**The neglected effects of demand characteristics on the sustainability of collusion**

# The neglected effects of demand characteristics on the sustainability of collusion*

Andrea Gallice †

Collegio Carlo Alberto, Via Real Collegio 30, 10024 Moncalieri (Torino), Italy

**Abstract**

According to standard IO models, the parameters that characterize market demand (intercept, slope, and elasticity) and technology (the level of symmetric marginal costs) do not play any role in defining the sustainability of collusive behaviors in Bertrand oligopolies. This paper modifies this counterintuitive result by showing that all of the aforementioned factors do indeed matter when prices are assumed to be discrete rather than continuous. The sign of these effects is clear. Their magnitude varies greatly; i.e., in some cases, it is totally negligible, while in others, it becomes extremely relevant.

*JEL Classification*: L13, L41.

*Keywords*: Collusion, Market demand, Discrete prices, Bertrand supergames.

## 1 Introduction

Collusion is profitable for participating firms but pernicious for the economy as a whole. In fact, collusive behaviors not only increase prices but may also undermine the incentives for

*I would like to thank Björn Bartling, Christopher Milde, Klaus Schmidt, an anonymous referee and participants at various seminars for useful comments. I also thank ICER (Turin) and CEPR (London) for financial and logistic support. The usual disclaimer applies.

† *Telephone*: +39 011.6705287. *Fax*: +39 011.6705088. *E-mail:* andrea.gallice@carloalberto.org

innovation and reduce the quality and the variety of products available on the market. Due to the importance of these negative effects, the analysis of collusion has always attracted a great deal of attention. Additionally, important links have been established between the vast body of theoretical literature and the daily activity of antitrust authorities.[1]

One key aspect in the study of collusion is the identification of the factors that can facilitate or hinder sustainability of non-competitive behaviors over time. From a theoretical point of view, an analysis of such an issue is common in the context of Bertrand supergames (as introduced in Friedman, 1971) where firms repeatedly compete and potentially collude on prices. In these models, collusion appears to be sustainable whenever firms prefer the stream of collusive profits rather than the short terms gains that would follow a deviation from the cartel.

In other words, collusive agreements hold if firms are patient and discount the future at a rate that is not lower than a certain threshold. Previous results show that many factors can modify this threshold and thus facilitate or hinder the sustainability of collusive behaviors (for a review, see Ivaldi et al., 2003 or Motta, 2004). Some of these factors are related to the supply side of the market. For instance, a high level of concentration in the industry, symmetry of the colluding firms, and product homogeneity facilitate the survival of a cartel. Yet, other factors are related to the demand side of the market. For example, a positive demand shock hinders collusion as it increases the incentives to deviate and conquer the entire market (Rotemberg and Saloner, 1986). In contrast, collusion is more easily sustainable if demand growth is prolonged because the incentives to start a price war decrease when collusive profits increase over time (Haltiwanger and Harrington, 1991).[2]

These evolutions of market demand are usually modeled exogenously, i.e., by introducing a multiplicative factor that proportionally inflates or deflates the demand function "from the

[1] For a recent and non-technical review of these issues see Porter (2005).

[2] Note that demand growth can also trigger future entry, which in turn hampers the sustainability of collusive agreements. See Vasconcelos (2008) for a detailed analysis of these two countervailing effects in a Cournot framework.

outside". In fact, the alternative strategy of modifying the internal parameters of the function would produce no effects whatsoever. This is a standard result of these models; i.e., the parameters that define the shape of market demand (the slope, the intercept, and the elasticity) and the level of symmetric marginal costs[3] while obviously affecting the profitability of collusion do not play any role in defining its sustainability. Therefore, collusive behaviors appear to be equally sustainable in two hypothetical markets where, everything else being equal, the demand function in market $A$ is $k$ times steeper than the demand function in market $B$ or the marginal costs in market $A$ are, say, 5% of the costs that firms in market $B$ face.

