Standardization and the Stability of Collusion

Luca Lambertini
Department of Economics
University of Bologna
Strada Maggiore 45
I-40125 Bologna, Italy
fax: (39) 51 6402664
lamberti@spbo.unibo.it

Sougata Poddar
CORE
Universit¶e Catholique de Louvain
34 Voie du Roman Pays
1348 Louvain-la-Neuve, Belgium
fax: (32) 10 47 4301
poddar@core.ucl.ac.be

&

Dan Sasaki
Economics Department
University of Melbourne
Parkville, Victoria 3052 Australia
fax: (61) 3 9344 6899
dsasaki@cupid.ecom.unimelb.edu.au

October 1997

Abstract

We characterize the interplay between ¯rms' decision in terms of product standardization and the nature of their ensuing market behaviour. We prove the existence of a non-monotone relationship between ¯rms' decision at the product stage and their intertemporal preferences.

Keywords : RJVs, product innovation, critical discount factor.

JEL classi¯cation : D43, L13, O31.

Acknowledgements : We would like to thank Svend Alb½k, Stephen Martin, Oz Shy, and other seminar participants at Institute of Economics, University of Copenhagen (May 1997) where all three authors were a±liated at the time of presentation. The usual disclaimer applies.

1 Introduction

Standardization and compatibility between products belonging to the same industry are receiving a growing attention in the current literature, with and without network externalities (for the first approach, see Katz and Shapiro, 1985; Farrell and Saloner, 1986, inter alia; for the second, Matutes and Regibeau, 1988; Economides, 1989; Chou and Shy, 1990). Besides, there exists a wide literature concerning the effects of product substitutability on the stability of implicit collusion either in output levels or in prices, leading to heterogeneous conclusions (Deneckere, 1983; Chang, 1991, 1992; Rothschild, 1992; Ross, 1992; Friedman and Thisse, 1993; Häckner, 1994, 1995; Lambertini, 1997, inter alia). Hence, a twofold question springs to mind, namely, whether supplying standardized products may facilitate implicit collusion in the market phase[1] or, whether the attempt at colluding may induce standardization. We setup a duopoly model where the cost and benefit of standardization are evaluated against the individual discount factor common to both firms, and we prove that the decisions concerning standardization and market behaviour are non-monotone in firms' intertemporal preferences.

The remainder of the paper is organized as follows. The basic model is laid out in section 2. Firms' interaction is analysed in section 3. Section 4 provides concluding remarks.

2 The setup

Two independent labs operating in the intermediate product market supply a component which contributes to characterize the service offered by the final product. The right to adopt each component costs Φ. The two components are equivalent in terms of their service but not fully compatible with each other. Two *a priori* identical firms operate on the market, selling possibly differentiated final products. Each firm faces the following inverse demand function (see Singh and Vives, 1984):

$$p_i = 1 - q_i - \gamma q_j \qquad (1)$$

in which $\gamma \in (0,1]$ measures the degree of substitutability or standardization. By inverting (1), the direct demand function obtains:

$$q_i = \frac{1}{1+\gamma} - \frac{1}{1-\gamma^2} p_i + \frac{\gamma}{1-\gamma^2} p_j . \qquad (2)$$

Marginal production cost of the final product is constant and normalized to zero.

We consider the following time structure. At the beginning of the game ($t = 0$), firms decide whether or not to share a licence, splitting its cost Φ evenly. If they do, they will produce a standardised final product with $\gamma = 1$ as a result. Otherwise, if each firm buys a

[1] A similar issue is addressed by Martin (1995), showing that cooperation in R&D leading to a cost-reducing innovation may enhance cartel stability.

