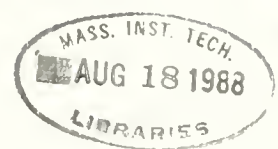


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STANDARDIZATION ACROSS MARKETS AND ENTRY

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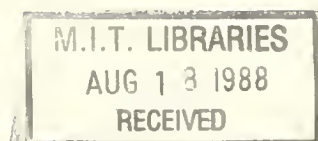
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ABSTRACT

In many industries, consumers combine several components to build their own "system". We analyze the incentives to standardize among firms selling a single component to consumers who have already acquired the rest of the system. By selling a component that can work with different systems, a firm credibly commits itself to charging the same price in all the submarkets. It is shown that this can be an optimal strategy for an incumbent who wants to restrict the scope of entry.

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Many multiproduct industries produce "systems", i.e. sets of components that cannot be used alone but might still be bought separately. Examples of such industries are the computer industry where a system includes several hardware components and software, the home-video industry, where a VCR, video cassettes and a TV screen must be used together, and the amateur photography industry, where the typical product line includes cameras, films and film processing services.

In such industries, the firms' compatibility decisions are of utmost importance since they determine the kinds of systems that can be assembled by the consumers. This raises two related questions about the firm's incentives to achieve compatibility. First, what are the firms' incentives to make their components compatible with the components produced by other firms? This issue of compatibility between manufacturers has been studied by several authors. Katz and Shapiro (1985) and Farrell and Saloner (1985, 1986) argue that compatibility creates positive consumption externalities, called "network externalities" that raise the profitability of the industry¹, while Klemperer's analysis of market with switching costs (1987 a,b) suggests that firms might prefer incompatibility in order to lock-in their customers. Finally, Matutes and Regibeau (1988) argue that, when every firm produces every component of a system, compatibility increases variety, raising industry demand and weakening the firm's price-cutting incentives.

A related question concerns the incentives of a firm that

specializes in the production of a single component to produce a standardized version of this component, i.e. a component that could be used with several incompatible systems. In other words, a single-product firm might have to decide whether to standardize its product across the different markets created by the existence of incompatible systems. This paper analyzes the effects of such standardization on entry. We consider the following setting.

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 independent² markets for software are created. 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 serve. They also decide whether to produce different software for each market ("diversification") or to sell software that 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 imposes a price constraint. This first stage is played sequentially, with the incumbent making its choice before the potential entrant. In the second stage of the game, both firms compete in prices in the market(s) that they have decided to serve.

This sequential game is solved for its subgame perfect Nash

equilibria. It is shown that, when the two firms' products are close substitutes and there are no entry costs, there is a unique equilibrium where the incumbent chooses to standardize, while the second firm enters a single market. 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 serve 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 profit in its monopoly market. In other words, the entrant must choose between entering two markets where it will face a very fierce competitor and serving 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. This kind of standardization equilibrium can still arise with positive entry costs, but less often since standardization, by raising the entrant's expected profits could actually encourage entry when it would have been completely deterred by diversification.

The paper is organized as follows. Section I discusses the general model, while several examples are presented in section II. Section III links our analysis to the literature on strategic self-restraint.

I. THE MODEL

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)

Each firm must incur an entry cost E if it wants to be active in the industry. To focus our attention on the main point of this paper, this entry cost is assumed to be independent of the number of markets served by the firm as well as of the firm's product choice (standardization or diversification)⁴.

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

- In each market, duopoly and monopoly profits are non-negative.
- In each market, a firm's monopoly profit is higher than its duopoly profit.
- The goods are produced at constant marginal cost⁵.

These assumptions imply that being the only firm to diversify (i.e. to sell different goods in each market) is at least as good as enjoying a monopoly in a single market and better than being a duopolist in both markets. This rules out as an equilibrium of the game the case where each firm serves one market⁶ since, given that the rival firm is only present in a single market, a firm will always prefer to enter both markets through diversification. Accordingly, we shall only consider the cases where the firms share at least one market.