Yet, this counterintuitive result is driven by the assumption that prices are continuous. With such an assumption, all of the aforementioned parameters similarly affect both the long term collusive profits and the short term gains from undercutting rivals. As a consequence, they disappear from the constraint that defines the incentives that sustain collusion. However, this paper shows that this result does not hold (i.e., demand characteristics and the level of symmetric costs do have an effect on the sustainability of collusion) if prices are assumed to be discrete rather than continuous.

The possibility of discrete prices is often mentioned in the discussion of Bertrand models, but the implications of such an assumption are usually studied under the conditions of perfect competition, i.e., as prices approach the lower bound of the admissible price interval. For instance, a typical textbook exercise may ask students to study how the standard Bertrand equilibrium (i.e., price equals marginal cost and zero profits) changes when prices are discrete and the condition $p = c$ is not feasible.[4] On the other hand, no studies have considered the implications of discrete prices in a non-competitive environment, i.e., when prices stabilize at

[3] We stress that this statement refers to symmetric marginal costs. Cost asymmetries have been shown to affect the sustainability of collusion even in the standard framework (Rothschild, 1999).

[4] The solution as follows: firms set the lowest possible price above marginal cost, profits are positive, and deviations are strictly costly. The same logic applies to the theoretical and experimental studies about "price floors" (see, for instance, Dufwenberg and Gneezy, 2000 and Dufwenberg et al., 2007).

a much higher level with respect to marginal cost. This paper investigates this issue.

Still, before moving to a proper analysis of the model, we must briefly discuss a few reasons that justify the assumption of discrete prices. First of all, prices are indeed discrete in reality due to the minimum unit of measurement used in determining prices (e.g., one cent for goods priced in Dollars or Euros). However, the actual minimum monetary unit is often wider than that. In some markets (e.g., the financial sector, regulated markets, and some kinds of auctions), a larger monetary unit can be legally enforced as the minimum. In others, social conventions aimed at reducing transaction costs can affect the minimum price difference; therefore, houses are traded in thousands of dollars, cars in hundreds, and nightly hotel stays in dollars.

Moreover, price competition appears to work through considerable price jumps even in markets where search costs should be negligible. For instance, Baye et al. (2004) showed that the difference between the two lowest prices for homogeneous electronic products sold over the Internet through a price comparison site ranges between 3.5% and 22%. Finally, the last evidence that points in the direction of discrete prices is implicitly rooted in the Bertrand model itself. The model is built on the assumption that a firm that undercuts its rivals conquers the entire market. However, for this to be true, the deviating firm's price must indeed be different from the price set by the rivals. According to economic and psychological literature about finite sensibility, just perceptible differences, and the various heuristics that consumers adopt, this difference must be sufficiently large to be noticed and appreciated.[5]

In summary, this paper studies a Bertrand supergame of price competition and finds that the parameters that define market demand and the level of symmetric marginal costs do indeed affect the sustainability of collusion when prices are assumed to be discrete rather than continuous. The analysis shows that the direction of these effects is clear but their importance varies

[5] As an example, Basu (2006) studied a Bertrand oligopoly in which the consumers could rationally ignore the last (i.e., the right-most) digits of prices because the cost of processing this information outweighs the savings that would follow from a fully informed decision.

greatly, i.e., in some situations, it is totally negligible, while in others, it can be quite relevant and radically modify the incentives that sustain collusive behaviors.

The remainder of this paper is organized in the following manner. Section 2 introduces the general framework. A more specific analysis is then undertaken for two different settings i.e., the case of a market characterized by linear demand (Section 3) and the case of a market characterized by constant elasticity demand (Section 4). Section 5 concludes the paper.