licence separately, paying Φ independently, then $\gamma = 1$ if the firms buy the component from the same lab,[2] or $\gamma = \Psi \in (0;1]$ if from different labs. Thenceforth, firms play a symmetric supergame in marketing over the horizon $t = (1;2;\cdots;\infty)$, either in prices or in quantities. Throughout the game, the discount factor δ is common to both firms. In establishing the critical threshold of the discount factor stabilizing collusion under either price or quantity competition, we follow the conventional folk theorem, implying that each firm cooperates as long as the rival does likewise; then, if deviation is detected, say at time t, both firms revert to the one-shot Nash equilibrium from $t+1$ onwards. As a consequence, the critical threshold of the discount factor turns out to be $\delta_K^* = (\pi_K^D - \pi_K^M)/(\pi_K^D - \pi_K^N)$; $K = B;C$; where K indicates the form of competition (B standing for Bertrand competition, and C for Cournot competition). Moreover, $\pi_K^M;\ \pi_K^D;\ \pi_K^N$ denote, respectively, cartel profit, deviation profit and one-shot Nash equilibrium profit per firm per period, under the type of competition K. For future reference, it is useful to derive explicitly here the threshold levels of the discount factor δ_K^* under both quantity and price competition. Straightforward calculations are needed to derive the per period per firm noncooperative profits (Singh and Vives, 1984):

$$\pi_C^N = \frac{1}{(2+\gamma)^2}; \quad \pi_B^N = \frac{1-\gamma}{(2-\gamma)^2(1+\gamma)}: \tag{3}$$

Obviously, the cartel profit is the same in both settings, i.e., $\pi_C^M = \pi_B^M = 1/[4(1+\gamma)]$, while deviation profits in the two cases can be obtained by the reaction functions of the cheating firm, under the assumption that the other firm sticks either to the monopoly price or to the monopoly output:

$$\pi_C^D = \frac{(2+\gamma)^2}{16(1+\gamma)^2} \quad \forall\gamma \in (0;1]; \quad \pi_B^D = \begin{cases} \dfrac{(2-\gamma)^2}{16(1-\gamma^2)} & \forall\gamma \in (0;\sqrt{3}-1]; \\[2ex] \dfrac{(2\gamma-1)}{4\gamma^2} & \forall\gamma \in (\sqrt{3}-1;1]: \end{cases} \tag{4}$$

As a result, the two critical thresholds of the discount factor are determined as follows:

$$\delta_C^* = \frac{(2+\gamma)^2}{8+8\gamma+\gamma^2} \quad \forall\gamma \in (0;1]; \quad \delta_B^* = \begin{cases} \dfrac{(2-\gamma)^2}{8-8\gamma+\gamma^2} & \forall\gamma \in (0;\sqrt{3}-1]; \\[2ex] \dfrac{(2-\gamma)^2(\gamma^2+\gamma-1)}{(2-\gamma)^2(\gamma^2+\gamma-1)+\gamma^4} & \forall\gamma \in (\sqrt{3}-1;1]: \end{cases} \tag{5}$$

In the case of Bertrand behaviour, the functional form of δ_B^* modifies as γ increases above $\sqrt{3}-1$, since above that value the non-negativity constraint on the quantity sold by the firm being cheated becomes binding (see Deneckere, 1983; and Ross, 1992). δ_B^* is increasing and convex in $\gamma \in (0;\sqrt{3}-1]$, decreasing and concave in $\gamma \in (\sqrt{3}-1;1]$. On the other hand, δ_C^* is increasing and convex over the whole range $\gamma \in (0;1]$. When $\gamma = 1$, $\delta_C^* = 9/17$ and $\delta_B^* = 1/2$:

Unlike Deneckere, we consider the choice of γ as a costly commitment. Therefore, firms face a tradeoff between the cost of differentiation and the increase in the stream of operative profits they may obtain through collusion in the market supergame.

[2] This is dominated by a joint licence and thus never chosen in equilibrium. Therefore, we ignore this case in sections 3 and 4.

3 The supergame

Depending upon whether the marketing stage is a Cournot supergame or a Bertrand supergame, we consider the following two subcases.

3.1 The Cournot supergame

In this case, the decision tree appears as in figure 1.

Figure 1 : Discounted profits per firm.

