta}{ds}, \\ &= p^{r^2}\left(\frac{1-\beta}{\beta^2}\left(\ln\frac{1+\beta}{1-\beta}\right)\left(\frac{1}{2\beta}\ln\frac{1+\beta}{1-\beta} - \frac{1}{1+\beta}\right) - \frac{2}{(1+\beta)^2}\right)\frac{d\beta}{ds},\end{aligned}$$

which is negative for β less than some $\widehat{\beta}$, and positive for β larger than $\widehat{\beta}$. In the relevant range, $\beta > \beta^*$, it is possible to observe both increased and decreased variance after a reduction of the search cost. This is due to the fact that $\widehat{\beta}$ is larger than β^*.

The profit in the stage game declines when the search cost is lowered, so the incentives to initiate collusion are greater. A reduced search cost, that is perceived to be permanent, makes it also easier to sustain collusion, as the lowest possible discount factor declines. It would therefore be natural to observe an increase in the price level as a result of a price publication, just as Albæk et al.[5] find in the Danish concrete market. The prices increased by 15 - 20 percent and the price dispersion was significantly reduced, which is in line with the model's predictions.

Another explanation for the differing results could be the difference in market structure. In markets like food retailing there are more firms active than in the concrete market. If the model is calculated with N firms instead of two, it can be shown that the expected price is decreasing in N. Furthermore the critical discount factor for the ability to sustain collusion is increasing in N, so it is less likely that a price publication leads to firms' initiating collusion, the more firms there are in the market.

5. Final Remarks

Whenever it is possible to identify a change in the price information in a market it would be possible to test the model on time series data, comparing the price level and the price dispersion before and after the change. Different price information regimes in different regions could also be a basis for testing the model on panel data.

One issue that would be interesting to look into is the arrival of the internet. With the help of shopping guides that search most of the internet shopping facilities the effective search cost has been reduced dramatically. Whether this new technology has lead to increased competition or not is a topic for future research.

The welfare implications of a model with unit demand are well known, there are no distortions due to collusive prices. With a more elaborate demand side there would be an efficiency loss from high prices and it would be clearer that the competition authority's aim should be to lower prices. With the model as it now stands, the competition authority is only interested in lowering price if it puts more weight on the consumer surplus than the producer surplus.

There is an important distinction between the effects of a permanent and a transitory increase of the transparency. Whereas a permanent increase results in lower expected price in the stage game, but facilitates collusion, a transitory increase of the transparency is unambiguously positive. Hence, this paper provides theoretical support for consumers' councils' practice of publishing price lists. A publication in a limited period should lower the expected price in the stage game without increasing the possibilities of sustaining collusion.

References

[1] Abreu, D. (1986), "Extremal Equilibria of Oligopolistic Supergames," Journal of Economic Theory 39, pp. 191-225.

[2] Abreu, D. (1988), "On the Theory of Infinitely Repeated Games with Discounting," Econometrica 56, pp. 383-396.

[3] Abreu, D., P. Milgrom and D. Pearce, (1991), "Information and Timing in Repeated Partnerships," Econometrica 59, pp. 1713-1733.

[4] Albæk, S., P. Møllgaard and P.B. Overgaard, (1996), "Law-Assisted Collusion? The Transparency Principle in the Danish Competition Act," European Competition Law Review 6, pp. 339-340.

[5] Albæk, S., P. Møllgaard and P.B. Overgaard, (1997), "Government-Assisted Oligopoly Coordination? A *Concrete* Case," Journal of Industrial Economics 45, pp. 429-443.

[6] Baye, M.R. and J. Morgan, (1998), "Information Gatekeepers and the Competitiveness of Homogeneous Products Markets," Indiana University (Mimeo), August 1998.

[7] Bester, H. and E. Petrakis, (1995), "Price Competition and Advertising in Oligopoly," European Economic Review 39, pp. 1075-1088.

[8] Bond, R.S., J.E. Kwoka Jr, J.J. Phelan and I. Taylor Whitten, (1980), "Effects of Restrictions on Advertising and Commercial Practice in the Professions: The Case of Optometry," Federal Trade Commission, US Government Printing Office 629-756/6007.

