"PRODUCT COMPATIBILITY AND THE SCOPE OF ENTRY"

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N° 87 / 40

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Director of Publication :

Charles WYPLOSZ, Associate Dean
for Research and Development

Printed at INSEAD,
Fontainebleau, France

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ABSTRACT

In many industries consumers derive utility from combining several components of a system that must be compatible with one another (e.g. hardware, software and peripheral equipment). In this paper we develop a framework to explore the incentives to produce a standardized good among manufacturers who produce a single component of the system. We find that, even without network externalities, standardization can be a credible commitment to limit the scope of entry.

We would like to thank R.M.Anderson, J.Farrell, D.Fudenberg, R.J.Gilbert, J. Perloff, K.Rockett, G.Saloner and X.Vives and two anonymous referees for their helpful comments.

* Support of the Álfred P. Sloan Foundation's doctoral dissertation program is gratefully acknowledged.

I . INTRODUCTION

Many multiproduct industries produce 'systems', i.e. lines of products where each good cannot be used alone but might still be bought separately. Examples of such industries are the computer industry where a 'system' includes both hardware and software (peripheral equipment, operation systems, programs,...), the home-video industry where a Video Cassette Recorder, video cassettes and a TV screen must be used together, and the amateur photography industry where the typical product line includes cameras, negatives and film processing services.

In such industries, the issue of product compatibility is of foremost importance since the opportunity to buy different components of the 'system' from different firms exists only when these components are compatible across manufacturers.

Katz and Shapiro (1985) have analyzed the firms' incentives to produce compatible goods. They argue that compatibility creates positive consumption externalities, called 'network externalities', because consumers' enjoyment of a product increases with the number of other consumers using compatible products : the larger the 'network' of compatible goods, the better the possibilities of exchange, the quality of after sale services and the information available.

One drawback of this recent literature on network externalities[1] is that each firm is modelled as selling a single good. This implicitly assumes that every firm sells every component of a system or that the firms considered only sell one similar component (e.g. software) to consumers who have already bought other parts of the 'system' (e.g. the personal computer).

In both cases, explicitly modelling a system as a combination of components reveals that network externalities are not necessary to provide some firms with an incentive to produce compatible goods. In another paper (Matutes-Regibeau 1986) we show that fully integrated firms tend to favor compatibility because it increases the variety of systems available and thus raises industry demand and because it reduces the aggressivity of their rivals. In the present paper, we analyze the behavior of two producers selling one similar component.

Two firms sell one component (e.g. software) of a two-component system. Consumers have already bought the first component (e.g. the personal computer) so that several independent[2] markets for software are determined. In other words, there is a separate market for the software compatible with each type of computer. We consider the case where there are two such markets and two firms play the following game.

In the first stage of the game, the firms choose the market(s) that they will supply. They also decide whether to produce a different software for each market ('diversification') or to sell some software which can be used with both types of computers ('standardization')[3]. In the first instance, the firm can price its product independently in each market, while in the latter it must charge the same price in the two markets, i.e. standardization acts as a price constraint. This first stage is played sequentially, with the incumbent (firm A) making its choice before the other firm, knowing A's decision, has to determine the goods that it will produce.

In the second stage of the game, both firms compete in the market(s) that they have decided to enter. The two competitors set prices and some degree of product differentiation is assumed whenever both firms enter the same market.

This sequential game is solved for its subgame perfect Nash equilibria (SPNE). It is shown that, when the firms' products are close substitutes, there is a unique equilibrium where the first firm chooses to standardize, while the second firm enters a single market. Standardization can thus be seen as a means for the incumbent to limit entry to one of the two markets.

Intuitively, by choosing standardization, the incumbent commits itself to charging the same price in the two markets. If the other firm chooses to enter both markets, competition will be intense. If, on the other hand, it chooses to enter only one market, competition in that market will be less severe; the incumbent will be less willing to cut its price since this would reduce its profits in its monopoly market. In other words, the entrant must choose between entering both markets where it will face a very fierce competitor and entering a single market where it will face a 'restrained' competitor. If the degree of product differentiation is low, price cutting is very damaging, leading the entrant to sell in a single market.

The same type of argument could be applied to other situation where an incumbent has the opportunity to price discriminate between two markets. In each case however, special attention has to be given to the credibility of the firms' equilibrium strategies.