First stage	Market stage	Discounted profits	
Independent Ventures ($\gamma = \nu$)	Collusion if $\delta \geq \delta_C^*(\nu)$	$\frac{1}{4(1+\nu)} \cdot \frac{\delta}{1-\delta} - \Phi$	(IM)
	Cournot Nash if $\delta < \delta_C^*(\nu)$	$\frac{1}{(2+\nu)^2} \cdot \frac{\delta}{1-\delta} - \Phi$	(IN)
Joint Venture ($\gamma = 1$)	Collusion if $\delta \geq \frac{9}{17}$	$\frac{1}{8} \cdot \frac{\delta}{1-\delta} - \frac{\Phi}{2}$	(JM)
	Cournot Nash if $\delta < \frac{9}{17}$	$\frac{1}{9} \cdot \frac{\delta}{1-\delta} - \frac{\Phi}{2}$	(JN)

Depending upon the firms' discount factor δ, the parameter space can be divided into the following three regimes:

1. $\delta \in [9/17, 1)$: In this region, firms cooperate in the market stage, irrespectively of their behaviour in the product development phase, that is, for either value of γ. Therefore, firms must choose IM over JM if and only if
$$\left[\frac{1}{4(1+\nu)} - \frac{1}{8}\right]\frac{\delta}{1-\delta} \geq \frac{\Phi}{2}. \tag{6}$$

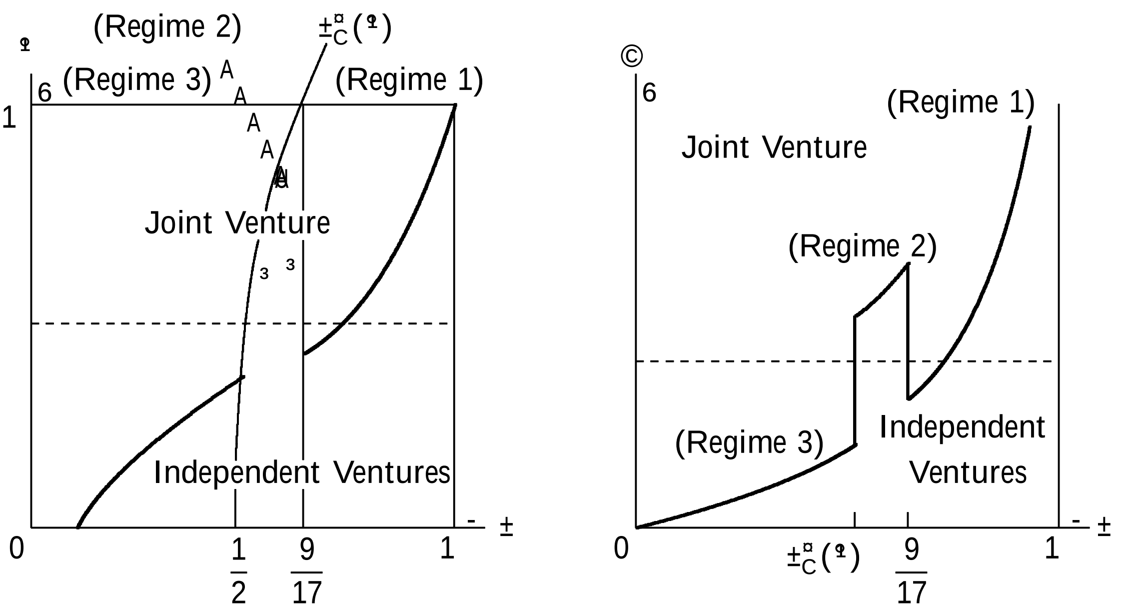
2. $\delta \in [\delta_C^*(\nu), 9/17)$: In this region, firms cooperate in the market stage if and only if they have previously chosen independent ventures. Hence, firms must choose IM over JN if and only if
$$\left[\frac{1}{4(1+\nu)} - \frac{1}{9}\right]\frac{\delta}{1-\delta} \geq \frac{\Phi}{2}. \tag{7}$$