[9] Burdett, K. and K.L. Judd, (1983), "Equilibrium Price Dispersion," Econometrica 51, pp. 955-969.

[10] Council of the European Communities, (1979), "Council Directive of 19 June 1979 on Consumer Protection in the Indication of the prices of Foodstuff," 79/581/EEC, Luxembourg.

[11] Devine, D.G. and M.H. Hawkins, (1972), "Implications of Improved Information on Market Performance," The Journal of Consumer Affairs 6, pp. 184-197.

[12] Devine, D.G. and B.W. Marion, (1979), "The Influence of Consumer Price Information on Retail Pricing and Consumer Behavior," American Journal of Agricultural Economics 61, pp. 228-237.

[13] Diamond, P. (1971), "A Model of Price Adjustment," Journal of Economic Theory 3, pp. 156-168.

[14] Faminow, M.D. and B.L. Benson, (1987), "On the Implications of Reporting Retail Food Prices over Extended Periods, " The Journal of Consumer Affairs 21, pp. 40-69.

[15] Feldman, R.D. and J.W. Begun, (1980), "Does Advertising of Prices Reduce the Mean and Variance of Prices?" Economic Inquiry 18, pp. 487-492.

[16] Fershtman, C. and A. Fishman, (1992), "Price Cycles and Booms: Dynamic Search Equilibrium," American Economic Review 82, pp. 1221-1233.

[17] Guimarães, P. (1996), "Search Intensity in Oligopoly," Journal of Industrial Economics 44, pp. 415-426.

[18] Häckner, J. (1996), "Optimal Symmetric Punishments in a Bertrand Differentiated Products Duopoly," International Journal of Industrial Organization 14, pp. 611-630.

[19] Kofmann Christensen, M. (1995), "Denmark," International Corporate Law Supplement April, pp. 14-15.

[20] Kühn, K-U. and X. Vives, (1995), "Information Exchanges Among Firms and their Impact on Competition," Office for Official Publications of the European Communities, Luxembourg.

[21] Kwoka Jr, J.E. (1984), "Advertising and the Price and Quality of Optometric Services," American Economic Review 74, pp. 211-216.

[22] Lambson, V.E. (1987), "Optimal Penal Codes in Price-setting Supergames with Capacity Constraints," Review of Economic Studies 54, pp. 385-397.

[23] McCracken, V.A., R.D. Boynton and B.F. Blake, (1982), "The Impact of Comparative Food Price Information on Consumers and Grocery Retailers: Some Preliminary Findings of a Field Experiment, "The Journal of Consumer Affairs 16, pp. 224-240.

[24] Ministry of the Interior, (1990), "Prisinformation till konsumenter", Statens Offentliga Utredningar 1990:106, Stockholm.

[25] Norwegian Competition Authority, (1994), "Norwegian Competition Legislation".

[26] Official Journal of the European Communities L 85, (1985), Office for Official Publications of the European Communities, Luxembourg.

[27] Official Journal of the European Communities L 124/64, (1998), Office for Official Publications of the European Communities, Luxembourg.

[28] Official Journal of the European Communities L 139/28, (1998), Office for Official Publications of the European Communities, Luxembourg.

[29] Phlips, L. (1988), The Economics of Imperfect Information," Cambridge University Press, Cambridge.

[30] Salonen, H. (1992), "Bertrand Equilibrium and Price Competition," European Journal of Political Economy 8, pp. 41-55.

[31] Scherer, F.M. and D. Ross, (1990), "Industrial Market Structure and Economic Performance," 3rd ed., Houghton Mifflin Company, Boston.

[32] Stahl, D. (1989), "Oligopolistic Pricing with Sequential Consumer Search," American Economic Review 79, pp. 700-712.

[33] Stigler, G. (1964), "A Theory of Oligopoly," Journal of Political Economy 72, pp. 44-61.

[34] Tirole, J. (1988), "The Theory of Industrial Organization," MIT Press, Boston.

[35] Van Miert, K. (1997), "Role of Competition Policy in Modern Economies," Speech held 10/11/1997 at the Danish Competition Council, Copenhagen.

[36] Varian, H.R. (1980), "A Model of Sales," American Economic Review 70, pp. 651-659.