The paper is organized as follows. Section 1 discusses the general model. In section 2, the game is solved with linear demand functions and our result is linked to the literature on strategic self-restraint. Section 3 examines the effect of assymetries in market demands. The results of the paper are summarized in section 4.

SECTION I

There are two markets, 1 and 2, and two firms, A and B. In the first stage of the game, each firm is faced with the following alternatives:

- To serve market 1 only.
- To serve market 2 only.
- To sell a different type of 'software' in each market (diversification).
- To sell a single standardized 'software' in both markets (standardization).

Firm A, the incumbent, chooses first. In the second stage of the game, the two firms compete on prices in the markets that they have entered. The following, rather harmless assumptions are made:

- In each market, duopoly and monopoly profits are positive
- In each market, a firm's monopoly profit is higher than its duopoly profit
- The goods are produced at constant marginal cost[4].

These assumptions imply that being the only firm to diversify (i.e. to sell different goods in both markets) is better than enjoying a monopoly in a single market or than being a duopolist in both markets. This rules out as an equilibrium of the game the case where each firm serves one market since, given that the rival firm serves only one market, a firm will always prefer to enter both markets through diversification. Accordingly, only the cases where at least one market is served by both firms will be considered in the rest of the analysis.

For most of the paper, it will be assumed that the demand functions are the same in the two markets and that the marginal cost of producing any good is the same for both firms in both markets.

This symmetry assumption considerably simplifies the solution of the game and helps emphasize that the results obtained do not depend on any 'accidental' differences in cost or demand conditions.
It will also be assumed that there are no fixed entry costs.
The implications of relaxing these assumptions are briefly examined in sections II and III.

If a firm diversifies, it can set different prices in the two markets, while, if it standardizes, it must charge the same price in the two markets. Because of the symmetry assumption however, the price constraint is not binding when both firms standardize since two diversifying firms would charge identical prices in the two markets anyway. In other words, with symmetry, the unconstrained maximum satisfies the price constraint whenever both firms serve both markets, so that the market equilibria where both firms diversify or standardize yield the same payoffs for each firm:

$$2\bar{\pi}$$

where $\bar{\pi}$ is a firm's duopoly profit in a single market.

The equilibrium profits corresponding to the different subgames are shown in Table 1. Only the cases where both markets are served by at least one firm are presented. Morever, if firm A (B) enters only one market, it is assumed to be market 1(2).

The following notation is used:

- $\pi^m = \pi^m_{ij}$ is firm j's monopoly profit in market i.
- $\bar{\pi}$ is a firm duopoly profit in a single market.
- $2\bar{\pi}$ is a firm total profit when both firms enter both markets, be it by diversification or by standardization.

- $\pi^{sn} = \pi_j^{sn}$ is firm j's profit when j standardizes and the other firm serves only one market.
- $\pi^{ns} = \pi_j^{ns}$ is firm j's profit when j serves only one market and the other firm standardizes.
- π_j^{dn} is firm j's profit when j diversifies and the other firm only serves one market. This is equal to $\pi^m + \bar{\pi}$.
- π_j^{nd} is firm j's profit when j only serves one market and its rival diversifies. This is equal to $\bar{\pi}$.

Similar notation applies to prices with , for example, p_{ij}^m representing firm j's monopoly price in market i.

TABLE I

FIRM B

		N_2	S	D
	N_1	π^m_{2B} π^m_{1A}	π^{sn}_B π^{ns}_A	$\bar{\pi} + \pi^m_{2B}$ $\bar{\pi}$
FIRM A	S	π^{ns}_B π^{sn}_A	$2\bar{\pi}$ $2\bar{\pi}$	$2\bar{\pi}$ $2\bar{\pi}$
	D	$\bar{\pi}$ $\bar{\pi} + \pi^m_{1A}$	$2\bar{\pi}$ $2\bar{\pi}$	$2\bar{\pi}$ $2\bar{\pi}$

N_i = only serve market i D = diversify S = standardize

Subgame Perfect Equilibria

If $2\bar{\pi} > \pi^{ns}$, the only Subgame Perfect Nash Equilibria are (D,D), (D,S), (S,D) and (S,S), i.e. both firms serve each markets by diversifying or standardizing.