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 every 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. The effect of differences in the markets' sizes is briefly discussed in section III.

If a firm diversifies, it can set a different price for each of its products, 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 payoff for each firm:

$$2\Pi^d$$

where Π^d 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. Moreover, if firm A (B) enters only one market, it is assumed to be market 1 (2). The following notation is used:

- Π^m is a firm's monopoly profit in one market.
- Π_j^{sn} is firm j's profit when j standardizes and the other firm serves only one market.
- Π_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 $\Pi^m + \Pi^d$.
- Π_j^{nd} is firm j's profit when j only serves one market and its rival diversifies. This is equal to Π^d .

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

Subgame Perfect Equilibria

If $2\Pi^d > \Pi^{ns}$, the only subgame perfect Nash equilibria are (D,D), (D,S), (S,D) and (S,S), i.e. both firms serve each market by diversifying or standardizing and get profits of $2\Pi^d$.

TABLE I
Payoffs of the Game

		Firm B		
		N_2	S	D
Firm A	N_1	Π_{2B}^m	Π_B^{sn}	$\Pi^d + \Pi_{2B}^m$
		Π_{1A}^m	Π_A^{ns}	Π^d
	S	Π_B^{ns}	$2\Pi^d$	$2\Pi^d$
		Π_A^{sn}	$2\Pi^d$	$2\Pi^d$
	D	Π^d	$2\Pi^d$	$2\Pi^d$
		$\Pi^d + \Pi_{1A}^m$	$2\Pi^d$	$2\Pi^d$

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

First line = firm B's payoffs.

If $\Pi^{ns} > 2\Pi^d$ and $E = 0$, the unique subgame perfect Nash equilibrium is one where the incumbent chooses to standardize, while the entrant chooses to serve a single market. With firm A as the incumbent, the argument is as follows:

- If A chooses to serve a single market, then firm B chooses to diversify, leaving A with Π^d , or to standardize, leaving A with Π^{ns} , depending on whether $\Pi^{Bd} + \Pi_B^m$ 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 $2\Pi^d > \Pi^d$), leaving A with profits of $2\Pi^d$.
- If A chooses to standardize, then firm B prefers to serve a single market (since $\Pi_B^{ns} > 2\Pi^d$), leaving A with Π_A^{sn} .

As $\Pi^{sn} > \Pi^{ns7}$, we also have $\Pi^{sn} > 2\Pi^d$, so that the incumbent chooses to standardize, while firm B limits its entry to one market⁸.

With $\Pi^{ns} > 2\Pi^d$ and $E > 0$, there are two cases. If entry cannot be totally prevented (i.e. if $2\Pi^d > E$), the incumbent standardizes, thereby limiting entry to one market. However, if $2\Pi^d < E < \Pi^{ns}$, standardization would actually induce entry so that the incumbent prefers to diversify, ensuring itself of profits equal to $2\Pi^m$.

That Π^{sn} can exceed $2\Pi^d$ 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 $2\Pi^d$ 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 (see appendix). 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 in market 2, firm A charges a higher price in this market when it standardizes than when it diversifies. Firm A's behavior in market 2 is, thus, less aggressive when A standardizes than when A diversifies. This is to the benefit of B, so that $\Pi_B^{ns} > \Pi^d$ and it may be the case that $\Pi_B^{ns} > 2\Pi^d$. Intuitively, it might be better for the entrant to face a 'restrained' competitor in a single market than to face a very aggressive competitor in both markets. As aggressive behavior is most damaging when the goods produced by the two firms are close substitutes, the (S,N) equilibrium is most likely to emerge in markets with little product differentiation (see example 2 below).

II. EXAMPLES

While the preceeding argument shows that (S,N) might be the unique perfect Nash equilibrium of the game, it does not establish that such an outcome would ever occur. That it does actually arise is shown in the following examples.