## 2 The framework

We consider an oligopoly where $N$ firms produce and sell a homogeneous good. Firms are perfectly symmetrical with marginal cost $c \geq 0$, discount rate $\delta \in [0,1]$, no fixed costs, and no capacity constraints. Market demand is given by $Q(p)$. Firms compete on prices (Bertrand competition) such that the individual demand for firm $i \in N$ is given by:

$$q_i(p) = \begin{cases} \frac{Q(p)}{1+\sum_j \left(1_{\{p_j = p_i\}}\right)} & \text{if } p_i \leq p_j \quad \text{for any } j \neq i \\ 0 & \text{otherwise} \end{cases}$$

In a one-time interaction, collusion cannot arise because the incentives to undercut rivals drive prices down to the marginal cost. Still, in an infinite repetition of the one-shot game, firms may profit from setting and maintaining a common price that is higher than the marginal cost. In what follows, we assume that through tacit or explicit agreements, firms are able to coordinate a price that maximizes industry profits, namely, the monopoly price $p_m$.[6] This price solves $\max_p \Pi = (p-c)Q(p)$ and leads to total profits $\Pi_m$. Because of symmetry, the per-period collusive profits for each firm are then given by $\pi_m = \frac{1}{N}\Pi_m$.

Collusion is sustainable if no firm has any incentive to unilaterally deviate from $p_m$. For

[6] More in general it is well known from the Folk theorem (see Friedman, 1971) that collusion can take place at any price $p \in (c, p_m]$.

this to be true, the stream of profits that follows a deviation must be smaller than the stream of collusive profits. Such a condition is formally captured by the following constraint:

$$\pi_m(1 + \delta + \delta^2 ...) \geq \pi_d + \pi_p(\delta + \delta^2 ...) \tag{1}$$

The term $\pi_d$, where $d$ stands for deviation, indicates the one-period profits of a deviating firm while $\pi_p$, where $p$ stands for punishment, refers to the firm's profits once competitors react to the initial deviation.

A deviating firm slightly undercuts the collusive price $p_m$. In the standard analysis with continuous prices, the size of this undercut is assumed to be negligible ($\epsilon \simeq 0$) such that the deviator is basically able to fully realize the monopoly profits ($\pi_d = \Pi_m$). In this paper, due to the reasons mentioned in the introduction, the minimal price undercut is assumed to be small but strictly positive ($\Delta > 0$).[7] This implies $\pi_d < \Pi_m$. For what concerns $\pi_p$, we let firms adopt trigger strategies that punish deviations in the harshest possible way (see, for instance, Porter, 1983). More precisely, firms react to a deviation by reverting to the one-shot Nash equilibrium such that $p = c$ and $\pi_p = 0$ in any future period. Using this result and the fact that $\sum_{t=0}^{\infty} \delta^t = \frac{1}{1-\delta}$, the constraint (1) can be solved for $\delta$, resulting in the following:

$$\delta \geq \delta^* = 1 - \frac{\pi_m}{\pi_d} = 1 - \frac{1}{N}\frac{\Pi_m}{\pi_d} \tag{2}$$

According to this expression, collusion is sustainable if the firms' discount rate is not smaller than a certain threshold defined by $\delta^*$. In other words, firms must be sufficiently patient and put adequate weight on future collusive profits rather than on short term gains that stem from breaking the cartel.

[7] Technically speaking, the assumption of discrete prices implies that the demand function is also discrete. We claim that for small $\Delta$ the price grid is dense enough such that the actual demand function can be smoothed into a well-behaved continuous function. As such, in what follows we keep using ordinary differentiation techniques and we implicitly assume that the optimal solution $p_m$ is feasible, i.e., it belongs to the price grid.