If $\pi_j^{ns} > 2\bar{\pi}$, the unique Subgame Perfect Nash Equilibrium is one where the first firm to move chooses to standardize, while the other firm chooses to serve a single market, (S,N). The argument goes as follows.
Assume that firm A moves first:

- if A chooses to serve a single market, then firm B chooses to diversify, leaving firm A with $\bar{\pi}$ or to standardize leaving A with π_A^{ns}, depending on whether $\bar{\pi} + \pi_B^{m}$ is greater or smaller than π_B^{sn}

- If A chooses to diversify into both markets, then firm B chooses to serve both markets as well (since $2\bar{\pi} > \bar{\pi}$), leaving A with profits of $2\bar{\pi}$

- If A chooses to standardize, then firm B prefers to serve a single market (since $\pi_B^{ns} > 2\bar{\pi}$).

As $\pi^{sn} > 2\bar{\pi}$ and $\pi^{sn} > \pi^{ns}$ [5], firm A chooses to standardize while firm B limits its entry to one market.

That π^{sn} can exceed $2\bar{\pi}$ is clear enough: being a monopolist in one of the two markets can make up for the disadvantage of having to charge the same price in both.

That π^{ns} can be larger than $2\bar{\pi}$ requires some explanation. It can be shown that the price charged by firm A when it standardizes must lie between the monopoly price and the duopoly price[6]. This means that if the monopoly price is higher than the duopoly price (which is the case under our symmetry assumption), then $P_A^{sn} > P_{2A}^{d}$ for any given P_{2B}. In other words, for any given price charged by firm B on market 2, firm A charges a higher price in this market when it standardizes than when it diversifies. Firm A's behavior on market 2 is, thus, less aggressive when A standardizes than when A diversifies. This is to the benefit of B, so that $\pi_B^{ns} > \bar{\pi}$ and it might be the case that $\pi_B^{ns} > 2\bar{\pi}$.

This argument does not establish under what conditions the effect of firm A's less aggressive behavior is strong enough to ensure that (S,N) is the unique subgame perfect equilibrium of the game. Indeed, a priori it is not obvious that such an outcome would ever occur. That it does actually arise is shown in the next section for a system of linear demands.

SECTION II

In each market, a representative consumer maximizes a utility function which is separable in the numeraire good Y:

$$V(Q_{iA},Q_{iB},Y) = U(Q_{iA},Q_{iB}) + Y \qquad i = 1,2$$

where Q_{ij} is the quantity of the good sold by firm j in market i[7]. If U is quadratic with parameters a,b,c, the resulting direct demand system is:

$$Q_{iA} = \frac{a}{b+c} - \frac{b}{b^2-c^2} P_{iA} + \frac{c}{b^2-c^2} P_{iB}$$

$$Q_{iB} = \frac{a}{b+c} + \frac{c}{b^2-c^2} P_{iA} - \frac{b}{b^2-c^2} P_{iB}$$

defined for all P_{iA}, P_{iB} such that Q_{iA} and Q_{iB} are positive.

$$Q_{iA} = \frac{a - P_{iA}}{b} \text{ if B has not entered market i}$$

$$Q_{iB} = \frac{a - P_{iB}}{b} \text{ if A has not entered market i}$$

From now on, it will be assumed that, within a given market, the products of the two firms are gross substitutes and that the own price effect dominates the cross-price effect, i.e. $c > 0$ and $b > c$. Firms are assumed to produce each good at a constant marginal cost k. Without loss of generality k is set equal to zero. These conditions are suficient for the existence of a unique equilibrium in every subgame[8].

Equilibrium Payoffs and Subgame Perfect Nash Equilibria

The equilibrium profits for the different subgames are summarized in Table 2. It is clear that $\pi_j^m > \bar{\pi} > 0$ since $b > c$, so that A1 and A2 are satisfied.

As discussed in section 1, the SPNE of the game will depend on the ranking of π_j^{sn}, π_j^{ns} and $2\bar{\pi}$. With linear demands, the following inequality holds:

$$\pi_j^{ns} \gtrless 2\bar{\pi} \text{ as}$$

$$64b^6 - 96b^4c^2 - 16b^3c^3 + 34b^2c^4 + 8bc^5 - c^6 \lessgtr 0 \qquad (4)$$

It follows that a situation where the first firm standardizes while the other firm supplies only one market is the only SPNE of the game if and only if:

$$64b^6 - 96b^4c^2 - 16b^3c^3 + 34b^2c^4 + 8bc^5 - c^6 < 0 \qquad (4)$$

This inequality will be satisfied for values of c close to b, i.e. when the goods sold by the two firms are close substitutes[9]. Intuitively, π_j^{ns} can exceed $2\bar{\pi}$ because it might be better for firm j to face a 'restrained' competitor in a single market than to face a very aggressive competitor in both markets. This is more likely to be the case when c is close to b since aggressive behavior (i.e. price cutting behavior) is most damaging when the goods produced by the two firms are close substitutes, and the degree of substitution is larger the closer is c to b.