3. $\delta \in [0, \delta_C^*(\nu))$: In this region, firms play the one-shot Cournot-Nash equilibrium at the market stage, irrespectively of their behaviour in the product development phase, that is, for either value of γ. Thus, firms shall choose IN over JN if and only if
$$\left[\frac{1}{(2+\nu)^2} - \frac{1}{9}\right]\frac{\delta}{1-\delta} \geq \frac{\Phi}{2}. \tag{8}$$

These three regimes span the parameter space f(±; °; ©)g: Figure 2 plots ° and © against ±: Overall, independent ventures tend to become more attractive as ± approaches 1. For intermediate values of ±, however, as is clear from the above, in the regime 2 the condition for independent ventures is loosened comparative to the adjacent areas. The intuition behind this result is the fact that, when their discount factor ± lies in regime 2, ¯rms can sustain quantity collusion if and only if they have chosen independent ventures. Note that the boundary between independent and joint ventures is monotone over the range ± 2 [0; 9=17) and over the range ± 2 [9=17; 1): Dotted lines indicate those values of ° and © with which ¯rms' venture decisions become non-monotone.

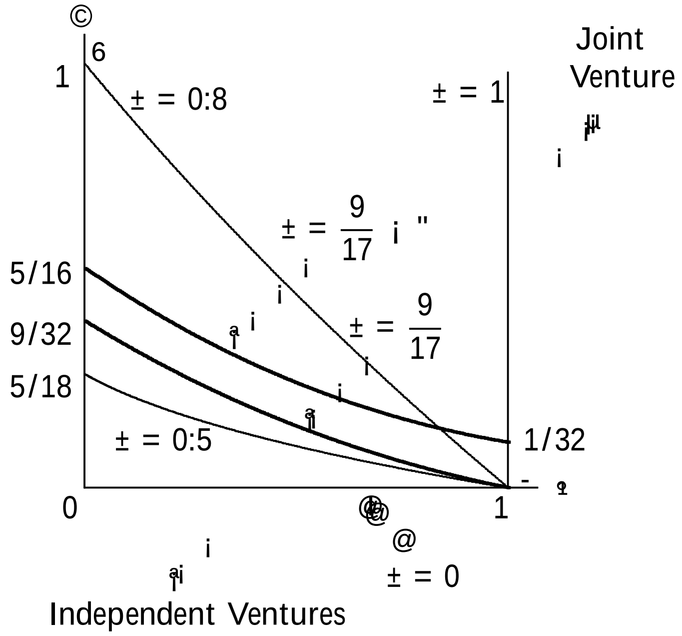
Figure 2 : Comparative statics with respect to the discount factor ±.

f(±; °)g given © f(±; ©)g given °



Finally, ¯gure 3 plots © against °: Over the range ± 2 [0; 9=17), the boundary between independent and joint ventures shifts up as ± increases. When ± reaches 9/17, the boundary jumps down (thick curves) and thereon shifts up again as ± approaches 1. In general, ¯rms' propensity for independent ventures increases in ±. Only in the area between the two thick curves, ¯rms' decisions between independent and joint ventures become non-monotone. In the neighbourhood of ± = 9=17, while ± is still in regime 2, ¯rms need independent ventures in order to sustain quantity collusion. Then, once ± crosses slightly above the threshold value 9/17, ¯rms are free from the fear of Cournot-Nash competition. Thus, now that quantity collusion is guaranteed, the incentives for independent ventures decrease and ¯rms collude in both phases. This reversal in ¯rms' product innovation decisions takes place only in this area, and only around ± = 9=17:

