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BARBARA BOEHNLEIN

European University Institute, Florence

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BARBARA BOEHNLEIN

BADIA FIESOLANA, SAN DOMENICO (FI)

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European University Institute
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I – 50016 San Domenico (FI)
Italy

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Barbara Boehnlein *
European University Institute
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Abstract

When two firms play an infinite time horizon game with trigger price strategies, the collusive equilibrium is sustainable provided the discount factor is relatively close to 1. In this paper I show that, when products are differentiated, firms can always sustain some degree of collusion for whatever value of the discount factor. This result is fairly general since it does not depend on the way product differentiation is modelled. I then examine under which conditions the introduction of multimarket contact can increase the degree of collusion in these games. Here, the outcome depends on whether a spatial or a quadratic utility model is used to model product differentiation. It seems that a spatial model leaves more room to firms to increase the degree of collusion, at least when the number of competitors is sufficiently small.

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1 Introduction

The purpose of this paper is to investigate the impact of product differentiation in a multimarket contact model. Multimarket contact is defined as a situation in which the same firms meet in several, separated markets. Collusion shall be defined as any level of profits/prices that exceeds the Bertrand-Nash level of profits/prices. Optimal or maximal collusion is then equivalent to the joint profit maximization level with a price p_k^M. In their paper on multimarket contact and collusive behavior, Bernheim and Whinston (1990) show that - under certain conditions - the existence of multimarket contact fosters collusion when compared to a situation where the constellation of competitors varies in each market. In applying Bernheim and Whinston's basic concept, I will analyse the behavior of two firms producing a differentiated commodity and selling it in two separated markets.

In a price competition game over an infinite time horizon, trigger strategies imply that deviation from the collusive path has very severe consequences when played with homogeneous products. Since a marginal deviation from the collusive price is sufficient for the deviating firm to capture the entire market during the deviation period, punishment for this defection will lead to the Bertrand-Nash equilibrium of pricing at marginal cost. Introducing product differentiation in this framework definitely alters the collusive outcome. Unfortunately however, we cannot determine the direction of the impact of product heterogeneity on the collusive outcome a priori. This stems from the fact that product differentiation has two opposing effects on collusive equilibria. On the one hand, it decreases the severity of punishments because the Bertrand-Nash equilibrium with differentiated products yields positive profits for the rivals [1]. Hence, post-deviation profits are no longer zero; this counts for the deviator(s) as well as for the punishing firm(s). This fact reduces the relative losses from deviation in all post-deviation periods. We may therefore speak of the negative (contra-) effect of product differentiation on the collusive outcome. On the other hand, the gains from deviation decrease as well. Unlike in the homogeneous product case, the deviator has to decrease its own price more than marginally

[1] At least in the standard case where upward sloping reaction functions with different steepness cross each other in an area where the quantities of all firms are positive.

in order to maximize its profits during the deviation period [2]. We may call this the positive (pro-) effect of product differentiation on collusion.

Consequently, the effect that dominates determines whether product differentiation enhances collusion or not. If we measure the degree of collusion with the minimum value of the discount factor required to sustain the collusive outcome, we can modify our initial question and ask whether the degree of product differentiation decreases or increases the critical value of the discount factor of the collusive equilibrium.

Section 2 introduces Bernheim and Whinston's basic argument on multimarket contact. An overview over the two standard approaches to model product differentiation is given in section 3. Section 4 links product differentiation to the multimarket contact model and discusses how Bernheim and Whinston's mechanism works in the models of the previous section. Finally, section 5 concludes with a remark on the scope and the limitations of the results.

2 The Effect of Product Differentiation in the Bernheim and Whinston Model

In one subsection of their paper on multimarket contact and collusive behavior, Bernheim and Whinston examine the range of collusive equilibria when products are differentiated. For this purpose they set up the following assumptions. Two firms $i = 1, 2$ sell a differentiated commodity in two markets $k = a, b$ with constant unit cost c_k which is equal for both firms. Information is complete throughout the game. Further, it is supposed that product differentiation is symmetric. With respect to the discount factor δ, Bernheim and Whinston assume that the maximum collusive price to be sustainable increases continuously as δ rises [3]. However, the degree of collusion may differ between markets even though δ remains the same for both

[2] Optimal defection requires a firm i to jump to its reaction function, since the reaction function comprises all best-response prices for any given price p_j of the rival.

[3] I will explain the argumentation behind this assumption in the next section where I give an overview over two different approaches to model product heterogeneity and its influence on the critical value of δ that sustains collusion.

firms and markets [4]. One could imagine a situation where products are more differentiated in market a than in market b (see Figure 1a and 1b) [5].