## 3 Discrete prices with linear demand

Assume that market demand is captured by the linear function $Q(p) = a - bp$ with both $a$ and $b$ positive. Individual demand for firm $i$ is given by:

$$q_i(p) = \begin{cases} \frac{(a-bp_i)}{1+\sum_j \left(1_{\{p_j=p_i\}}\right)} & \text{if } p_i \leq p_j \quad \text{for any } j \neq i \\ 0 & \text{otherwise} \end{cases}$$

The collusive price and quantity are $p_m = \frac{a+bc}{2b}$ and $Q_m = \frac{a-bc}{2}$ such that each firm realizes per-period profits of $\pi_m = \frac{1}{N}\frac{(a-bc)^2}{4b}$. If prices are discrete, a firm that deviates from the cartel sets $p_d = \frac{a+bc}{2b} - \Delta$ which leads to quantity $q_d = \frac{a-b(c-2\Delta)}{2}$ and profits $\pi_d = \frac{(a-bc)^2-4b^2\Delta^2}{4b}$. Notice that a necessary condition for a firm to consider the possibility of deviating is that $p_d > c$. This is verified if and only if $\Delta < \frac{a-bc}{2b}$, which we assume from now on.

By substituting $\pi_d$ and $\Pi_m = N\pi_m$ in the incentive constraint (2), one obtains that collusion is sustainable if:

$$\delta \geq \delta^* = 1 - \frac{1}{N}\frac{(a-bc)^2}{(a-bc)^2 - 4b^2\Delta^2} \tag{3}$$

This expression clearly shows two related results. First, if $\Delta = 0$ (continuous prices), the constraint simplifies to the standard one $\left(\delta \geq \delta^* = 1 - \frac{1}{N}\right)$ and the characteristics of market demand (the parameters $a$ and $b$) and technology (the parameter $c$) do not influence the sustainability of collusion. Second, with $\Delta > 0$, a mismatch occurs between the numerator and the denominator of the ratio; collusive profits and short term gains from deviations differ and do not cancel out any more. This implies that changes in $a$, $b$, or $c$ impact the sustainability of the cartel because they change $\delta^*$, i.e., the critical discount rate below which collusion breaks

In general, notice that the mismatch between the numerator and the denominator is in-

creasing in $\Delta$. Therefore, the higher is $\Delta$ the lower is $\delta^*$ and non-competitive agreements are more easily sustainable. The intuition behind this result is straightforward. A large $\Delta$ moves the price set by a deviating firm away from the monopoly price. This implies that the profits of a deviator are substantially lower than the stream of collusive profits. It follows that firms are willing to break the cartel only if they are very impatient (low $\delta$). At the same time, a large $\Delta$ brings the price set by the deviating firm near to the competitive price $p = c$. As such, and conditional on a deviation taking place, consumer surplus is increasing in $\Delta$.[8]

To sum up, a large price tick make deviations from a cartel less attractive for firms but more beneficial for consumers. Nevertheless, our main interest is to study how condition (3) is affected by changes in the values of $a$, $b$, or $c$ when the price tick is small. In what follows we assume a $\Delta$ that is on the order of 1-2% of the monopoly price.

## 3.1 Marginal effects and their magnitude

Starting from the constraint defined by (3), computing the marginal effects that the parameters $a$ (i.e., the vertical intercept of the demand function), $b$ (i.e., the slope of the demand function) and $c$ (i.e., the level of symmetric marginal costs) have on $\delta^*$ is easy. These are as follows:

$$\frac{\partial \delta^*}{\partial a} = \frac{1}{N} \frac{8b^2\Delta^2 (a - bc)}{\left((a - bc)^2 - 4b^2\Delta^2\right)^2} > 0 \tag{4}$$

$$\frac{\partial \delta^*}{\partial b} = -\frac{1}{N} \frac{8ab\Delta^2 (a - bc)}{\left((a - bc)^2 - 4b^2\Delta^2\right)^2} < 0 \tag{5}$$

[8] Formally, consumer surplus at the collusive equilibrium is given by $cs_m = \frac{1}{8b}(a - bc)^2$. On the contrary, if a firm deviates to $p_d$ then the surplus becomes $cs_d = \frac{1}{4b}(a + 2b\Delta - bc)\left(\frac{1}{2}a + b\Delta - \frac{1}{2}bc\right)$. The difference $cs_d - cs_m = \frac{1}{2}\Delta(a + b\Delta - bc)$ is positive and increasing in $\Delta$.