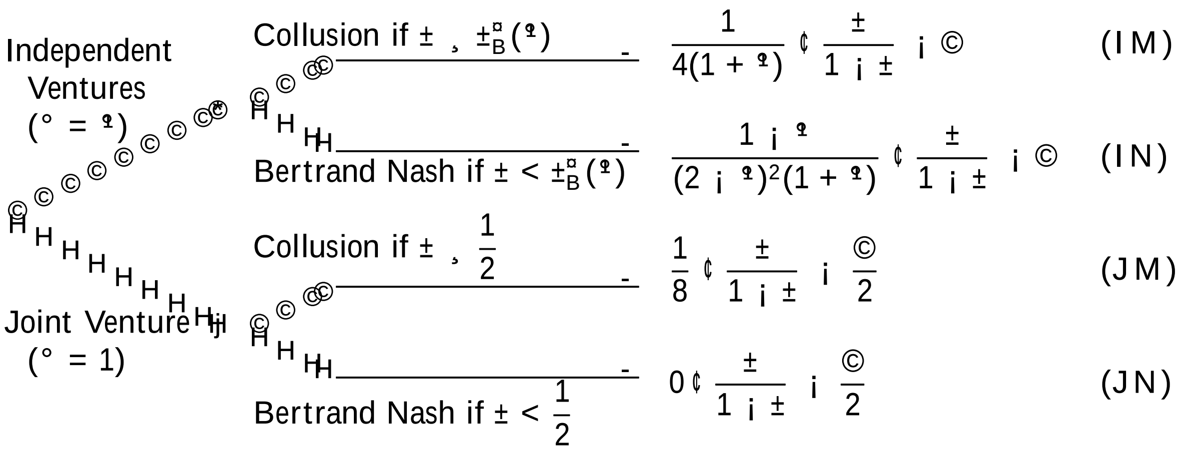
Figure 3 : Cost (©) - bene¯t (²) comparative statics given ±.



3.2 The Bertrand supergame

In this case, the decision tree appears as in ¯gure 4.

Figure 4 : Discounted pro¯ts per ¯rm.



Depending upon the ¯rms' discount factor ±, the parameter space can be divided into the following three regimes:

1. ± 2 [±¤B(²); 1): In this region, ¯rms cooperate in the market stage, irrespectively of their behaviour in the product development phase, that is, for either value of °. Therefore, ¯rms must choose IM over JM if and only if

$$\left[\frac{1}{4(1+²)} ¡ \frac{1}{8}\right] \frac{±}{1 ¡ ±} ¸ \frac{©}{2}: \qquad (9)$$

2. $\delta \in [1/2; \delta_B^*(\varepsilon))$: In this region, firms cooperate in the market stage if and only if they have previously chosen to undertake a joint venture. Hence, firms must choose IN over JM if and only if

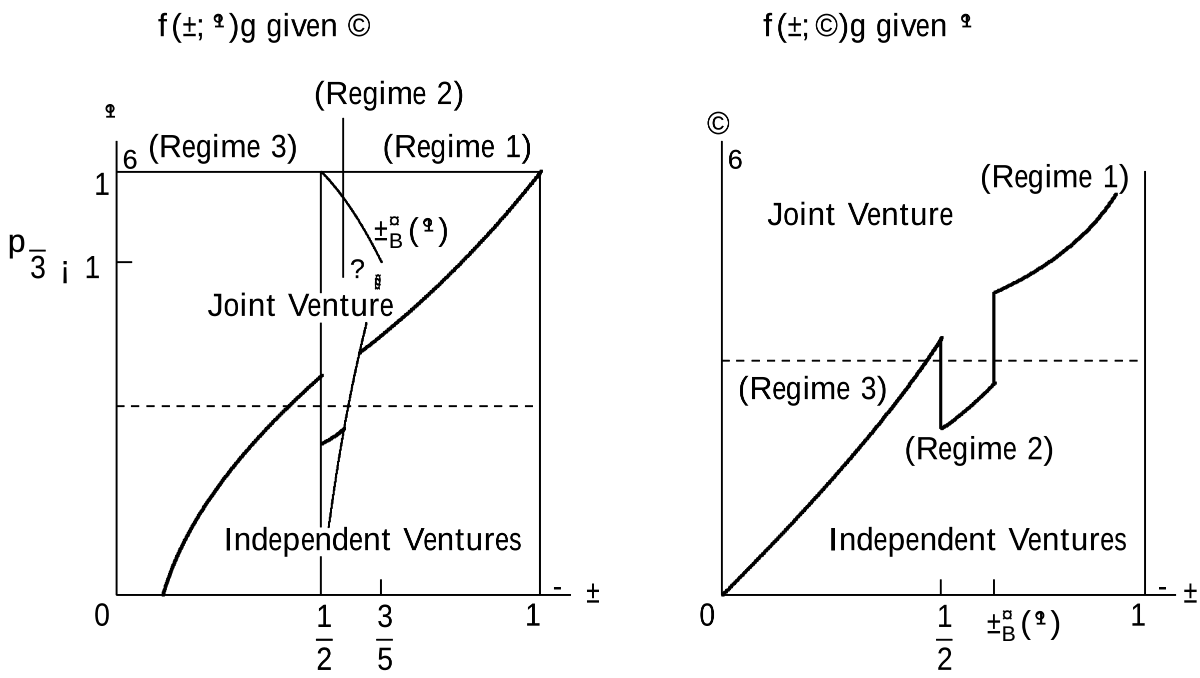
$$\left[\frac{1-\varepsilon}{(2-\varepsilon)^2(1+\varepsilon)} - \frac{1}{8}\right]\frac{\delta}{1-\delta} \geq \frac{\Phi}{2}. \tag{10}$$