Example 1: Homogenous Products

The firms sell an homogenous product in each market that they share. The demand in each market is a continuous function given by

$$D(P), D'(P) < 0, D''(P) < 0$$

Firm A's profit in market i is

$$\Pi_{iA} = \begin{cases} \Pi^m(P_{iA}) & \text{if } P_{iA} < P_{iB} \\ \Pi^m(P_{iA})/2 & \text{if } P_{iA} = P_{iB} \\ 0 & \text{if } P_{iA} > P_{iB} \end{cases}$$

where $\Pi^m(P)$ represents the profits of a monopolist charging a price equal to P . Both firms have constant marginal cost of production.

If the firms compete in prices, the payoff structure is extremely simple since diversification or standardization by both firms yield zero profits.

The equilibrium payoffs when the incumbent standardizes and the entrant operates in a single market are harder to characterize. First there does not exist a Nash equilibrium in pure strategies for this subgame. For all prices above marginal cost, the entrant finds it profitable to undercut the incumbent prices, while the incumbent will undercut the entrant's price as long as serving both markets is preferable to just serving its own monopoly market. i.e. as long as the entrant's price is greater than P_{lim} , defined as $\Pi^m(P^m) = 2\Pi(P_{lim})$ ⁹. It follows that there cannot be an equilibrium where the entrant's price is greater or equal to P_{lim} . If the entrant charges a price smaller than P_{lim} , the incumbent prefers to serve its monopoly market only at a price P^m . But then, the entrant's best response is to charge a price just below P^m ,... which would be undercut by the

incumbent so that there cannot be an equilibrium where the entrant sets a price below P_{li}^m either.

Fortunately, the subgame satisfies Dasgupta-Maskin's conditions for the existence of a mixed strategy equilibrium¹⁰. Although it does not seem possible to explicitly solve for the mixed strategy, one can show that the entrant's expected profit will be positive. The incumbent will never put any weight on a price lower than P_{lim} since it can do better by setting P^m . Given this, the entrant can always get at least $\Pi^m(P_{lim} - \sigma)$, with σ arbitrarily small. It follows that the entrant's optimal mixed strategy must yield an expected profit of at least $\Pi^m(P_{lim})$, which is positive. Also, the incumbent's expected profits must be at least equal to $\Pi^m(P^m)$.

The resulting payoff matrix is shown in figure #2. If there is no entry cost and we assume that a firm enters a market whenever its (expected) profit from entry is non-negative¹¹, the perfect Nash equilibrium will involve standardization by the incumbent and entry into a single market since any other choice would yield zero profit for both firms. Standardization by the incumbent has effectively limited the scope of entry.

If there is any positive entry cost, however, a very different type of equilibrium occurs: the incumbent diversifies and entry is fully deterred. In such a case, standardization by the incumbent would indeed induce entry, as long as the entry cost is not too high.

Example 2: Product Differentiation

TABLE 2

Payoffs with Homogenous Demands

		FIRM B		
		N_2	S	D
FIRM A	N_1	Π^m	$\text{Min } \Pi^{sn} = \Pi^m$	Π^m
	S	Π^m	$\text{Min } \Pi^{ns} = \Pi^m(P_{lim})$	0
		$\text{Min } \Pi^{ns} = \Pi^m(P_{lim})$	0	0
	D	$\text{Min } \Pi^{sn} = \Pi^m$	0	0
		0	0	0
		Π^m	0	0

N_i : Enter market i only; S: Standardize; D: diversify. Π^m represents a firm's monopoly profit on one market, i.e. $\Pi^m(P^m)$. The top line represents firm B's payoff.

It is now assumed that there is some horizontal product differentiation whenever both firms compete in the same market. This allows us to restrict our attention to cases where a firm only enters a market if the benefits from entering are strictly positive.

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

$$V[Q_{iA}, Q_{iB}, Y] = U(Q_{iA}, Q_{iB}) + Y$$

where Q_{ij} is the quantity of the good sold by firm j in market i ¹².