$$\frac{\partial \delta^*}{\partial c} = -\frac{1}{N} \frac{8b^3\Delta^2 (a-bc)}{\left((a-bc)^2 - 4b^2\Delta^2\right)^2} < 0 \tag{6}$$

The signs of these marginal effects are clear given that all the terms of the ratios are positive. In particular, $(a-bc) > 0$ given that $p > c$ and thus, $(a-bc) > (a-bp) = D(p) > 0$. Therefore, an increase in $a$ (a market expansion) increases $\delta^*$ and makes collusion more difficult to sustain.[9] Alternatively, one could say that, everything else being equal, collusion is marginally less sustainable in larger markets. On the other hand, positive shocks to $b$ or $c$ decrease $\delta^*$, thereby facilitating collusion.

In relation to the parameter $b$, notice that in the equation for the inverse demand curve (i.e., $P(q) = \alpha - \beta q$ with $\alpha = \frac{a}{b}$ and $\beta = \frac{1}{b}$), $b$ influences both the vertical intercept and the slope. In a standard $(q, p)$ diagram, an increase in $b$ not only lowers the vertical intercept but also makes the demand curve flatter. In order to disentangle the possibly conflicting contributions of these two effects, we plug the parameters of the inverse demand ($b = \frac{1}{\beta}$ and $a = \alpha b = \frac{\alpha}{\beta}$) in (3), and we study how changes in $\beta$ affect the new constraint.

$$\delta \geq \delta^* = 1 - \frac{1}{N} \frac{\left(\frac{\alpha}{\beta} - \frac{c}{\beta}\right)^2}{\left(\frac{\alpha}{\beta} - \frac{c}{\beta}\right)^2 - \frac{4\Delta^2}{\beta^2}} = 1 - \frac{1}{N} \frac{(\alpha - c)^2}{(\alpha - c)^2 - 4\Delta^2} \tag{7}$$

The parameter $\beta$ cancels out and does not appear in (7). Therefore the effects of $b$ on $\delta^*$ work through the changes that $b$ causes in the intercept $\alpha$ and not on the slope $\beta$.[10] In a $(q, p)$ diagram, a lower $b$ implies a higher vertical intercept, i.e., a larger demand for any given price. As in the case of the parameter $a$, a market expansion makes collusion less sustainable.[11]

[9] Thinking in terms of the inverse demand function (standard quantity-price diagram) we have that $P(q) = \alpha + \beta q$ with $\alpha = \frac{a}{b}$ and $\beta = \frac{1}{b}$. Obviously an increase in $a$ implies a positive demand shock also under this formulation.

[10] Alternatively, equation (5) can be formulated as $\frac{\partial \delta^*}{\partial b} = -\alpha \frac{\partial \delta^*}{\partial a}$ where $\alpha = \frac{a}{b}$ and $\frac{\partial \delta^*}{\partial a}$ is as in (4). This expression again shows that the effects of $b$ on $\delta^*$ are channeled through the changes that $b$ causes on $\alpha$.

[11] This result is in line with the classical contribution by Rotemberg and Saloner (1986). Still notice that in our case the effects on $\delta^*$ are triggered by endogenous variations of the demand and not by an exogenous shock.

The magnitude of the effects of variations in $a$, $b$, and $c$ on the degree of sustainability of collusion varies greatly. A common pattern is that these effects are small and possibly negligible for a vast range of the domain. Yet, for certain configurations of the parameters, these effects can be huge. This is due to the fact that the three marginal effects (4), (5), and (6) display a vertical asymptote that is implicitly defined by the condition $2b\Delta = a - bc$. This condition identifies the upper bound of the set of admissible parameters. In fact we already saw that the problem under study is meaningful if and only if $p_d > c$, i.e., if and only if $2b\Delta < a - bc$. In the neighborhood of this bound, small variations in the parameters can have major impacts on the sustainability of a cartel.

