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TECHNOLOGICAL INCOMPATIBILITY, ENDOGENOUS SWITCHING COSTS AND LOCK-IN*

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Systems are goods comprising of durables that are sequentially updated with complements. With sequential purchases, if suppliers produce incompatible brands, consumers who upgrade systems with complements of a different brand must replace the durables they own. Thus, the price of these durables is an endogenous switching cost. The paper deals with the concern that firms may use incompatibility to create consumers' switching costs to reduce competition in aftermarkets. However, it shows that, with homogenous durables, and small costs of reaching compatibility, endogenous switching costs increase intertemporal price competition to the extent that producers prefer to have compatible technologies.

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vi. Brand Loyalty

The conclusion of the paper is that, for homogeneous durables, it is desirable for firms to achieve compatibility unless the costs of achieving it are large. However, in most real world examples, durables are not homogenous. In particular, this is the case in the examples provided in the introduction, in which despite the small costs of achieving compatibility, firms chose to have incompatible brands[1]. In this section, I provide a motivation for firms' incompatibility choices, which stems from consumers who have preferences for differentiated durables and complements and who are brand loyal (wish to use components of the same brand)[2]. I show that with these preferences, under certain parameter conditions, firms might choose to produce incompatible systems while compatibility would be socially desirable.

I consider the following preferences: At t=1, the durable is differentiated à la Hotelling. If a consumer, whose ideal durable is located at r, purchases from A he has utility $w\text{-}r/2\text{-}Q_A$, (if he purchases from B his utility is $w\text{-}(L\text{-}r)/2\text{-}Q_B$). Similarly, at t=2, consumer's preferences for the system are uniformly distributed in the L-length Hotelling line. A consumer whose ideal system is located at z, suffers a cost of *z/2* from consuming any component produced by A, and *(L-z)/2* cost from consuming any component produced by B[3]. Then, at t=2, if an owner of x_A purchases y_A he attains $v - z - P_{AY}$, while purchasing y_B his utility is $v - L/2 - P_{BY}$. Finally, at t=2, all consumers change tastes, and the location of the ideal "system", *z*, is for every consumer independent of *r*.

I proceed by analyzing the differences between this preference setting and the previous one with no brand loyalty and a homogeneous durable. To complement this, Table 1 reports the level of the subgame equilibrium profits under each technological regime and under each preference setting for *F=0* and c_x £*L/2*[4].

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[1] A striking case of differentiated durables is the digital television example. There the initial contracts with providers supply consumers with set up boxes and television services that vary between providers.

[2] If producers are specialists and provide product lines within the same range, consumers with a preference for a range will wish to consume parts of the same specialist brand. An example is a sports broadcaster that as well as the regular programmes, broadcasts special sports events.

[3] There is perfect correlation of consumer's tastes for parts.

[4] If *L* £*2cx*, there is no pure strategy equilibrium with compatibility.

Table 1	Brand Loyalty.	X Homogenous
Incompatibility	$p_{1J} = L^2/4 - dc_x L/3,$ $p_{2J} = L^2/2 + c_x^2/18,$ $p_{EA,J} = L^2/4 + d(L^2/2 + c_x^2/18 - L c_x/3)$	$p_{1J} = - dc_x L/3,$ $p_{2J} = L^2/2 + c_x^2/18,$ $p_{EA,J} = d(L^2/2 + c_x^2/18 - L c_x/3)$
Compatibility	$p_{1J} = L^2/4 + d/2(L/4 - c_x/2)^2$ $p_{2J} = L^2/4 + 1/2\ (L/4 - c_x/2)^2$ $p_{EA,J} = L^2/4\ (1+d) + d(L/4 - c_x/2)^2$	$p_{1J} = 0,$ $p_{2J} = L^2/2,$ $p_{EA,J} = dL^2/2$

Incompatibility: At t=2, indifferent consumers are as reported in equation 1 and firm's profits are as reported in equation 2. Therefore, Lemma 1 describes the second period equilibrium prices and market shares. At t=1, since x is differentiated à la Hotelling profits raise by $L^2/4$.

