Endogenous Integration and Welfare in Complementary Goods Markets*

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December 2005

Abstract

This paper analyzes the strategic decision to integrate by firms that produce complementary products. Integration entails bundling pricing. We find out that integration is privately profitable for a high enough degree of product differentiation, that profits of the non-integrated firms decrease, and that consumer surplus need not necessarily increase when firms integrate despite the fact that prices diminish. Thus, integration of a system is welfare-improving for a high enough degree of product differentiation combined with a minimum demand advantage relative to the competing system. Overall, and from a number of extensions undertaken, we conclude that bundling need not be anti-competitive and that integration should be permitted only under some circumstances.

Keywords: complementary products; integration; bundling

JEL classification: L13; L41; D43

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*We are grateful to Inés Macho-Stadler, José Sempere-Monerris and Ramon Faulí-Oller for their comments and suggestions. Flores-Fillol acknowledges financial support from the Spanish Ministry of Education and Science (fellowship SEC2002-02506 and research grant BEC2003-01132) and Generalitat de Catalunya (research grant 2005SGR00836).

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1 Introduction

There are many industries where firms produce complementary products or components. Indeed, the final goods from which consumers derive utility are obtained from the combination of such complementary products into a composite good or system. Examples include automatic teller machines (ATMs) and bankcards, an airline traveller that uses two different airlines on a one-stop itinerary, personal computers and software, transportation and hotel services, manufacturing and distribution activities and so on. This paper examines the strategic incentives to integration by firms that produce complementary products when composite goods (or systems) are (differentiated) substitutes for one another both from a private and a social viewpoint. When products are complements, an additional incentive for bundling arises. We will also look into the potential anti-competitive effects of bundling behavior.

As a motivating example, and to illustrate the interest of our analysis, consider the proposed merger between General Electric and Honeywell. Although there are quite a number of elements at play, this integration process has got the special feature of bringing complements together along with bundling issues.[1] The European Commission expressed serious concerns by arguing that General Electric had a dominant position in aircraft engines whereas Honeywell had a leading position in aircraft systems; the Commission claimed that the proposed merger would allow the new firm to bundle these complementary products and that, on the whole, this would lead to market dominance. Integration of complementary goods and the theory of bundling can be traced as far back as Cournot (1838). However, as Nalebuff (2002) himself puts it, the Cournot model - where the producer of copper and the producer of zinc integrate into one firm to make brass - does not consider the impact of the merger on any other firms in the market. As a first approximation to the issues involved, we assume that firms play the following two-stage game. In the first stage,

[1] Concentration may occur through mergers, takeovers, acquisitions and integration. These terms all describe situations where independently owned firms join together under the same ownership. Our analysis does neither consider mergers between competitors (horizontal mergers) nor mergers between firms operating at successive stages of the production process (vertical mergers). Although some authors talk about a conglomerate merger in cases where complementary products are involved, we will rather refer in the sequel to *integration* of complementary products to better account for the specific relationship that a consumer combines the two products together. It is also more natural when integration carries the use of bundling pricing.

firms that produce system (or composite good) 1 and firms that produce system (or composite good) 2 decide simultaneously and independently whether to integrate or not. We may then have three different scenarios: *independent ownership*, *single integration* and *parallel integration* (when both systems integrate). In stage two, given the inherited outcome from the first stage, firms set prices; in case of integration, the firms will engage in bundling pricing. The following questions then raise: Is it a profit-maximizing strategy for producers of complementary goods to integrate when faced with a differentiated system whose producers can also respond with integration? If so, what are the welfare implications? What happens to profits of outsider firms? How are results related with bundling practices?