Consider the following examples that focus on the effects of $b$ on $\delta^*$.[12] Figure 1.a depicts $\delta^*$ as defined in (3) as a function of $b \in (0, 10)$ when $N = 2$, $a = 1$, $c = 0$, and $\Delta = 0.01$. Figure 1.b refers instead to the case with $N = 2$, $a = 1$, $c = 0.3$, and $\Delta = 0.01$. Therefore, the only difference between the two duopolies is that in the second case marginal costs are positive.

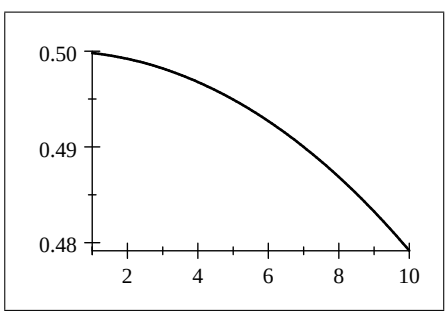


Fig. 1.a: The effects of $b$ on $\delta^*$ for $c = 0$.

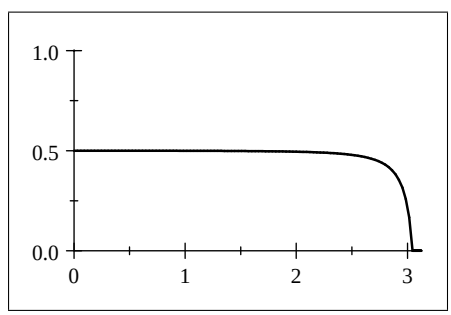


Fig. 1.b: The effects of $b$ on $\delta^*$ for $c = 0.3$.

In the first scenario, the discontinuity that characterizes constraint (3) arises at $b = \frac{a}{2\Delta + c} = 50$. Therefore, the effects of $b$ on $\delta^*$ are limited. In the second situation, the discontinuity arises at $b = 3.125$, and small variations of $b$ in the neighborhood of this asymptote can have

[12] Analogous examples can be easily constructed for what concerns the effects of $a$ or $c$.

a dramatic impact on $\delta^*$. Consider for instance two hypothetical markets that are defined by $N = 2$, $a = 1$, $c = 0.3$, and $\Delta = 0.01$ and that only differ in the level of the parameter $b$. In particular, $b = 1$ in market $A$, and $b = 3$ in market $B$. With continuous prices, these differences in the demand curve would not influence the incentives to maintain a cartel. Therefore, in both markets, collusion would be sustainable for any $\delta \geq 0.5$. Our analysis shows instead that the situation is radically different when prices are assumed to be discrete. More precisely, by plugging the actual parameters in (3), we find that collusion is much more easily sustainable in market $B$ ($\delta \geq 0.219$) rather than in market $A$ ($\delta \geq 0.4996$).

# 4 Discrete prices with constant elasticity demand

The elasticity of market demand is often mentioned as a factor that may affect the sustainability of collusion. Nevertheless, the formal analysis of its effects remains a bit vague at least for the concerns within the framework of Bertrand competition.[13] Scholars have indicated that elasticity and the profitability of collusion are inversely related (see Ivaldi et al., 2003 or Motta, 2004).[14] From this perspective, elasticity surely has an indirect effect on cartel stability. In fact, low elasticity makes collusion more profitable such that firms are more likely to try to implement and maintain non-competitive behaviors. Nevertheless, the standard analysis does not find any direct effect from elasticity on the sustainability of collusion. The reason again lies in the fact that under the assumption of continuous prices the characteristics of the demand function do not affect the critical discount factor above which collusive agreements become sustainable.