According to Bernheim and Whinston, a specific discount factor could be sufficient to sustain the maximum collusive level in market a (point A where the isoprofit-curves of the two firms have a tangency point), while only a lower level of collusion can be achieved in market b (point B where two isoprofit-curves intersect at a level above the Bertrand-Nash equilibrium, point N_b). As in the homogeneous product case, firms deviate through undercutting the collusive price in each market and maximize their one-period profit from deviation (points D_a and D_b). If a firm decides to deviate it will do so in both markets since it knows that it will be punished for deviation in both markets anyway.

To determine the optimal collusive outcome under multimarket contact, Bernheim and Whinston set up the joint profit maximization function

$$max_p\ (\Pi_{ia} + \Pi_{ib}) \qquad i = 1, 2 \tag{1}$$

and maximize (1) subject to

$$\Phi_i(p_a) + \Phi_i(p_b) + \frac{\delta}{1-\delta}(v_{ia} + v_{ib}) \leq \frac{1}{1-\delta}(\Pi_{ia} + \Pi_{ib}) \quad i = 1, 2 \tag{2}$$

where $\Phi_i(p_k)$ is the one-period optimal deviation level and v_{ik} is the post-deviation profit of firm i in market k. Thus, for collusion to be sustainable, (2) must be fulfilled. The solution of this problem implies that

$$\frac{\partial \Pi_{ia}/\partial p_a}{\partial \Phi_{ia}/\partial p_a} = \frac{\partial \Pi_{ib}/\partial p_b}{\partial \Phi_{ib}/\partial p_b}. \tag{3}$$

Bernheim and Whinston conclude from (3) that multimarket contact makes it possible for firms to equalize marginal profits from collusion to marginal

[4] Bernheim and Whinston give no explanation for this. In my opinion, it can only arise from the fact that the degree of product differentiation differs across markets. Then, making the assumption that the minimum discount factor for collusion rises with the degree of product substitutability, a common δ may be in line with different degrees of collusion.

[5] The 45° line reflects the fact that the reaction functions in the figure are mirrored because product differentiation is symmetric. By the same token, collusive prices and Nash prices lie on this line.

profits from deviation across markets. The reason why this possibility may increase each firm's overall profits is illustrated by an example. Suppose that for a given δ, optimal collusion (i.e. the joint profit maximization outcome, the point at which two iso-profit curves of the two rivals are at a tangency point) is just sustainable in market a whereas some lower collusive level is sustainable in market b. Thus, it has to be true that

$$\partial\Pi_{ia}/\partial p_a = 0 \quad \text{and} \quad \partial\Pi_{ib}/\partial p_b > 0. \tag{4}$$

This would be the solution for the single market setting. With multimarket contact, (3) suggests that firms can improve overall profits for the two markets through increasing marginal profits from collusion in market a and decreasing marginal profits from collusion in market b. This would involve agreement on a joint decline in the collusive price in market a and on a joint increase in the collusive price in market b.

There is an intuitive argument behind the fact that firms gain from equalizing marginal profits across markets. As marginal profits approach zero, the value of one additional unit of profits is steadily declining. If a firm can swap one unit of profits in market a against one unit in market b, it makes a gain since

$$\partial\Pi_{ia}/\partial p_a \leq \partial\Pi_{ib}/\partial p_b \tag{5}$$

until (5) holds with equality.

3 Models of Product Differentiation and the Effect on Sustainable Collusion

Generally speaking, there exist two different approaches to model horizontal product differentiation. The first one is a spatial approach, based on Hotelling's model (1929) on stability in competition. The degree of product differentiation is measured by the distance between the production/selling locations of two commodities in a certain product space. If for instance this product space consists in an interval of a certain length, the further away two product locations, the more differentiated the two respective commodities.

The second approach goes back to Chamberlin (1933) and is derived from a quadratic utility function for a representative consumer, as introduced by Spence (1976) and further developed by Dixit and Stiglitz (1979). It has the convenient property of yielding linear inverse demand functions. Firm i's price p_i is a linear function of its own quantity q_i and the quantity of the competing commodity, q_j [6]. If both quantities influence p_i with equal weights, the two goods are homogeneous.

Both types of models have been examined with respect to the degree of collusion sustainable in oligopolistic supergames over an infinite time horizon. Below, I will give a brief description of some of these studies together with a comparison of their results concerning the collusive outcome.