Compatibility[5]**:** Here the differences between preference settings are striking. First, here, with preference reconsideration, some consumers wish to repurchase x at t=2. If at t=1 the market is covered, then, at t=2, indifferent consumers[6] in segment A are: $I_{AM}^{A} = P_{BY} - P_{AY} + L/2$ (who is indifferent between $x_A y_A$ or $x_A y_B$) and $I_{BM}^{A} = (L/2 + P_{BX})$ (who is indifferent between $x_B y_B$ or $x_A y_B$). With mix and match in both segments, profits for firm A result:

(12)

$$p_{2A} = (P_{AY} - c_y)(s_A / L.\ I_{AM}^{A} + s_B / L.\ I_{BM}^{B}) + (P_{AX} - c_x)(s_B / L.\ I_{AM}^{B})$$

The first part of (12) are profits due to sales of the complement in segments A and B. The second part, are profits due to sales of the primary part to consumers in segment B who switch brands. Solving for the equilibrium prices, Lemma 5 is obtained.

Lemma 5

For $c_x \le L/2$, second period equilibrium prices, market shares and profits for firm J are:

[5] A complete derivation of the results with compatibility can be found in the Appendix.

[6] The indifferent consumer superscript stands in for the segment. The subscripts stand in for the type of bundle: either mixed: M or pure: (B and A).

$$P_{JY} = L/2 + c_{y,}\ P_{JX} = 1/2\cdot(c_x + L/2),\ I^{A}_{AM} = I^{B}_{BM} = L/2,\ I^{A}_{BM} = 3/4\cdot L + c_x/2\,,\ I^{B}_{AM} = L/4 - c_x/2$$

and $p_{2J} = L^2/4 + (L/4 - c_x/2)^2 \cdot s_K / L,\ J = \{A,B\}, J \neq K.$[7]

These profits are smaller than the second period equilibrium profits with a homogenous durable. The reason is that, with perfect correlation of tastes for durables and complements, consumers who mix and match suffer a variety loss of *L/2*. This reduces their willingness to pay and hinders profits. The extra profits made by sales of durables to consumers who switch brands do not overcome the loss in the complement market.

On the contrary, at t=1, profits are higher with brand loyalty than with a homogenous durable. As with incompatibility, competition is softened because the durable is horizontally differentiated. Moreover, competition is also softened because since durables are sold at a positive margin at t=2, firm's second period profits depend positively on the rival's first period market share (sales of x at t=2 increase with the rivals' market share- see Lemma 5)).

Overall, relative to the case where the durable is non-differentiated, ex-ante profits increase both with compatibility and incompatibility (see Table 1). However, if *L* is large relative to c_x, ex-ante profits raise more with incompatibility than with compatibility. The reason is that in this case the variety loss of mix and match is large. Lemma 6 results.

Lemma 6

With F=0, if c_x £0.5 L, ex-ante profits are higher with incompatibility than with compatibility.

Now, I compare the technological regimes from a welfare point of view. To do this, I only need to consider second period welfare. Two differences with the case where the durable is homogeneous explain why, here, the socially optimal technological choice is biased towards incompatibility. First, since there is primary part repurchase, compatibility does not nullify second period durable production costs (although these costs are smaller than with incompatibility). Second, there is the variety loss of consumers who mix and match. If *L* is large relative to c_x, the repurchasing costs are not that relevant in the comparison of welfare and the variety loss explains why incompatibility is better than compatibility. If instead, *L* is small relative to c_x, both a small variety loss and a larger

[7] Note that these prices do not depend on first period market shares. The same happens with the prices for the second period equilibrium prices with incompatibility.

difference between the durable replacement costs between incompatibility and compatibility, explains why compatibility dominates.

Proposition 7

With F=0, for c_x £0.185 L, welfare is higher with incompatibility while the reverse is true if c_x ³0.185 L.

Finally, by carefully analysing Proposition 7 and Lemma 6, it is clear that for an intermediate range of L, ($2\ c_x \leq L \leq 1/0.185\ c_x$), there is <u>excess incompatibility</u>. That is, firms choose to design incompatible parts but welfare is higher with compatibility. It is in this case that incompatibility decisions should be cause of public concern.