3. $\delta \in [0; 1/2)$: In this region, firms play the one-shot Bertrand-Nash equilibrium at the market stage, irrespectively of their behaviour in the product development phase, that is, for either value of γ. Hence, firms shall choose IN over JN if and only if

$$\frac{1-\varepsilon}{(2-\varepsilon)^2(1+\varepsilon)} \cdot \frac{\delta}{1-\delta} \geq \frac{\Phi}{2}. \tag{11}$$

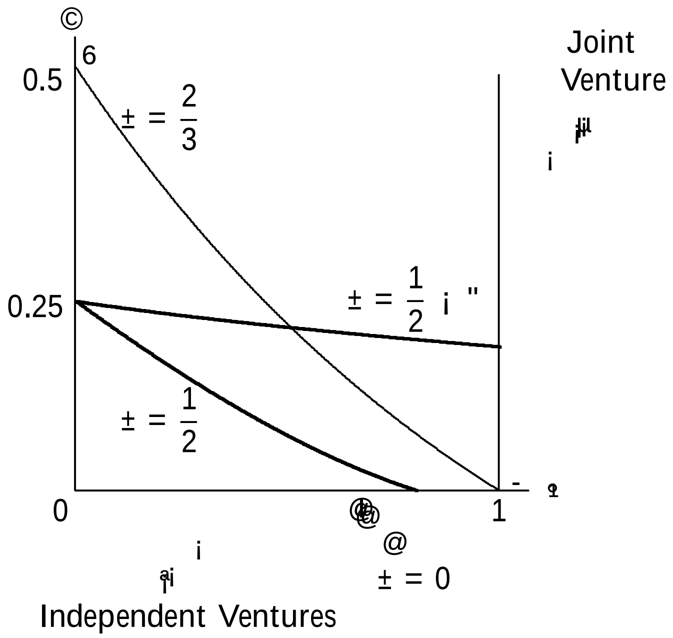
Again, these three regimes span the parameter space $\{(\delta; \varepsilon; \Phi)\}$. Figure 5 plots ε and Φ against δ. In general, independent product development tends to become more attractive as δ increases. For intermediate values of δ, contrarily to the Cournot case, in the regime 2 the condition for independent ventures is tightened as compared to the adjacent areas. The intuition behind this result traces back to the fact that, when their discount factor δ lies in regime 2, firms can sustain price collusion if and only if they have chosen a joint venture. Note that the boundary between independent and joint ventures is monotone over the range $\delta \in [0; 1/2)$ and over the range $\delta \in [1/2; 1)$. Dotted lines indicate those values of ε and Φ with which firms' decisions between independent and joint ventures are non-monotone.