3.1 The Spatial Model

In a recent article Chang (1991) investigates the impact of product differentiation in collusive pricing in a spatial competition model. The basic framework concerning the modelling of spatial differentiation is equivalent to that of Neven (1985). Two firms $i = 1, 2$, located at $x_i = x_1, x_2$ within an interval of length $[0, 1]$, engage in an infinitely repeated price game of simultaneous competition. Consumers are uniformly distributed over $[0, 1]$ where the location of a consumer represents its most preferred product. Each consumer has a reservation price r and he will purchase one unit of his most preferred variety (which consists in the product that is located the closest to his own location) up to a price of r. The consumer measures product differentiation with a transportation cost according to the distance of his own location and the location of the two products. Following d'Aspremont et al. (1979), transportation costs are assumed to be quadratic which implies that the marginal transportation cost increases with the distance to the product.

Since the purpose of the analysis is to look at the influence of different degrees of product heterogeneity on the level of collusion, product locations are taken to be exogenous to the model. The closer two products are located within the interval, the higher the degree of substitutability between them. Throughout the investigation it is assumed that products are located symmetrically at $x_1 = x$ and $x_2 = 1 - x$. At the beginning of each period

[6] In an oligopolistic framework with n firms, the quantities of all competing commodities $q_j = 1, ..., n$ will enter firm i's inverse demand function. For the purpose of this analysis however, I will restrict myself to the duopolistic case.

t, each firm chooses a price $p_i(t)$ out of its strategy set S_i [7]. $p_i(t)$ lies in the interval $[0, r]$. Firms are assumed to play trigger strategies, i.e. to start at the collusive price level in period $t = 1$. Players continue to adhere to the collusive agreement for all subsequent periods provided that no player deviated from the collusive price in the previous period. If deviation occurred in period t, prices drop to the Bertrand-Nash equilibrium in period $t+1$. If a firm deviates, it chooses its best-response price p_i^D for the collusive price that is charged by its rival. This implies that the deviation price of firm i must lie on its reaction function RF_i. Note that there are two possibilities: either firm i shares the market with its rival during the deviation period or firm i decreases its deviation price sufficiently to capture the entire market. The latter occurs whenever the best-response price for a collusive price of the rival lies above the kink of the deviator's reaction function.

As Friedman (1971) pointed out, if the discount factor δ is sufficiently high, joint profit maximization may become the equilibrium outcome in this game. In order to determine the required δ to sustain joint profit maximization, Chang sets up a loss and a revenue function from deviation. Thus, each firm finds it more profitable to collude than to deviate if the loss exceeds the gain from deviation. The loss from deviation consists in

$$L(p^M, \delta) \equiv \left(\frac{\delta}{1-\delta}\right)(\Pi_i^C - \Pi_i^N). \tag{6}$$

where Π_i^C are firm i's profits from collusion and Π_i^N are its profits from the Nash equilibrium. Equation (6) measures the discounted foregone profits if firm i defects from the joint profit maximizing price p^M in the current period. Since deviation is punished by a reversion to the Bertrand-Nash equilibrium, it will deprive firm i from collecting the collusive profit in all future periods. The revenues from deviation on the other hand are

$$R(p^M) \equiv \Pi_i^D - \Pi_i^C \tag{7}$$

where Π_i^D represents firm i's profit from optimally defecting from p^M. From (7) it is obvious that deviation is rewarded with a one-shot gain since $\Pi_i^D \geq \Pi_i^C$. Now, if

$$L(p^M, \delta) \geq R(p^M) \tag{8}$$

[7] Note that firms a re restricted to use pure strategies.

for each firm, then joint profit maximization is an equilibrium strategy.

To see that there exists a critical boundary for $\delta \in [0,1]$ from which on the collusive equilibrium will be sustainable, we can argue as follows: while $L(p^M, \delta)$ is monotonically increasing in δ, $R(p^M)$ does not depend at all on δ. Hence, since

$$lim_{\delta \rightarrow 1} L(p^M, \delta) = \infty \tag{9}$$

there must exist some δ^* for which

$$L(p^M, \delta) \geq R(p^M) \qquad \text{if} \qquad \delta \geq \delta^*. \tag{10}$$

Equivalently, it can be shown that there exists a collusive price range $p^C \in (p^N, p^M)$ which is sustainable under a discount factor $\delta < \delta^*$ (see Figure 2). This would correspond to a situation where two iso-profit curves intersect above the Bertrand-Nash point. In other words, unless $\delta = 0$, there always exists a collusive price $p^C > p^N$ which is sustainable under any discount factor $\delta \in (0, 1]$.