TABLE 2

FIRM B

		N_2	S	D
	N_1	$\frac{a^2}{4b}$ $\frac{a^2}{4b}$	$\frac{a^2(b-c)(4b-3c)^2(b^2-c^2)}{b(b+c)(8b^2-5c^2)^2}$ $\frac{a^2(b-c)(4b^2+2bc-c^2)^2}{b(b+c)(8b^2-5c^2)^2}$	$\frac{a^2}{4b} + \frac{a^2 b\ (b-c)}{(b+c)(2b-c)^2}$ $\frac{a^2 b\ (b-c)}{(b+c)(2b-c)}$
FIRM A	S	$\frac{a^2(b-c)(4b^2+2bc-c^2)^2}{b(b+c)(8b^2-5c^2)^2}$ $\frac{a^2(b-c)(4b+3c)^2(2b^2-c^2)}{b(b+c)(8b^2-5c^2)^2}$	$\frac{2a^2 b\ (b-c)}{(b+c)(2b-c)^2}$ $\frac{2a^2 b\ (b-c)}{(b+c)(2b-c)^2}$	$\frac{2a^2 b\ (b-c)}{(b+c)(2b-c}$ $\frac{2a^2 b\ (b-c)}{(b+c)(2b-c}$
	D	$\frac{a^2 b\ (b-c)}{(b+c)(2b-c)^2}$ $\frac{a^2}{4b} + \frac{a^2 b\ (b-c)}{(b+c)(2b-c)^2}$	$\frac{2a^2 b\ (b-c)}{(b+c)(2b-c)^2}$ $\frac{2a^2 b\ (b-c)}{(b+c)(2b-c)^2}$	$\frac{2a^2 b\ (b-c)}{(b+c)(2b-c}$ $\frac{2a^2 b\ (b-c)}{(b+c)(2b-c}$

How product standardization makes the first firm less aggressive can be visualized more easily by considering the firms' reaction functions. Again, assume that firm A moves first. Whether firm B serves only market 2 or diversifies into market 1 as well, its reaction function on market 2 is:

$$P_{2B} = \frac{a(b - c)}{2b} + \frac{c}{2b} P_{2A}$$

If firm A diversifies, its reaction function on market 2 is:

$$P_{2A} = \frac{a(b - c)}{2b} + \frac{c}{2b} P_{2B}$$

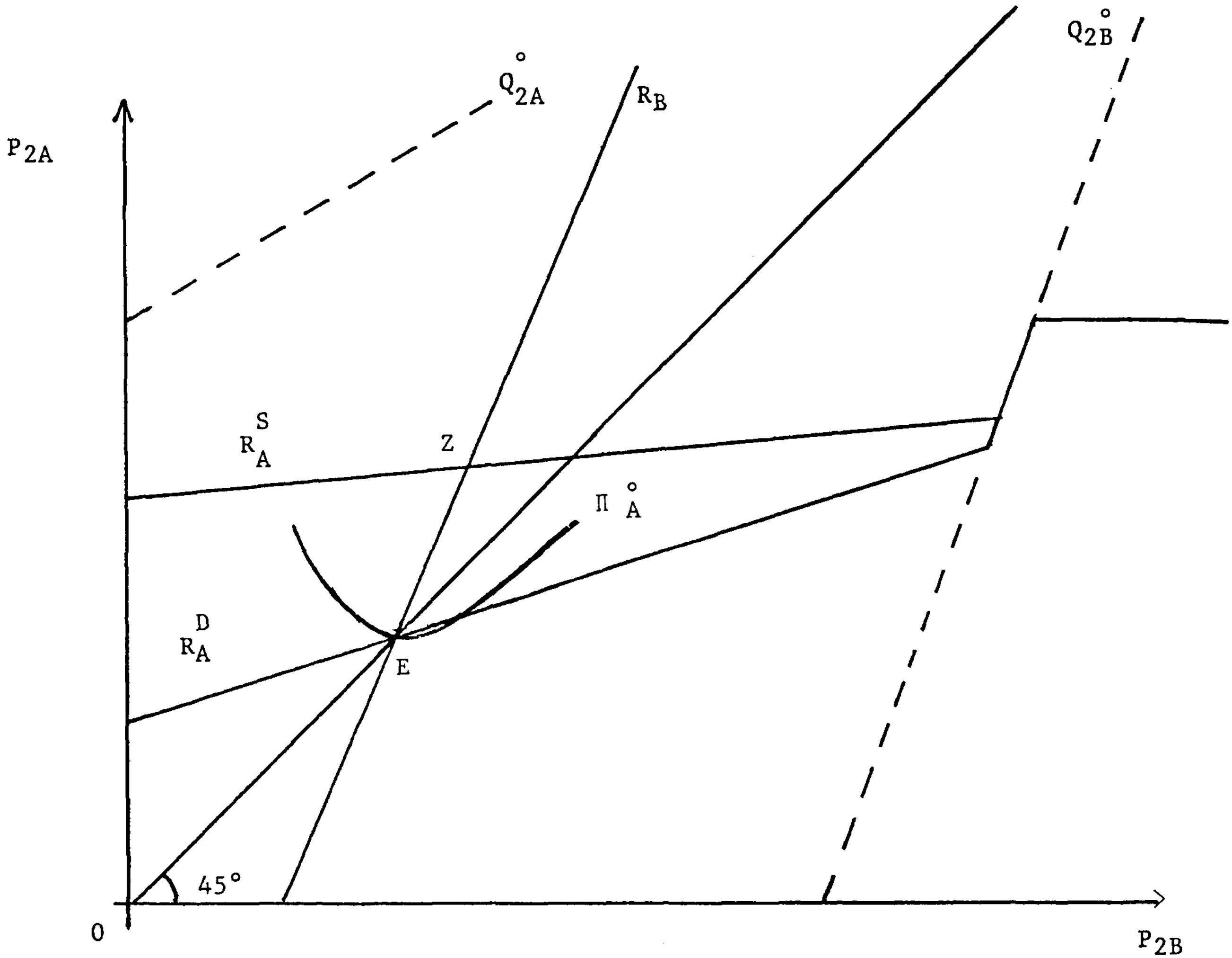
If firm A standardizes, its reaction function is:

$$P_{1A} = P_{2A} = \frac{a(2b+c)(b-c)}{4b^2 - 2c^2} + \frac{cb}{4b^2 - 2c^2} P_{2B}$$

As $\frac{cb}{4b^2-2c^2} < \frac{c}{2b}$ and $\frac{a(2b+c)(b-c)}{4b^2-2c^2} > \frac{a(b-c)}{2b}$, it appears that firm A' s reaction function has a higher intercept and is flatter if it standardizes as shown on Figure 1.

The reason for the upward shift in A' s reaction function is clear: as the monopoly price on market 1 is higher than the duopoly price on market 2, the firm charges an intermediate price when forced to charge the same price in the two markets.

The intuition behind the decrease in the slope of A's reaction function is the following. At given prices, a change in P_{2B} affects firm A' s marginal revenue similarly in both cases since it only affects its marginal revenue on market 2; however, in the case of standardization, a smaller change in P_{2A} is required for firm A to return to equilibrium since a change



<u>**F I G U R E 1**</u>

in P_{2A} affects the firm' s marginal revenue in both markets. Over the range of prices for which both firms sell positive quantities in market 2, firm A' s reaction function when A standardizes (R_A^s) lies above A's reaction function when A diversifies (R_A^d).

Figure #1 shows the two firms' reaction functions on market 2. E is the equilibrium when A diversifies, while Z is the equilibrium when firm A standardizes. Q_{2A}^o and Q_{2B}^o are the combinations of prices for which firm A and firm B respectively just leave the market.

As firm B' s profit increases along R_B, firm B is better off (in market 2) when A standardizes than when A diversifies (as shown by the position of Z above the isoprofit contour π_A^o). On the other hand, firm A' s profit on market 2 can apparently either decrease or increase, depending on the slope of A' s isoprofit contours. With linear demands however, A' s profit on market 2 can only be lower under standardization. If firm B' s profit at Z is sufficiently higher than at E, then a situation where A standardizes, while B serves only market 2 is the unique subgame perfect Nash equilibrium of the game.