If U is quadratic with parameters a, b, c , the resulting direct demand system for market i is:

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

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

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

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

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

As before, there is no difficulty in determining the two firms'

profits except where the incumbent standardizes and the entrant decides to serve only one market. In this subgame, there is a pure strategy equilibrium if monopoly profits are smaller than the profits obtained by the incumbent if it sets the same price and sells positive quantities in both markets, i.e. if

$$a^2/4b < a^2(b-c)(4b+3c)^2(2b^2-c^2)/b(b+c)(8b^2-5c^2)^2$$

which is satisfied if there is enough horizontal product differentiation (i.e. if $c < 0.826b$).

If this condition is not satisfied, however, no pure strategy equilibrium exists since, as with homogenous goods, the entrant would undercut the lowest price that the incumbent is willing to charge in the shared market. There is however a mixed strategy equilibrium that can be characterized. As before, the incumbent can always get $\Pi^m(P^m)$. A lower bound for the entrant's expected profit is given by the profit it could make by reacting optimally to the lowest price that the incumbent can possibly charge. More precisely,

$$\text{Min } E(\Pi_{2B}) = \text{MAX}_{P_B} \Pi_{2B}(P_B, P_{\text{lim}})$$

where P_{lim} is defined as in example 1.¹³

Performing these computations with our set of linear demands yields the payoffs shown in figure #3. In the absence of entry fees, an equilibrium where the incumbent standardizes while the entrant

FIRM B

	FIRM A		FIRM B	
	N ₁	S	N ₂	D
	$\frac{a^2}{4b}$	$\frac{a^2}{4b}$	$\frac{a^2}{4b}$	$\frac{a^2}{4b} + \frac{a^2 b(b-c)}{(b+c)(2b-c)^2}$
			$\text{Min } \pi^{SN} = \frac{a^2}{4b} \text{ if } c > 0.83b^*$	
			$\text{Min } \pi^{JS} = \frac{a^2(b-0.854c)^2}{(b+c)(2b-c)^2} \text{ if } c > 0.83b^*$	
			$\text{Min } \pi^{JS} = \frac{2a^2 b(b-c)}{(b+c)(2b-c)^2}$	
			$\text{Min } \pi^{SN} = \frac{a^2}{4b} \text{ if } c > 0.83b^*$	
			$\frac{a^2 b(b-c)}{(b+c)(2b-c)^2}$	$\frac{2a^2 b(b-c)}{(b+c)(2b-c)^2}$
			$\frac{a^2 + a^2 b(b-c)}{4b(b+c)(2b-c)^2}$	$\frac{2a^2 b(b-c)}{(b+c)(2b-c)^2}$

TABLE # 3: Payoffs with Differentiated Products and Linear Demands

N₁: enter only market i, S: standardize, D: diversify. The first line represents B's payoffs.

* For $c < 0.83b$ one has:

$$\pi^{SN} = - \frac{a^2(b-c)(4b-3c)^2(4b^2-2c^2)}{2b(b+c)(8b^2-5c^2)^2} \quad \pi^{JS} = \frac{a^2(b-c)(4b^2+2bc-c^2)^2}{b(b+c)(8b^2-5c^2)}$$

serves only one market arises whenever¹⁴:

$$\text{MAX } \Pi_{2B}(P_B, P_{\text{lim}}) = \frac{a^2 [b - 0.8536c]^2}{4b[b^2 - c^2]} > \frac{2a^2 b[b-c]}{[b+c][2b-c]^2} = 2\Pi^d$$

which is satisfied when the goods produced by the firms are close substitutes (i.e. when $c > 0.916b$). This reflects the fact that the incumbent's restraint is most valuable to the entrant when the degree of product differentiation is low.

Contrary to the homogenous product case, there is now a range of positive entry costs for which the standardization equilibrium emerges. For larger entry fees, standardization might indeed facilitate entry so that the incumbent prefers to diversify¹⁵.