In order to examine the effect of product differentiation on sustainable collusion, Chang calculates the respective δ^* as the products become closer substitutes. His result implies that collusion is more difficult to sustain when products become more homogeneous. In other words, the critical discount factor δ^* to support the collusive equilibrium increases monotonically with decreasing product differentiation. Thus, in Chang's analysis, the temptation to deviate decreases with the increase in the distance of product locations. Apparently, the pro-effect of product differentiation on the collusive outcome dominates the contra-effect in this model, a result which holds for any difference in product location as x goes from zero to $1/2$.

3.2 The Quadratic Utility Model

Deneckere (1983) and Ross (1992) [8] employ a quadratic utility model to investigate the impact of product differentiation on collusive equilibria. Ac-

[8] In fact, Ross' model is exactly the same as Deneckere's, thus leading to the same results as well. For this reason, I will refer to the quadratic utility model on product differentiation just as Deneckere's model from now on.

cordingly, the inverse demand functions in these models are given by

$$p_i = a - bq_i - eq_j \tag{11}$$

$$p_j = a - bq_j - eq_i \tag{12}$$

in the two firm case $i, j = 1, 2$ with average zero cost. Though Deneckere examines also the case where products are complements and where firms choose quantity instead of price, I will restrict this summary to product substitutability and price competition. The degree of product differentiation is measured by the ratio $\alpha = e/b$ which lies in the range of $[0, 1]$ for all $e \leq b$. While for $\alpha = 1$, products are perfect substitutes, $\alpha = 0$ represents the case where products are completely independent of each other.

Determining critical values for δ above which collusion can be sustained is done in the way as in Chang's model. After the Nash profits Π_i^N, the collusive profits Π_i^C from the joint profit maximization function and the deviation profits Π_i^D have been calculated, Deneckere measures the degree of sustainable collusion with an equation equal to (8). As in Chang, (8) is computed by equalizing (6) and (7). Despite this equivalence in the formal procedure, Deneckere's results concerning the critical values δ^* are quite different from the previous model. In contrast to Chang, he finds a non-monotonic relationship between δ^* and the degree of product differentiation. More precisely, the minimum value for $\delta = \delta^*$ to support the collusive equilibrium increases and then decreases again as the products become closer substitutes. In fact, δ^* rises from $\alpha = 0$ until $\alpha = 0.73$ and decreases from there on until $\alpha = 1$, i.e. until the two products are perfect substitutes. Consequently, collusive outcomes are less likely when products are moderate substitutes than when they are close substitutes or relatively independent.

Despite these differences in the shape of δ^* between both models, we can state the following:

Proposition 1: For any $\delta < \delta^*$ it can be shown that there exists a $p^C \in (p^N, p^M)$ in the quadratic utility model.

For this purpose I set up a two-firm model very similar to Deneckere's, with inverse demand functions as in (11) and (12). Without loss of generality I assume $b = 1$. $e \in [0, 1]$ measures then the degree of product differentiation. Marginal costs are constant and hence, can be taken as zero. Solving this problem in the standard way one obtains

$$p_i^N = \frac{(1-e)a}{2-e}; \quad \Pi_i^N = \frac{a^2(1-e)}{(2-e)^2(1+e)} \qquad i = 1,2 \tag{13}$$

for firm i. From (13) it is straightforward that product differentiation is symmetric in our model and thus, that each firm charges the same Nash price. Maximizing joint profits yields

$$p_i^M = \frac{a}{2}; \quad \Pi_i^M = \frac{a^2}{4(1+e)} \qquad i = 1,2\ . \tag{14}$$

To determine the optimal defection price $p_i^D(p_j^M)$ we have to plug p_i^M into RF_i, the reaction function of the defecting firm. Since RF_i is piecewise linear, we actually have to consider two parts of RF_i, depending on whether the deviator monopolizes the market during defection or whether he prefers to share the market with the rival (i.e. whether the optimal defection price lies above or below the kink of the RF_i). I will call the former *constraint* and the latter *unconstraint* defection whenever a distinction seems to be necessary. Unconstrained defection profits for firm i are given by

$$\Pi_i^D = \frac{a^2(2-e)^2}{16(1-e^2)} \tag{15}$$

while constrained defection yields

$$\Pi_i^D = \frac{a^2(2e-1)}{4e^2}. \tag{16}$$

From the preceding discussion we know that optimal collusion is the equilibrium result if

$$\Pi_i^D - \Pi_i^M \leq \left(\frac{\delta}{1-\delta}\right)(\Pi_i^M - \Pi_i^N) \qquad i = 1,2. \tag{17}$$

We know further that (17) holds if $\delta \geq \delta^*$.