The pioneering paper by Salant *et al.* (1983) initiated an extensive literature on exogenous mergers. These authors, in a setting with strategic substitutes, suggested the idea that profits of the merged firms need not increase unless the merger includes a sizeable number of firms in the industry, that profits of outsiders increase and that welfare goes down. In fact, Salant *et al.* (1983) focused on the strategic competition effect of an exogenous merger by dispensing with any efficiency cost effects. On the other hand, Deneckere and Davidson (1985) have shown that exogenous mergers are always privately profitable with strategic complements; outsiders' profits increase and welfare decreases. As noted by Gaudet and Salant (1992a), who survey some important contributions on horizontal mergers, a merger under price competition and perfect complements is much similar to a merger with quantity competition and perfect substitutes yet with a significant change: it will increase social welfare.[2] We wish to extend previous work on price competition with complementary products (where each product is produced by one and a different firm) by introducing rivalry from a competing composite good, to address the possible concerns of bundling in such a setting, and to endogenize the merger decision in order to answer the questions posed above.

Although there are some papers that have dealt with endogenous mergers, an analysis like the one herein developed seems, to the best of our knowledge, not to have been undertaken. Kamien and Zang (1990) first formulated a two-stage game

[2]Further, Gaudet and Salant (1992b) have shown that mergers may be privately unprofitable if some members of the industry do not participate in the merger agreement.

where the merger decision is endogenized.[3] Apart from other modeling assumptions they focus on quantity competition with homogeneous products and instead we assume price competition with complementary products. The model that we propose also touches on the issue of bundling, a pricing possibility when integration occurs.[4] Relevant contributions on competition among complementary components of composite goods include Economides and Salop (1992) and Matutes and Regibeau (1992). The former provides an extensive analysis of complementary systems to analyze the effect on prices of alternative market structures. However, they neither examine whether producers of complementary products find it profitable to integrate nor the welfare implications. The latter considers a duopoly where each firm makes two components of a system but again the integration decision is not an issue. Firms first decide about compatibility and then about marketing strategies: to price the components separately (pure component pricing), to sell them as a system (pure bundling) or do both (mixed bundling). In contrast, we assume that each component is produced by a different firm and that the systems are potentially asymmetric in terms of market size. Thus, if firms are non integrated then the marketing strategy will be one of pure component pricing. On the other hand, if firms integrate then they will employ pure bundling.

In this paper we will exclusively focus on strategic motives behind the integration decision and as such the model will be stylized to obtain closed-form solutions and thus provide some useful policy implications. With this aim in mind, we solve the two-stage game proposed above. As shall shortly be seen, our results can be

[3] A couple of recent contributions that merit to be cited are Faulí-Oller (2000) and Qiu and Zhou (2005). These papers focus on the possibility of strategic merger waves.

[4] There are quite a number of papers devoted to the analysis of integration in complementary markets but they focus on the question of price equilibria when separate and joint consumption are possible (as e.g. in Gabszewicz *et al.*, 2001), on foreclosure issues (as e.g. in Church and Gandal, 2000, and Garmon, 2004) or on the interplay between vertical integration, market power and the incentives to innovate (as e.g. in Heeb, 2003).

Liao and Tauman (2002) review some important references on the literature of bundling. Whether bundling strategies are allowed is crucial for equilibrium existence. The literature on bundling has examined its role as a potential price discrimination device, as a facilitating means to soften competition and as a tool that creates entry barriers. Recent work by Gans and King (2004) discusses when the economic consequences of bundling should be of concern for competition authorities.

intuitively presented by relating the market size ratio and the degree of product differentiation between both composite goods. In this setting, we show that integration is profitable for a high enough degree of product differentiation, and that consumer surplus need not necessarily increase when firms integrate despite the fact that prices of composite goods diminish. Furthermore, the equilibrium structure can result in a prisoner's dilemma; firms would earn higher profits had they not integrated. We also find the interesting result that, if integration occurs then the profits of rival firms, whether integrated or not, always decrease which is in contrast to earlier findings. Indeed one must resort to introduce sequentiality in the merger decision or assume cost heterogeneity to possibly have outsiders harmed by a merger. Concerning the welfare analysis, a conflict may arise because privately profitable integration will occur under conditions where higher welfare would be attained without any integration at all. Essentially, (pure) bundling need not be anti-competitive if linked to an integration process as both a sufficient degree of product differentiation together with a low enough market size asymmetry ensure an equilibrium with integration that is privately and socially desirable.