In this section, we study the role of demand elasticity when prices are discrete. An ideal

[13] For the case of Cournot oligopolies, Collie (2004) relies on numerical simulations to show that high elasticity makes collusion more easily sustainable.

[14] In fact, as it is made explicit by the formulation of the Lerner index, the optimal collusive price (i.e., the monopoly price) is negatively related with the elasticity of market demand.

framework for analyzing such an issue is provided by demand functions that are characterized by a constant elasticity. The general form for such a function is given by $Q(p) = ap^{-\eta}$ where $\eta$ is the parameter that captures elasticity. For the sake of tractability, in what follows we set $a = 1$. As before, firms are assumed to be perfectly symmetric with marginal cost $c > 0$, discount rate $\delta$, no fixed costs, and no capacity constraints. Competition on prices is such that generic firm $i$ faces the following demand function:

$$q_i(p) = \begin{cases} \frac{p^{-\eta}}{1+\sum_j \left(1_{\{p_j = p_i\}}\right)} & \text{if } p_i \leq p_j \quad \text{for any } j \neq i \\ 0 & \text{otherwise} \end{cases}$$

The collusive monopoly price is given by $p_m = \frac{\eta c}{\eta - 1}$ which implies total quantity $Q_m = \left(\frac{\eta-1}{\eta c}\right)^{\eta}$. It follows that each colluding firm realizes per period profits of $\pi_m = \frac{1}{N\eta}\left(\frac{\eta-1}{\eta c}\right)^{\eta-1}$. At the opposite, a deviating firm sets the price $p_d = \frac{\eta c}{\eta-1} - \Delta$ that leads to quantity $q_d = \left(\frac{\eta c}{\eta-1} - \Delta\right)^{-\eta}$ and one-off profits $\pi_d = \frac{(c+\Delta-\eta\Delta)}{(\eta-1)} \frac{1}{\left(\frac{1}{\eta-1}(\Delta+\eta c-\eta\Delta)\right)^{\eta}}$. Again, we impose the condition $p_d > c$ which is fulfilled by $\eta < \frac{c+\Delta}{\Delta}$. According to the incentive constraint (2), collusion is then sustainable if the following condition holds:

$$\delta \geq \delta^* = 1 - \frac{1}{N\eta}(\eta - 1) \frac{\left(\frac{1}{\eta-1}(\Delta + \eta c - \eta\Delta)\right)^{\eta}}{c + \Delta - \eta\Delta} \left(\frac{1}{\eta c}(\eta - 1)\right)^{\eta-1} \tag{8}$$

This is quite a complicated function (notice the discontinuity at $\eta = \frac{c+\Delta}{\Delta}$) and its first derivative with respect to $\eta$ is too cumbersome to be discussed. In order to have a feeling for the sign and the magnitude of the effects of $\eta$ on $\delta^*$ we thus rely on a numerical example. Figure 2 reports the case with $N = 2$, $c = 0.1$, $\Delta = 0.01$ and $\eta \in (1, 11)$.

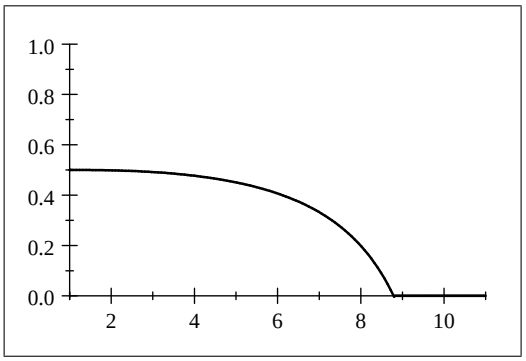


Fig. 2: The effects of $\eta$ on $\delta^*$.

The graph shows that $\delta^*$ is initially a strictly decreasing function of $\eta$ such that collusion becomes more easily sustainable as elasticity increases (in absolute value). Then, an area exists in which the actual $\delta^*$ would be negative such that it is constrained to $\delta^* = 0$, thereby making collusion always sustainable.