This type of equilibrium is somewhat similar to a situation discussed by D.Fudenberg and J.Tirole (1986). They specify a two-period model where two firms, an incumbent and a potential entrant compete to sell their product to consumers who are initially unaware of the existence and price of either good. In the first period, the incumbent can advertise, at a cost, to inform some consumers of the existence of its product and he sells its good to the informed consumers whose reservation price is below the sale price. These first period consumers are forever loyal to the incumbent, constituting his 'captive' market. In the second period, when both firms can advertise and compete on prices, this 'captive' market can prove to be a

mixed blessing for the incumbent because it makes him more reluctant to match the price of the potential entrant.
Using Fudenberg and Tirole' s terminology, the captive market has turned the incumbent into a 'fat cat' who cannot deter entry as efficiently as a 'lean and hungry looking' feline.

Another member of Fudenberg and Tirole' s menagerie is the 'puppy dog ploy' (also called 'judo economics' by Gelman and Salop (1983)) by which a potential entrant tries to look as harmless as possible to convince the incumbent to tolerate his entry.

The situation discussed in this paper can be seen as resulting from the unlikely pairing of 'fat cat' and 'puppy dog' effects[10]. By choosing standardization, the incumbent turns himself into a potential fat cat in the sense that, if entry is limited to one market, the incumbent' s 'captive' monopoly market limits the aggressivity of his response. However, the 'fat cat' effect is only triggered if the entrant chooses to serve only one market, i.e. if the entrant opts for a 'puppy dog' strategy.

In the presence of fixed entry cost however, diversification might be a more effective entry deterring strategy, even though standardization reduces the scope of entry (i.e. $\pi^{ns} > 2\,\bar{\pi}$). This would be the case it the entry fixed cost, F, were such that a second firm would not generate enough revenue to cover the fixed cost if the incumbent diversified but it would if the incumbent standardizes, (i.e. $\pi^{ns} > F > 2\bar{\pi}$) [11]. In other words, our main analysis implicitly assumed that fixed costs were not high enough to fully deter entry under either regime.

SECTION III

Our analysis could be interpreted more broadly as showing that an incumbent might want to give up his ability to discriminate between markets in order to partially deter entry. However, the case of product standardization is special in two ways that make such a generalization difficult. First, the issue of credibility is easily resolved[12]. Second, the incumbent does not have any initial incentive to price discriminate since we have assumed that the demand functions were the same in the two markets. The potential for price differentials is only introduced by firm B' s entry into a single market. This section briefly discusses this last issue.

If the demand functions are allowed to differ across markets, the analysis must be qualified in two respects.

First, the existence of a monopoly market only restraints the incumbent' s aggressiveness in the other market if the monopoly price in the 'captive ' market is higher than the duopoly price in the shared market. It will never be the case that the entrant only serves a higher price market (i.e. a market where the duopoly price is higher than the monopoly price in the other market).

Second, without symmetry, the price constraint associated with standardization is binding even when both firms choose to standardize so that the pair of strategies (D,D), (D,S), (S,D) and (S,S) no longer generate identical profits. This could change the whole structure of the payoff matrix and thus the type of equilibrium that emerges. Unfortunately, the lack of symmetry makes the determination and the comparison of the firms' profits in the different subgames very hard to carry on analytically.

We have performed simulations to explore the sensitivity of our results to the symmetry assumptions. Starting from a symmetric equilibrium with linear demands, three types of asymmetries have been considered. In the first case, one firm has a cost advantage in both markets so that $a_{1A} = a_{2A} \neq a_{1B} = a_{2B}$. In the second case, one market is inherently more profitable than the other in the sense that $a_{1A} = a_{1B} \neq a_{2A} = a_{2B}$. Finally, we also consider the case where each firm has a comparative advantage in a different market, i.e. $a_{1A} = a_{2B} \neq a_{1B} = a_{2A}$.

The specific results of the simulation for each type of asymmetry are described below. All of them, however, share three characteristics. First, standardization can potentially be used to limit the scope of entry since the monopoly price in the "captive" market is higher than the duopoly price in the shared market. Second, standardization never dominates diversification as the second mover best response. Finally, the SPNE does not depend on the absolute value of the asymmetry but on its relative value, i.e. multiplying all a_{ij} by a constant does not modify the outcome of the game. This suggests that the result of the simulation are strong since starting from any symmetric equilibrium we know the critical value of c above which standardization can deter entry. It is worth noticing however, that the range of asymmetries considered is limited to cases where, in every market a firm can make non negative profits even when its rival sets a price equal to its marginal cost of production. In practice this means that the asymmetries introduced are relatively small.