Example 3: Unequal Market Sizes

Consider the case where the demand in market 2 is equal to N times the demand in market 1, i.e. $D_2(P) = N D_1(P)$ with $N > 1$. This type of asymmetry has the convenient property that monopoly and duopoly prices are still equal between markets so that each firm still makes a profit of $2\Pi^d$ if they each serve both markets¹⁶. Defining $P_{\text{lim}i}$ as the lowest price that the incumbent could possibly charge in the shared market if it has a monopoly in market i , one gets:

$$\frac{\Pi^m(P^m)}{\Pi^m(P_{\text{lim}1})} = N + 1 \text{ and } \frac{\Pi^m(P^m)}{\Pi^m(P_{\text{lim}2})} = \frac{N + 1}{N}$$

where $\Pi^m(P)$ is the profit made by a single firm setting a price P in

market 1. As Π^m is increasing in P for all $P < P^m$, it follows that $P_{lim2} > P_{lim1}$, i.e. the incumbent will be more restrained in the shared market if the entrant stays out of the larger market. This means that the entrant faces a trade off between entering a more profitable market and facing a more restrained competitor. As the incumbent's restraint matters most to the entrant when the two firms produce close substitutes, there is a tendency for firm B to enter the smaller market when the degree of product differentiation is low. Using the same demands as in example 2 it can be shown that¹⁷:

1. Over the range of parameters for which NS is the equilibrium outcome of the game, the entrant chooses to enter the smaller of the two markets, leaving the larger one entirely to the incumbent.
2. The range of parameters for which NS is an equilibrium shrinks as the market sizes become more uneven. This is hardly surprising as an increase in the relative size of the incumbent's monopoly market makes diversification more attractive to the entrant.

III. DISCUSSION

The standardization equilibrium discussed in the two preceding sections is somewhat similar to a situation discussed by Drew Fudenberg and Jean 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 advertises, at a cost, to inform some consumers of the existence of

its product and he sells his 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 in 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 referred to as 'judo economics' by Gelman and Salop (1983)) by which a potential entrant tries to look harmless enough 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',¹⁸. 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.

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1. This does not mean that compatibility will always prevail. Larger firms have an incentive to prevent smaller firms from taking a free ride (Katz-Shapiro) and there might be a bias toward excessive or insufficient adoption of new technologies (Farrell-Saloner).
2. It is assumed that there are not any repeat purchases. With repeat purchases, a firm might want to set a low initial price in order for consumers to choose the system compatible with their component. 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. Defining E_1 , E_2 and E_s as the fixed costs of serving one market, diversifying or standardizing respectively, there seems to be two reasonable cases: $E_1 < E_2 < E_s$ and $E_1 < E_s < E_2$. $E_1 < E_2$ makes the standardization equilibrium more attractive to the entrant (but less attractive for the incumbent if entry through diversification can be deterred), while $E_s < E_2$ makes standardization more attractive to the incumbent. The analysis is easily adapted to these different cases.
5. Economies of scope would tend to make diversification more attractive, while economies of scale tend to make standardization more attractive. These complications are ignored to focus on the demand side of the model.

6. This is true if it is assumed that a firm enters a market whenever the benefits from entry are non-negative. As shown in section II, this convenient tie-breaking rule is only necessary when the two firms sell homogenous products.

7. With identical markets, $\Pi^{sn} > \Pi^{ns}$ follows from the fact that $\min \Pi^{sn} = \Pi^m = \max \Pi^{ns}$. Moreover, if B sets $P_B = P^m$, A could profitably set $P_A = P^m - \epsilon$ 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.

8. 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 where firms can modify their product. 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, or that this stage is again played sequentially.

9. i.e. $\arg\max_P \Pi_1^m(P) + \Pi_2(P, P_{2B}) < P_{lim}$ as long as $Q_{2B} > 0$. This

P

reflects the fact that, facing a lower residual demand in market 2, the incumbent cannot reach a level of profits $\Pi^m(P^m)$ by charging a lower price so that its best response is either to raise its price or not to serve the shared market at all.