Now, we transfer Chang's result for $\delta < \delta^*$ to the quadratic utility model. Recall that Chang argued that there exists a sustainable collusive price $p_i^C < p_i^M$ for any $\delta < \delta^*$. This stems from the fact that the losses from deviation $L(p^C, \delta)$ have the shape of a parabola increasing to infinity whereas the gains from deviation $R(p^C)$ are a horizontal line. It is easy to see that this fairly general condition applies to the quadratic utility model as well. Since the model is symmetric, firms agree on one single collusive price p_k^C in each market k [9]. When both firms sell at p^C, collusive profits will be given by

$$\Pi_i^C = \frac{(1-e)(a-p^C)p^C}{1-e^2}. \tag{18}$$

Note that if $p^C = p^M = a/2$, $\Pi_i^C = \Pi_i^M$. A deviating firm i on the other hand gets

$$\Pi_i^D = \frac{((1-e)a + ep^C)^2}{4(1-e^2)} \tag{19}$$

in the constraint region and

$$\Pi_i^D = \frac{ae(a-p^C) - (a-p^C)^2}{e^2} \tag{20}$$

in the unconstraint region. Nash profits are independent of the collusive price and can be taken from (13) therefore. In order to illustrate the mechanism behind the collusive outcome below the joint profit maximization level, consider the following. Let $\delta < \delta^*$ such that p^M cannot be sustained in equilibrium. Hence,

$$\frac{\delta}{1-\delta} \leq \frac{\Pi_i^D - \Pi_i^C}{\Pi_i^C - \Pi_i^N} \qquad \text{for} \quad \Pi_i^C = \Pi_i^M. \tag{21}$$

To achieve the collusive solution firms must agree to jointly decrease p^M to some $p^C \in (p^N, p^M)$ until (21) holds with equality. Equations (18), (19) and (20) indicate that, for a given e, profits from deviation as well as profits from collusion decrease with decreasing p^C. Since Π_i^N remains fixed for different p^C, it is obvious that the numerator in (21) has to decrease faster than the denominator if we want the left hand side of the equation to decrease. Comparing (18) with (19) and (20) we realize in fact that the profits from deviation fall much faster than the profits from collusion when lowing p^C. In other words, through decreasing the collusive price, firms reduce the gains relative to the losses from deviation. Deviation becomes therefore a less and less preferable strategy until the discounted losses from deviation exceed its one- shot gains. Consequently, similar to Chang's spatial model, a certain level of collusion below joint profit maximization is sustainable in Deneckere's quadratic utility model for all $\delta \in (0, \delta^*)$.

[9] As long as I will stick to the single market framework, I will drop the index k on the collusive price p^C.

4 Comparison between the Models and the Impact of Multimarket Contact

We are now ready to examine the differences between the two models in connection with the multimarket contact argument. First, we have to explain where the differences in the shape of δ^* between the two models come from. Since δ^* depends on the shape of Π_i^C, Π_i^D and Π_i^N as the product space moves from independence (perfect heterogeneity) to perfect homogeneity, I will look at the differences in these profit functions.

It is straightforward that the shape of Π_i^N is monotonically declining for both models, reflecting the fact that the Nash equilibrium prices decrease with increasing product substitutability. Major differences occur however in the shape of Π_i^C [10]. In Chang's model, Π_i^C rises with increasing homogeneity until $x = 1/4$ and starts to decline again until $x = 1/2$. In other words, the joint profit maximization level is highest when both firms locate at 1/4 and 3/4, respectively. This is due to the fact that the average transportation cost for all consumers is lowest at these locations. Thus, for a constant reservation price r, firms can charge the highest net price (consumer price minus transportation cost) from these locations provided that the two firms prefer to collude than to deviate. In Deneckere on the other hand, Π_i^C decreases monotonically with increasing substitutability. A declining demand for more homogeneous products is the underlying reason for this shape. Since the representative consumer has a preference for variety, he will consume less the closer the two products are.