The range of $\frac{c}{b}$ for which SN is an equilibrium shrinks (spands) as the second mover cost advantage (disadvantage) increases. Intuitively, as the relative cost advantage of the second mover increases, so increases the profit forgone in the market where it does not enter, so its best reply becomes diversification. (The equilibrium where both firms diversify coincides with the equilibrium where both firms standardize since the constraint is not binding).

The range of $\frac{c}{b}$ for which SN is an equilibrium does not change when consumers in one market value the product more than in the other market (i.e. $a_{2A} = a_{2B} > a_{1A} = a_{1B}$). However, the second mover always enters the more profitable market. The outcome is the result of two opposing effects. On the one hand, the monopoly price in the captive market decreases relative to the duopoly price in the shared market. This means that the incumbent's pricing in the shared market is less restrained. On the other hand, the entrant is less likely to be willing to jeopardize any given decrease in the incumbent's aggressivity by entering both markets, since the captive market is less valuable than the shared market. With linear demands these two effects offset each other perfectly.

Finally, if each firm has a comparative advantage in a different market, the range of $\frac{c}{b}$ for which (S,N) is an equilibrium increases with the asymmetry. The second mover enters the market where it has an advantage. The rationale behind this result is that the first mover becomes even less aggressive in the market where the second mover has a comparative advantage in the (S,N) equilibrium and the profit forgone in the market where the entrant has a comparative disadvantage is smaller.

IV - CONCLUSION

Other authors have analyzed the incentives for firms to produce compatible products. Katz and Shapiro (1985) emphasize the role of 'network externalities' : the benefits enjoyed by consumers increase with the number of other consumers using compatible products because the possibilities of exchange, the availability of qualified servicing and other related factors increase accordingly.

The present paper shows that the existence of network externalities is not necessary for a firm to choose to sell a standardized product. In our framework, standardization can be used as a credible commitment enabling an incumbent to limit the scope of entry. While this might not be the most compelling explanation for the emergence of compatibility in many industries, it suggests, more generally, that an incumbent firm faced with a threat of entry might want to give up its ability to price discriminate.

FOOTNOTES

1. For a recent survey of the literature on product compatibility, see J.Farrell and G.Saloner (1987).

2. It is assumed that there is not any repeat purchase. With repeat purchase, a firm might want to set a low initial price in order for consumers to choose the 'computer' compatible with their product. For an analysis of the case where consumers rationally expect such a pricing strategy, see N. Gallini (1986).

3. Or can be made compatible by the consumer at a negligible cost (e.g. by using a cheap adaptor).

4. Economies of scope would tend to make diversification more attractive, while economies of scale tend to make standardization more attractive (although, by decreasing the marginal cost of the standardizing firm, it makes it a less restrained competitor, making it less likely that the standardization equilibrium discussed later would emerge).

5. With identical markets, $\pi^{sn} > \pi^{ns}$, follows from the fact that min. $\pi^{sn} = \pi^{m}$ = max. π^{ns}. Moreover, if B sets $P_B = P^m$, A could profitably set $P_A = P^m - \varepsilon$ so that firm B's equilibrium profit will always be $\pi^{ns} < \pi^{m}$ and thus $\pi^{sn} > \pi^{ns}$. This result does not generalize to non-symmetrical markets.

In such a case, two other sets of equilibria must be considered:

- if $\pi^{ns} > 2\bar{\pi} > \pi^{sn}$, then (D,D) and (D,S) are the Subgame Perfect Nash Equilibria.

- if $\pi^{ns} > \pi^{sn} > 2\bar{\pi}$ and $\bar{\pi} + \pi^{m} < \pi^{sn}$, there is a unique subgame perfect equilibrium where the incumbent serves a single market while the entrant standardizes.

- if $\pi^{ns} > \pi^{sn} > 2\bar{\pi}$ and $\bar{\pi} + \pi^{m} > \pi^{sn}$, the equilibrium remains (S,N) as with identical markets, although now the entrant is better off than the incumbent.

