Standardization and the Stability of Collusion

Luca Lambertini  
*University of Bologna*

Sougata Poddar  
*Chapman University, poddar@chapman.edu*

Dan Sasaki  
*University of Melbourne*

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Abstract

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

Keywords: RJVs, product innovation, critical discount factor.


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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; HÄackner, 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 set up 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 \(©\). 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):

\[ p_i = 1 - q_i - °q_j \]  

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

\[ q_i = \frac{1}{1 + °} - \frac{1}{1 + °} p_i + \frac{°}{1 + °} p_j \]  

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 \(©\) evenly. If they do, they will produce a standardised final product with \(° = 1\) 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.
licences separately, paying © independently, then ° = 1 if the ®rms buy the component from
the same lab,2 or ° = ² 2 (0; 1) if from different labs. Henceforth, ®rms play a symmetric
supergame in marketing over the horizon t = (1; 2; . . . ; 1 ), either in prices or in quantities.
Throughout the game, the discount factor ° is common to both ®rms. 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 ®rm cooperates
as long as the rival does likewise; then, if deviation is detected, say at time t, both ®rms
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 \[ \gamma_E = \frac{1}{(2 + \delta)^2}; \quad \gamma_B = \frac{1}{(2 + \delta)^2(1 + \delta)}. \] (3)

Obviously, the cartel pro®t is the same in both settings, i.e., \[ \gamma_E = \gamma_B = 1 = 4(1 + \delta), \]
while deviation pro®ts in the two cases can be obtained by the reaction functions of the
deviation ®rm, under the assumption that the other ®rm sticks either to the monopoly
price or to the monopoly output:
\[ \gamma_E = \frac{(2 + \delta)^2}{16(1 + \delta)^2}; \quad \gamma_B = \frac{8}{4(2 + \delta)}; \]
\[ \gamma_B = \frac{(2 + \delta)^2}{16(1 + \delta)^2}; \quad \gamma_B = \frac{8}{4(2 + \delta)}. \] (4)

As a result, the two critical thresholds of the discount factor are determined as follows:
\[ \gamma_E = \frac{(2 + \delta)^2}{8 + 8\delta + \delta^2}; \quad \gamma_B = \frac{8}{8\delta + \delta^2}; \]
\[ \gamma_B = \frac{(2 + \delta)^2}{16(1 + \delta)^2}; \quad \gamma_B = \frac{8}{4(2 + \delta)}. \] (5)

In the case of Bertrand behaviour, the functional form of \[ \gamma_B \] modifies as \[ \delta \] increases above
\[ \delta = 1, \] since above that value the non-negativity constraint on the quantity sold by
the ®rm being cheated becomes binding (see Deneckere, 1983; and Ross, 1992). \[ \gamma_E \] is
increasing and convex in \[ \delta \geq 2 (0; \delta < 1), \] decreasing and concave in \[ \delta \geq 2 (\delta < 1). \] On
the other hand, \[ \gamma_B \] is increasing and convex over the whole range \[ \delta \geq 2 (0; 1). \] When \[ \delta = 1, \]
\[ \gamma_E = 9 = 17 \] and \[ \gamma_B = 1 = 2; \]

Unlike Deneckere, we consider the choice of \[ \delta \] as a costly commitment. Therefore,
®rms face a tradeoff between the cost of differentiation and the increase in the stream of
operative pro®ts they may obtain through collusion in the market supergame.

2This 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.

![Decision Tree](image)

Figure 1: Discounted profits per rm.