These results basically remain valid under a number of extensions: mixed bundling, compatibility and competition from another system. However, there are some disparities that convey different policy recommendations. In particular, under mixed bundling, a *single integration* process has positive effects for consumers both in the systems and in the components markets but *parallel integration* of both systems is always welfare reducing. Compatibility of components improves upon the situation under incompatibility both from a private and a social point of view. Finally, when there is a third competing system, privately profitable integration requires softer conditions in terms of the degree of product differentiation and therefore integration processes are more likely to arise in equilibrium.

The paper is structured as follows. Section 2 introduces the model presenting the private profitability analysis and the equilibrium on the integration decision. Some welfare considerations and the corresponding policy implications are discussed in Section 3 and three possible extensions of the basic model are examined in Section 4. Some concluding remarks close the paper.

2 Model and Private Profitability

Suppose that there are two differentiated brands of each of two components, A and B, so that there are four firms. Let us assume that marginal costs of production are zero. Differentiated brand A_1 has to be combined with differentiated brand B_1 to form system 1. Similarly, A_2 combined with B_2 form system 2. Both systems are partially substitutes for one another and, for the sake of the exposition, no other combinations are allowed.[5] We will assume that demand functions for systems 1 and 2 are linear as follows,

$$\begin{aligned} Q_1 &= \alpha - b(p_{A1} + p_{B1}) + d(p_{A2} + p_{B2}) \text{ and} \\ Q_2 &= \beta - b(p_{A2} + p_{B2}) + d(p_{A1} + p_{B1}), \end{aligned} \tag{1}$$

where Q_i represents the demand for system i, for $i = 1, 2$; α, β stand for system-specific market size; $p_{Ai} + p_{Bi}$ denotes the (total) price of system i, for $i = 1, 2$; b, d are positive and $b > d$. This demand system for differentiated products follows from solving the optimization problem of a representative consumer with a quasi-linear utility function à la Dixit; it reflects that systems are less differentiated as d tends to b. Furthermore, systems are potentially asymmetric in the sense of different market sizes and, for the sake of the exposition, we assume that $\alpha \geq \beta$.[6]

There are three scenarios to be analyzed. We begin by characterizing the *independent ownership (I)* scenario when the four firms choose simultaneously and non-cooperatively their respective profit-maximizing prices; this entails pure component pricing. The profit functions are $\pi_{A1} = p_{A1}Q_1$, $\pi_{B1} = p_{B1}Q_1$, $\pi_{A2} = p_{A2}Q_2$, and $\pi_{B2} = p_{B2}Q_2$. The equilibrium prices are given by,

$$p^I_{A1} = p^I_{B1} = \frac{3b\alpha + 2d\beta}{9b^2 - 4d^2}; \quad p^I_{A2} = p^I_{B2} = \frac{3b\beta + 2d\alpha}{9b^2 - 4d^2}. \tag{2}$$

[5] This assumption is justified when demands for hybrid composites A_1B_2 and A_2B_1 are small compared to own-product demands A_1B_1 and A_2B_2, in which case a firm does not want compatibility. Nevertheless, the possibility of compatibility and how results are modified is contemplated in the extensions section.

[6] In line with most of the literature, we will refer to the demand intercepts as the respective market sizes. Note that some authors consider these as parameters that measure some vertical characteristic such as the quality of the product. We will stick to the former concept to avoid any confusion. Indeed, following Dixit (1979), the ratio $\frac{\beta}{\alpha}$ would reflect absolute advantage in demand whereas $\frac{d}{b}$ would stand for the cross-price effect. In our case, both these ratios range between 0 and 1.

Equilibrium outputs and profits are the following,

$$Q_1^I = \frac{b\left(3b\alpha + 2d\beta\right)}{9b^2 - 4d^2} = bp_{A1}^I; \quad Q_2^I = \frac{b\left(3b\beta + 2d\alpha\right)}{9b^2 - 4d^2} = bp_{A2}^I; \tag{3}$$

$$\pi_{A1}^I = \pi_{B1}^I = b\left(p_{A1}^I\right)^2; \quad \pi_{A2}^I = \pi_{B2}^I = b\left(p_{A2}^I\right)^2. \tag{4}$$

Notice that prices (and therefore quantities and profits) are increasing with both market sizes, but quite naturally the effect of own market size is stronger.