6. We show here that this is true even when demands are not linear. The general framework follows Singh and Vives (1984).
   Let the demand functions be:

$$Q_{ij} = k_{ij}\,(P_{iA},\ P_{iB}) \qquad i = 1,2 \quad j = A,B$$

and assume that, in each market, products are gross substitutes and strategic complements (see Bulow et al.), and that the own price effect dominates the cross price effect. Furthermore, to guarantee the existence of a unique interior equilibrium in the duopoly case, we assume that each firm can make non-negative profits even when its rival charges a price equal to zero and that:

$$\delta_{jj}\pi^{d}_{ij} + \delta_{ik}\pi^{d}_{ij} < 0 \qquad i,k = A,B, \qquad i = k$$

Likewise, to guarantee a unique equilibrium for the standardization outcome, we require:

$$| \delta_{AA}\pi^{m}_{1A} + \delta_{AA}\pi^{d}_{2A} | > | \delta_{AB}\pi^{d}_{2A} |$$

Under these assumptions, from the first order conditions of profit maximization, it can be shown that:

If $P^{m}_{1A} > P^{d}_{2A}$, then $P^{sn}_{2A} > P^{d}_{2A}$, $P^{ns}_{2B} > P^{d}_{2B}$, and $\pi^{ns}_{2B} > \pi^{d}_{2B}$, since:

$P_{1A}^{m} > P_{2A}^{d}$ implies that $\delta\pi_{2A}^{d}(P_{1A}^{m},P_{2B}) < 0$ for all P_{2B} such that (P_{1A}^{m},P_{2B}) correspond to positive quantities of the two goods. It follows that $\delta_A\pi_{1A}^{m}(P_{1A}^{m}) + \delta_A\pi_{2A}^{d}(P_{1A}^{m},P_{2B}) < 0$ since $\delta_A\pi_{1A}^{m}(P_{1A}^{m}) = 0$. This inequality implies that $P_{1A}^{m} > P_{A}^{sn}$.

$P_{1A}^{m} > P_{A}^{sn}$ means that $\delta_A\pi_{1A}^{m}(P_{a}^{sn}) > 0$. This, together with :

$\delta_A\pi_{1A}^{m}(P_{A}^{sn}) + \delta_A\pi_{2A}^{d}(P_{A}^{sn}, P_{2B}) = 0$, implies that :

$\delta_A\pi_{2A}(P_{A}^{sn},P_{2B}) < 0$ and thus $P_{A}^{sn} > P_{2A}^{d}$ for any given P_{2B}.

Summarizing, it has been shown that for all P_{2B} corresponding to an interior solution, A′ s reaction function on market 2 in the case of standardization lies everywhere above A′ s reaction function when A diversifies.

As B′ s reaction function is the same in the two cases and is upward sloping, it follows that in the standardization equilibrium prices are higher than in the diversification equilibrium. Finally, one can check that firm B′ s profit on market 2 increases along B′ s reaction function (see Cheng), so that $\pi_{B}^{ns} > \bar{\pi}$.

If $P_{1A}^{m} < P_{2A}^{d}$, all the results are reversed so that $\pi_{B}^{ns} < \bar{\pi}$ and (S,N) cannot be a perfect equilibrium of the game.

7. With such a utility function, all income effects are on the numeraire good and one can perform partial equilibrium analysis with the consumer maximizing :

$$U(Q_{iA},Q_{iB}) - P_{iA}Q_{iA} - P_{iB}Q_{iB} \quad i = 1,2$$

$$\text{If } U = a(Q_{iA}+Q_{iB}) - \frac{1}{2}\,[bQ_{iA}^{2} + 2cQ_{iA}Q_{iB} + bQ_{iB}^{2}]$$

with $i = 1,2$, $a > 0, b > 0$ and $c > (<) 0$ if Q_{iA} and Q_{iB} are gross substitutes (complements). The first order conditions of this problem yield the demand system as in the text.

8. The Jacobian matrix of the first order conditions is everywhere negative definite under these assumptions.

9. The inequality is satisfied for all c larger than .924b.

10. These two effects are also present in Bulow, Geanakoplos and Klemperer (1985).

11. Or $\pi^{ns} - F > 0 > 2\bar{\pi} - G$, if the cost of entry into one market, F, is lower than the cost of entry into two markets, G.

12. Although, given that B only serves one market, A would be better off diversifying, it should not be optimal for the incumbent to renege on its commitment and switch to diversification. Formally, this problem does not arise in our model since there is no third stage in which firms can modify their products. If such a stage were introduced however, the analysis would be unchanged provided that the costs of altering the design of the products are high. For further discussion of the credibility issue see P. Regibeau (1987)

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