The difference in the shape of Π_i^C implies that the shape of Π_i^D differs as well between both models because the profit from deviation depends on the level of collusion attainable for a specific degree of product differentiation. More specifically, Π_i^D monotonically increases in Chang's model while Π_i^D in Deneckere's model is concave. When products are relatively weak substitutes, Π_i^D moves parallel to Π_i^C in both models. This is the region where the deviator prefers to share the market with the rival (i.e. we are below the kink of the reaction function in case of deviation). As products become closer substitutes however, Π_i^D does not longer move parallel to Π_i^M

[10] Note that if $\delta = \delta^*$, $\Pi_i^C = \Pi_i^M$.

but rises in both models. The reason for this is that a deviator prefers to monopolize the market during defection when products are relatively homogeneous. In fact, if e is close to 1, a deviating firm can capture the entire market for one period without lowering its defection price very much. The difference in the shape of Π_i^C and Π_i^D as product heterogeneity varies from complete independence to perfect substitution is hence responsible for the fact that we obtain different shapes of δ^* in the two models.

Now, consider Bernheim and Whinston's argument again: firms can increase global profits by simultaneously increasing marginal profits in one market and decreasing marginal profits in another market. It was supposed that for a given δ, the joint profit maximization level is just sustainable in market a ($\delta_a = \delta_a^*$) but not in market b ($\delta_b < \delta_b^*$) while δ should be the same for both firms and markets. In general, it is not necessary that $\delta_k = \delta_k^*$ in one market for firms to gain from exchanging marginal profits in Chang's model. As long as $\delta_k < \delta_k^*$ in at least one market and $e_a \neq e_b$, fims always gain through exchanging maginal profits across markets. As discussed in the previous section, there is a p_k^C yielding Π_{ik}^C for each $\delta_k \in (0, \delta_k^*)$ with $\partial\Pi_{ik}^C/\partial p_k^C > 0$. The monotonicity of δ_k^* as e_k approaches 1 implies then that

$$\partial\Pi_{ia}^C/\partial p_a^C > \partial\Pi_{ib}^C/\partial p_b^C \qquad i = 1,2 \tag{22}$$

whenever $e_a > e_b$ and

$$\partial\Pi_{ia}^C/\partial p_a^C < \partial\Pi_{ib}^C/\partial p_b^C \qquad i = 1,2 \tag{23}$$

whenever $e_a < e_b$. Therefore, a different degree of product heterogeneity across markets ensures that firms can improve through increasing marginal profits in one market and decreasing marginal profits in another market.

Things may turn out to be quite different when we apply Bernheim and Whinston's argumentation to the quadratic utility model. As has been pointed out in the previous section, Deneckere found a non-monotonic relationship between the minimum discount factor for optimal collusion δ_k^* and the degree of product differentiation. More precisely, since δ_k^* increases and then decreases again with increasing product substitutability, it may well be that $\delta_a^* = \delta_b^*$ although the degree of product differentiation across both markets is not the same.

Proposition 2: In the quadratic utility model, the fact that $e_a \neq e_b$ does not guarantee that multimarket contact improves a firm's global profits even if $\delta_k \leq \delta_k^*$ in one or both markets.

To shed more light into the effect of multimarket contact in the quadratic utility model, let's look at an example. Suppose the actual discount factor $\delta_k \geq 1/2$ is as given in the upper diagram of Figure 3, such that $\delta_k \geq \delta_k^*$ for $e \in (0, e')$ and for $e \in (e'', 1)$. These are the areas in which optimal collusion is sustainable in both markets independent of multimarket contact. The first thing to note is that if $e_a = e'$ and $e_b = e''$, $\delta = \delta_a^* = \delta_b^*$. This corresponds to the argument that even though $e_a \neq e_b$, the minimum discount factor δ_k^* to enforce the optimal collusive outcome is the same for both markets. Second, for each horizontal line we draw through the curve of δ_k^* between e' and e'', we find a pair of e_k for which the difference between the minimum required discount factor and the actual discount factor $\delta_k^* - \delta_k$ is equal for $k = a, b$. The dashed line in Figure 3 is an example connecting such a pair of product differentiation parameters e_k. It is then straightforward to see that the collusive price p_k^C has to be equal for $k = a, b$ as well (see lower diagram of Figure 3). Consequently,

$$\partial \Pi_{ia}^C / \partial p_a^C = \partial \Pi_{ib}^C / \partial p_b^C \tag{24}$$

i.e. there is no scope for increasing global profits through swapping marginal profits across markets.

Intuitively, one might argue that each firm could increase its discounted profit stream through a segmentation of markets, e.g. firm 1 serves market a and firm 2 serves market b only. Thus, firms may be better off in colluding by creating two national monopolies than by colluding in two duopolies. While this solution is feasible in the homogeneous product case, it is not an equilibrium when products are differentiated.