Depending upon the firms' discount factor \( \delta \), the parameter space can be divided into the following three regimes:

1. \( \delta \in [9; 1] \): In this region, firms cooperate in the market stage, irrespectively of their behaviour in the product development phase, that is, for either value of \( \alpha \): Therefore, firms must choose IM over JM if and only if
   \[
   \frac{1}{4(1 + \delta)} i \left( \frac{1}{8} \frac{\pm}{1 + i} \right) \leq \frac{\pm}{2}.
   \] (6)

2. \( \delta \in \left[ \delta_C(\alpha); 9 \right] \): 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
   \[
   \frac{1}{4(1 + \delta)} i \left( \frac{1}{9} \frac{\pm}{1 + i} \right) \geq \frac{\pm}{2}.
   \] (7)

3. \( \delta \in [0; \delta_C(\alpha)) \): 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 \( \alpha \): Thus, firms shall choose IN over JN if and only if
   \[
   \frac{1}{(2 + \delta)^2} i \left( \frac{1}{9} \frac{\pm}{1 + i} \right) \geq \frac{\pm}{2}.
   \] (8)
These three regimes span the parameter space $f(\pm^*; \odot)g$. Figure 2 plots $^*$ and $\odot$ against $\pm$. Overall, independent ventures tend to become more attractive as $\pm$ approaches 1. For intermediate values of $\pm$ 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 $\pm$ lies in regime 2, firms 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 $\pm \in [0; 9/17)$ and over the range $\pm \in [9/17; 1)$. Dotted lines indicate those values of $^*$ and $\odot$ with which firms’ venture decisions become non-monotone.

Figure 2: Comparative statics with respect to the discount factor $\pm$.

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

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

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

1. ± 2 \((\pm_0^\ast); 1\): In this region, rms cooperate in the market stage, irrespectively of their behaviour in the product development phase, that is, for either value of \(\ast\). Therefore, rms must choose IM over JM if and only if

\[
\frac{1}{4(1 + \ast)} \leq \frac{\pm}{\pm_i} \leq \frac{1}{2} \Rightarrow \text{Collusion if } \pm \geq \frac{2}{3} (1 + \ast) \quad (9)
\]
2. $\pm 2 [1=2; \pm \theta (\ast))$: 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
\[
\frac{1 \mp \theta}{(2 \mp \theta) (1 + \theta)} \leq \frac{1}{8} \left( \frac{\pm \theta}{1 \mp \theta} \right). \tag{10}
\]

3. $\pm 2 [0; 1=2)$: 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 $\theta$: Hence, firms shall choose IN over JN if and only if
\[
\frac{1 \mp \theta}{(2 \mp \theta) (1 + \theta)} \leq \frac{1}{8} \left( \frac{\pm \theta}{1 \mp \theta} \right). \tag{11}
\]

Again, these three regimes span the parameter space $f(\pm \theta; \circ)$: Figure 5 plots $\theta$ and $\circ$ against $\pm$. In general, independent product development tends to become more attractive as $\pm$ increases. For intermediate values of $\pm$, 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 $\pm$ 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 $\pm 2 [0; 1=2)$ and over the range $\pm 2 [1=2; 1)$: Dotted lines indicate those values of $\theta$ and $\circ$ with which firms' decisions between independent and joint ventures are non-monotone.

Figure 5: Comparative statics with respect to the discount factor $\pm$.

\[
f(\pm \theta) g \text{ given } \circ
\]

\[
f(\pm \circ) g \text{ given } \theta
\]

Finally, figure 6 plots $\circ$ against $\theta$: Over the range $\pm 2 [0; 1=2)$, the boundary between independent and joint ventures shifts up as $\pm$ increases. When $\pm$ reaches $1/2$, the boundary
rotates clockwise (thick curves). Thereafter, the boundary shifts up again as $\pm$ approaches 1. In general, rms' propensity for independent ventures increases in $\pm$, except in the area between the two thick curves. Over this area, while $\pm$ is in regime 3, rms have no hope for price collusion, whereas once $\pm$ 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 ($\circ$) - bene"t ($) comparative statics given $\pm$.

The above analysis can be summarized in the following Proposition. Under both Cournot and Bertrand competition, there exists a range of parameter values ($^*$; $\circ$) over which rms' decisions on product standardization are non-monotone in their discount factor $\pm$.

4 Concluding remarks

We have analysed the unfolding of rms' behaviour in a differentiated 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 differentiation) 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