10. The conditions of Dasgupta-Maskin's Theorem #5 are satisfied: we can define the action sets as closed intervals $[0, P^m]$, the sum of the players' payoffs is upper semicontinuous (it is indeed continuous), firm i 's payoff is left lower semi-continuous and hence weakly lower semi-continuous in its own action (since firm i discontinuously increases its profit by decreasing its price from a position where $P_i = P_j$) and the set of discontinuities satisfies their definition of $A^*(i)$. We could also invoke their Theorem #5b.

11. Again, this convenient tie-breaking rule is no longer necessary for (S.N) to be an equilibrium when there is some product differentiation.

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

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

with

$$U = a(Q_{iA} + Q_{iB}) - 0.5(bQ_{iA}^2 + 2cQ_{iA}Q_{iB} + bQ_{iB}^2)$$

where $a, b, c > 0$ and $0 < c < b$ if the two goods are gross substitutes.

13. That the incumbent will never charge a lower price than P_{lim} is shown as follows. Any positive quantity sold by the entrant reduces the incumbent's residual demand in the shared market and any decrease in price below P_{lim} reduces the firm's profit in its monopoly market. This implies that the incumbent cannot get more than $\Pi^m(P^m)$ by setting

a price lower than P_{lim} . More formally, for all $P < P_{lim}$ and all P_{2B} such that $Q_{2B}(P, P_{2B}) > 0$, $\Pi^m(P_{lim}) > \Pi^m(P) > \Pi(P, P_{2B})$ and $\Pi^m(P_{lim}) > \Pi^m(P)$ so that $\Pi^m(P^m) = \Pi^m(P_{lim}) + \Pi^m(P_{lim}) > \Pi^m(P) + \Pi(P, P_{2B})$ so that the incumbent would set P^m rather than charge $P < P_{lim}$.

14. These are sufficient conditions for the (S,N) equilibrium to arise. It follows that, although these conditions are more easily satisfied when the goods produced are close substitutes, we cannot be sure that, for a given entry fee, the (S,N) equilibrium is more likely to arise the closer substitutes the goods are. Such a conclusion could only be drawn with certainty if we could compute the actual payoffs in the mixed strategy equilibria. This qualification also applies to our third example where we analyze the effect of a change in the relative size of the two markets.

15. This occurs if $E(\Pi^{ns}) > E > 2\Pi^d$.

16. It would be interesting to consider cases where the monopoly prices in the two markets are different since the discrepancy between the incumbent's monopoly price and the duopoly price in the shared market is an important determinant of the incumbent's restraint. Unfortunately, it would no longer be possible to put a lower bound on the payoffs in the mixed strategy equilibria since the lowest price set by the incumbent could no longer be characterized by $\Pi_1^m(P_{lim}) + \Pi_2^m(P_{lim}) = \Pi_1^m(P^m)$ since we could have $\Pi_1^m(P) > \Pi_1^m(P_{lim})$ with $P < P_{lim}$ (market 1 being the incumbent's monopoly market). This could happen if the monopoly price in the share market is higher than in the monopoly market.

17. Computations and simulation results can be obtained from the authors.

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

APPENDIX

We show that $P^M \geq P^{SN} \geq p^d$, even when demands are not linear. The general framework follows Singh and Vives (1984). Let the demand functions be:

$$Q_{ij} = k_{ij} (P_j, P_{iB}) \quad \begin{array}{l} i = 1, 2 \\ j = A, B \end{array}$$

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:

$$\delta_{jj} \pi_{ij}^d + \delta_{ik} \pi_i^d < 0 \quad i, k = A, B, \quad i = k$$

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

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

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

If $P_{1A}^m > P_{2A}^d$, then $P_{2A}^{sn} > P_{2A}^d$, $P_{2B}^{ns} > P_{2B}^d$, and $\pi_{2B}^{ns} > \pi_{2B}^d$, 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 $P_1^m > P_A^{sn}$.

$P_{1A}^m > P_A^{sn}$ 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:

$\delta_A \pi_{2A}^d(P_A^{sn}, P_{2B}) < 0$ 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 $\pi_B^{ns} > \tilde{\pi}$.

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

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