Proposition 3: For all $0 < e < 1$, optimal collusion never requires firms to withdraw from one market and to transform markets a and market b into two separate monopolies.

Discounted monopoly profits in one single market exceed collusive profits in the two duopolies if

$$\frac{1}{1-\delta} \Pi_{1a}^{NM} \geq \frac{1}{1-\delta} (\Pi_{1a}^M + \Pi_{1b}^M) \tag{25}$$

for firm 1, provided firm 1 would agree with firm 2 to monopolize market a while firm 2 monopolizes market b. Since the model is symmetric, (25) applies to firm 2 as well when exchanging the indices. Π_{1a}^{NM} measures the per period profit collected from a national monopoly in market a whereas Π_{1k}^{M} are the collusive profits out of the two duopolies from equation (14). From there, we can also infer that $\Pi_{1a}^{NM} = \frac{a_k^2}{4}$, since products are independent on the demand side ($e = 0$) if each firm restricts its activity to one single market. Therefore, (25) becomes

$$\frac{a_k^2}{4} \geq \frac{a_k^2}{2(1+e)} \tag{26}$$

which never holds for $0 < e < 1$. A particular characteristic of the quadratic utility model can explain this result. It is implicit in the model that consumers have a taste for variety and hence, consume more of the product if they are offered more than one variety. Consequently, the overall demand increases in each market when a firm enters with a new variety, thereby increasing collusive profits for each firm aggregated over both markets relative to the profits from national monopoly [11].

5 Conclusion

In this paper I have illustrated that Bernheim and Whinston's multimarket contact hypothesis for heterogeneous products is not generally valid but depends on the way product differentiation is modelled. Two additional remarks are to be made. First, the validity of Bernheim and Whinston's argument in Chang's spatial model appears to depend on a specific characteristic of this model. We saw that the profits under optimal collusion were concave when plotted for locations $x \in (0, 1/2)$. this shape stems from the fact that Chang uses a model in which firms and consumers are distributed over a linear space with two endpoints. However, there are other spatial

[11] A respecification of the quadratic untility model such that demand remains fixed when product differentiation increases would modify the above result. Clearly, firms would be better off staying out of each other's market if they cannot increase market size by introducing a new variety. For a modification of the Spence model with constant market size, see Martin (1985).

models that do not necessarily comprise these features, such as linear model without endpoints or a circular model. Generally speaking, it might be more reasonable for collusive profits to decrease monotonically with increasing product substitutability. Therefore, it seems to me that the unconstraint validity of Bernheim and Whinston's argument for different degrees of product differentiation is a rather special phenomenon that is based on a spatial model such as Chang's.

Second, if we increase the number of firms n competing in the quadratic utility model, we obtain a linear relationship between δ^* and the degree of product differentiation. In particular, Martin (1989) showed that this is the case for $n \geq 5$. The concavity in the shape of δ^* disappears thus as we move to a more competitive market structure. The reason for the change in the shape of δ^* is quite clear: the more firms in the market, the less the market power of each firm to monopolize the market during defection.

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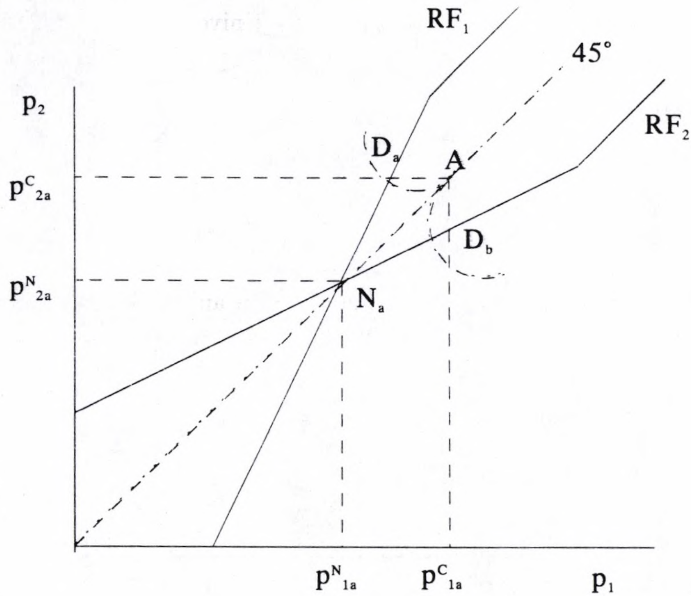
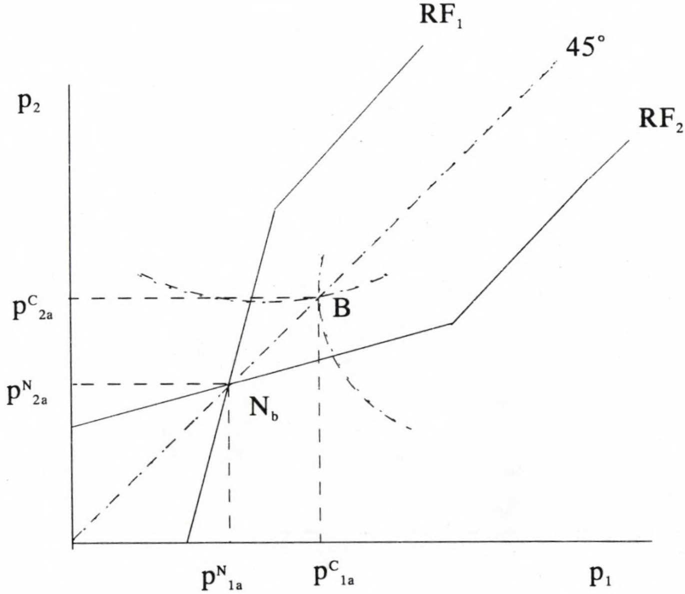