The second scenario corresponds with the case of merger of the two firms producing components A_1 and B_1, which is a situation of single complementary integration. For the sake of the exposition it will be referred to as *single integration (S)*. These two firms set the price of system 1 cooperatively, denoted by p_1, while competition remains in setting the price of components for system 2. This means that there is pure bundling in system 1 and pure component pricing in system 2. Therefore, demand functions take now the form: $Q_1 = \alpha - bp_1 + d(p_{A2} + p_{B2})$ and $Q_2 = \beta - b(p_{A2} + p_{B2}) + dp_1$. The profit functions are given by $\pi_1 = p_1 Q_1$, $\pi_{A2} = p_{A2}Q_2$, and $\pi_{B2} = p_{B2}Q_2$, where it is assumed that profits are shared equally when two firms integrate. Solving the system formed by $\partial\pi_1/\partial p_1 = 0$, $\partial\pi_{A2}/\partial p_{A2} = 0$ and $\partial\pi_{B2}/\partial p_{B2} = 0$ yields the following equilibrium prices,

$$p_1^S = \frac{3b\alpha + 2d\beta}{2(3b^2 - d^2)}; \quad p_{A2}^S = p_{B2}^S = \frac{2b\beta + d\alpha}{2(3b^2 - d^2)}. \tag{5}$$

The remaining equilibrium variables are,

$$Q_1^S = \frac{b\left(3b\alpha + 2d\beta\right)}{2(3b^2 - d^2)} = bp_1^S; \quad Q_2^S = \frac{b\left(2b\beta + d\alpha\right)}{2(3b^2 - d^2)} = bp_{A2}^S; \tag{6}$$

$$\pi_1^S = b\left(p_1^S\right)^2; \quad \pi_{A2}^S = \pi_{B2}^S = b\left(p_{A2}^S\right)^2. \tag{7}$$

The next result follows directly by comparing the *single integration* situation vis-à-vis the *independent ownership* solution. With no loss of generality, we will look at the case of integration of producers of system 1 (the computations in case of integration of producers of system 2 are similar and follow straightforwardly). Proofs are provided in the Appendix**.**

Lemma 1 *The move from independent ownership to single integration implies:*
i) The price p_1^S *is lower than that under independent ownership* $p_{A1}^I + p_{B1}^I$.
ii) Profits of the integrated firms are higher than before for $0 < \frac{d}{b} < 0.66$.
iii) The prices and profits of the non-integrated firms are lower.

The above results partially confirm Cournot's (1838) model of complementary duopoly. Cournot considered the merger of two monopolists that produce complementary goods (zinc and copper) into a single (fused) monopolist that produces the combination of them (brass). The price of the composite good after merger is lower than under *independent ownership* because the integration of firms that offer complementary components internalizes the externality that arises when they set prices independently thus ignoring the effects on their individual markups. If there were no competition from a substitute composite good, then integration would always turn out profitable - as in Cournot's example. However, the presence of the two non integrated firms unveils that *single integration* will only be profitable whenever competition is not too intense. Values of b far from values of d (low $\frac{d}{b}$) imply that product differentiation is strong and hence competition intensity is low; the difference in prices is smaller for smaller values of d. Then, although prices go down the increase in output is such that profits under *single integration* situation are higher. Strategic complementarity pushes prices of rival firms down and consequently their profits.