The finding that the sustainability of collusion increases with the elasticity of demand is consistent with the numerical results that Collie (2004) provides for what concerns Cournot oligopolies. At first sight, such a result may seem surprising. In fact, one may imagine that a firm that operates in a more elastic market has higher incentives to deviate as, given any price tick $\Delta$, the firm would conquer a larger market share. Nevertheless, such an argument does not apply in our Bertrand framework with homogeneous goods. In fact, Bertrand competition implies that a deviating firm conquers all the market no matter the elasticity of demand. Moreover, the absence of substitute goods prevents consumers to divert their demand to other markets.

On the contrary, we agree with Collie (2004) and we think that the positive relation between the sustainability of collusion and the elasticity of demand is triggered by the effects that elasticity has on the price-cost margin. More precisely, a higher elasticity leads to a lower monopoly price and thus to a lower margin over marginal costs. This in turn implies that the

one-off profits stemming from a deviation are limited as a deviating firm must set a price that is even closer to marginal costs and thus exploit an even lower margin. Therefore, only a very impatient firm (low $\delta$) would break the cartel.

# 5 Conclusions

This paper analyzed the sustainability of collusion in Bertrand supergames under the assumption of discrete prices rather than continuous prices. In particular, the analysis highlighted the effects that previously neglected factors, like the characteristics of market demand and the symmetric level of marginal costs, may create in terms of shaping the incentives that sustain a cartel.

Notice that some of the results within this paper could be tested against the data. For instance, the model implies that the degree of sustainability of collusive behaviors is an increasing function of the price tick $\Delta$. For European countries, an important exogenous variation of $\Delta$ was caused by the introduction of the Euro in January 2002. For example, $\Delta$ increased by a factor of around 6.5 for goods previously priced in French Francs, while it increased by a factor of almost 20 for goods priced in Italian Liras. In markets characterized by high volumes and low unitary price (e.g., some raw materials), these variations may have had an actual impact on the sustainability of non competitive behaviors.

# References

Basu, K., 2006. Consumer cognition and pricing in the nines in oligopolistic markets. Journal of Economics & Management Strategy 15, 125-141.

Baye, M.R., Morgan, J., Scholten, P., 2004. Price dispersion in the small and in the large: Evidence from an internet price comparison site. Journal of Industrial Economics 52, 463-496.

Collie, D., 2004. Collusion and the elasticity of demand. Economics Bulletin 12, 1-6.

Dufwenberg, M., Gneezy, U., 2000. Price competition and market concentration: An experimental study. International Journal of Industrial Organization 18, 7-22.

Dufwenberg, M., Gneezy, U., Goeree, J.K., Nagel, R., 2007. Price floors and competition. Economic Theory 33, 211-224.

Friedman, J.W., 1971. A non cooperative equilibrium for supergames. The Review of Economic Studies 38, 1-12.

Haltiwanger, J., Harrington Jr., J.E., 1991. The impact of cyclical demand movements on collusive behaviors. RAND Journal of Economics 22, 89-106.

Ivaldi, M., Jullien, B., Rey, P., Seabright, P., Tirole, J., 2003. The economics of tacit collusion. Report for the DG Competition - European Commission.

Motta, M., 2004. Competition policy: Theory and practice. Cambridge University Press, Cambridge.

Porter, R.H., 1983. Optimal cartel trigger-price strategies. Journal of Economic Theory 29, 313-338.

Rotemberg, J.J., Saloner, G., 1986. A supergame-theoretic model of price wars during booms. American Economic Review 76, 390-407.

Rothschild, R., 1999. Cartel stability when costs are heterogeneous. International Journal of Industrial Organization 17, 717-734.

Vasconcelos, H., 2008. Sustaining collusion in growing markets. Journal of Economics & Management Strategy 17, 973-1010.