Market a

Figure 1b



Market b

FIGURE 2

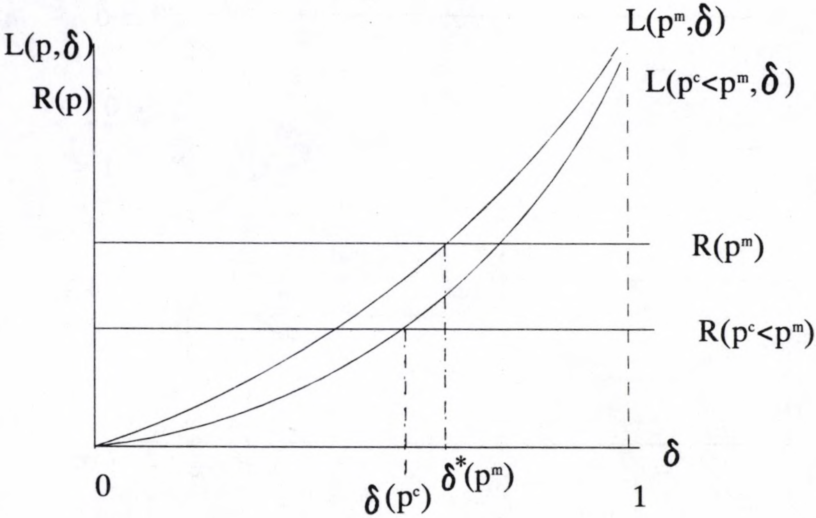
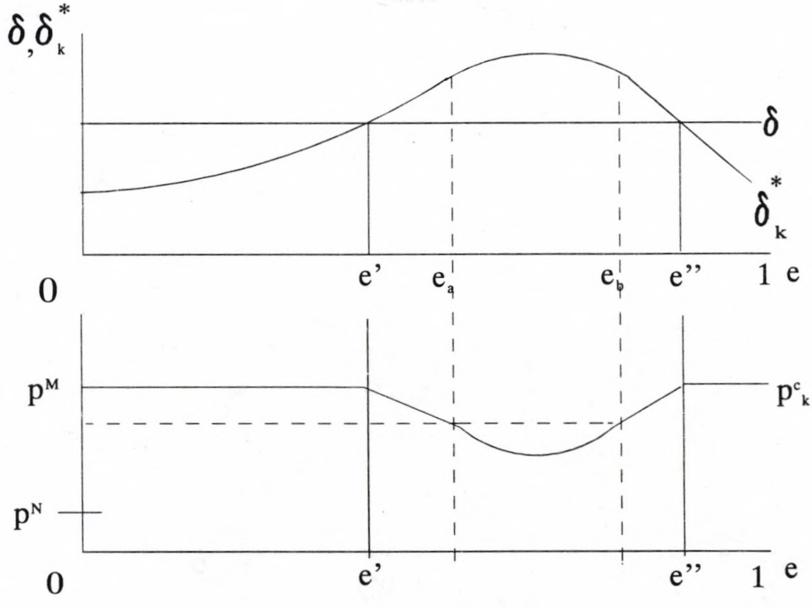


FIGURE 3



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