Figure 5 : Comparative statics with respect to the discount factor δ.



Finally, figure 6 plots Φ against ε. Over the range $\delta \in [0; 1/2)$, the boundary between independent and joint ventures shifts up as δ increases. When δ reaches 1/2, the boundary rotates clockwise (thick curves). Thereafter, the boundary shifts up again as ± approaches 1. In general, ¯rms' propensity for independent ventures increases in ±, except in the area between the two thick curves. Over this area, while ± is in regime 3, ¯rms have no hope for price collusion, whereas once ± crosses above the threshold value 1/2, ¯rms can collude only after a joint venture. This makes a joint venture in product development more attractive in regime 2. Note that the area between the two curves is far larger than in the Cournot case, the reason being that the prospect of collusive pro¯ts in the future is more relevant under Bertrand competition.

Figure 6 : Cost (©) - bene¯t (º) comparative statics given ±.



The above analysis can be summarized in the following

Proposition. Under both Cournot and Bertrand competition, there exists a range of parameter values (º; ©) over which ¯rms' decisions on product standardization are non-monotone in their discount factor ±.

4 Concluding remarks

We have analysed the unfolding of ¯rms' behaviour in a di®erentiated duopoly where ¯rms must ¯rst decide upon product compatibility and then play an in¯nitely repeated market game where they have the option to implicitly collude. Contrary to some of the earlier beliefs, we have established that the relationship between product compatibility (or di®erentiation) and the discount factor can indeed be non-monotone. This seemingly counterintuitive result stems from the balance between cost consideration in choosing between standardization and variety, and ¯rms' concern towards future cartel stability.

References

Chang, M.H. (1991), \The E®ects of Product Di®erentiation on Collusive Pricing", International Journal of Industrial Organization, 9, 453-69.

Chang, M.H. (1992), \Intertemporal Product Choice and Its E®ects on Collusive Firm Behavior", International Economic Review, 33, 773-93.

Chou, C. and O. Shy (1990), "Network E®ects without Network Externalities", International Journal of Industrial Organization, 8, 259-70.

Deneckere, R. (1983), \Duopoly Supergames with Product Di®erentiation", Economics Letters, 11, 37-42.

Economides, N. (1989), \Desirability of Compatibility in the Absence of Network Externalities", American Economic Review, 79, 1165-81.

Farrell, J. and G. Saloner (1986), \Standardization and Variety", Economics Letters, 20, 71-74.

Friedman, J.W. and J.-F. Thisse (1993), \Partial Collusion Fosters Minimum Product Di®erentiation", RAND Journal of Economics, 24, 631-45.

Häckner, J. (1994), \Collusive Pricing in Markets for Vertically Di®erentiated Products", International Journal of Industrial Organization, 12, 155-77.

Häckner, J. (1995), \Endogenous Product Design in an In¯nitely Repeated Game", International Journal of Industrial Organization, 13, 277-99.

Katz, M. and C. Shapiro (1985), \Network Externalities, Competition, and Compatibility", American Economic Review, 75, 424-40.

Lambertini, L. (1997), \Prisoners' Dilemma in Duopoly (Super)games", Journal of Economic Theory, forthcoming.

Martin, S. (1995), \R&D Joint Ventures and Tacit Product Market Collusion", European Journal of Political Economy, 11, 733-41.

Matutes, C. and P. Regibeau (1988), \Mix and Match: Product Compatibility without Network Externalities", RAND Journal of Economics, 19, 221-34.

Ross, T.W. (1992), \Cartel Stability and Product Di®erentiation", International Journal of Industrial Organization, 10, 1-13.

Rothschild, R. (1992), \On the Sustainability of Collusion in Di®erentiated Duopolies", Economics Letters, 40, 33-7.

Singh, N. and X. Vives (1984), \Price and Quantity Competition in a Di®erentiated Duopoly", RAND Journal of Economics, 15, 546-54.