Finally, the third scenario is the case of *parallel* (complementary) *integration (P)*, i.e. firms that produce A_i and B_i integrate so that now there is bundle-against-bundle competition. That is, we wish to address whether it is always strategically optimal for the non-integrated firms to cooperate in setting the price, p_2, for system 2 provided that the rivals have integrated. Demands are now $Q_1 = \alpha - bp_1 + dp_2$ and $Q_2 = \beta - bp_2 + dp_1$ and the corresponding equilibrium prices are given by,

$$p_1^P = \frac{2b\alpha + d\beta}{4b^2 - d^2}; \quad p_2^P = \frac{2b\beta + d\alpha}{4b^2 - d^2}; \tag{8}$$

which yield the following equilibrium outputs and profits,

$$Q_1^P = \frac{b\left(2b\alpha + d\beta\right)}{4b^2 - d^2} = bp_1^P; \quad Q_2^P = \frac{b\left(2b\beta + d\alpha\right)}{4b^2 - d^2} = bp_2^P; \tag{9}$$

$$\pi_1^P = b\left(p_1^P\right)^2; \quad \pi_2^P = b\left(p_2^P\right)^2. \tag{10}$$

Their comparison with *single integration* leads to the next result.

Lemma 2 *The move from single to parallel integration implies:*
i) The price p_2^P is lower than that under single integration $p_{A2}^S + p_{B2}^S$.

ii) Profits of the former non integrated firms are now higher for $0 < \frac{d}{b} < 0.77$*.*
iii) Furthermore, p_1^P *is also lower than* p_1^S *and profits of the former integrated firms decrease.*

Again, the integration of firms providing complementary components drives prices down. Not only the price set by the newly integrated firms decreases but also that of the rival, due to strategic complementarity of prices. It then follows that, as illustrated in Lemma 1, integration is disadvantageous for rivals no matter prices are set cooperatively (as in scenario P) or non cooperatively (as in scenario S). The intuition for firms producing system 2 to strategically integrate is the same as before. The price decrease is lower the higher the degree of product differentiation. Consequently, low values of the ratio $\frac{d}{b}$ make it such that integration is profitable despite the loss associated with lower prices. It is also worth mentioning that a setting with *parallel integration* leads to lower prices and higher total output.

The foregoing analysis suggests that integration is profitable only under some circumstances. The comparison of the above profits in the three considered scenarios allows us to characterize the equilibrium on the integration decision (first-stage equilibrium). The next proposition follows in a straightforward manner from the above results.

Proposition 1 *Given Lemmas 1 and 2, the equilibrium on the integration decision is:*
i) No integration (independent ownership) will occur in equilibrium for $\frac{d}{b} \in (0.77, 1)$*.*
ii) Parallel integration takes place in equilibrium for $\frac{d}{b} \in (0, 0.66]$*.*
iii) Both independent ownership and parallel integration are equilibria for $\frac{d}{b} \in (0.66, 0.77]$*.*

The degree of product differentiation indicates how intense competition is in the market. We conclude that a setting with *parallel integration* arises when competition intensity is low whereas *independent ownership* occurs in equilibrium when competition intensity is tough. It is interesting to note that market sizes do not influence the decision to integrate. However, these are relevant for equilibrium price differences, and hence equilibrium profit levels, within a particular scenario; equilibrium price differences increase as systems become more differentiated. In fact, for given α and β, the price difference under *independent ownerswhip* is greater than under *parallel integration.* Thus, it seems that *parallel integration* leads to a reduction in the asymmetry between systems. As the analysis below shows, asymmetric market sizes do play a role when evaluating potential consumers' gains and consequently the welfare effects of integration processes. It is also worth mentioning that although asymmetric equilibria are possible, *single integration* is not an equilibrium in our demand-based setting. This suggests that some cost structure (e.g. economies of scope, fixed costs and the like) should be introduced in the model if we searched for a theoretical explanation to some observed behavior in certain industries.

Furthermore, part *ii)* of the above proposition can be qualified since it may lead to a prisoners' dilemma situation whenever product differentiation across systems is not very tough.

Corollary 1 *Whenever parallel integration arises:*
i) Firms producing system 1 are better off than under independent ownership for low values of $\frac{d}{b}$ *combined with low values of* $\frac{\beta}{\alpha}$.
ii) Firms producing system 2 are better off than under independent ownership for low values of $\frac{d}{b}$ *combined with high values of* $\frac{\beta}{\alpha}$.

Figure 1 below specifies all possible outcomes:

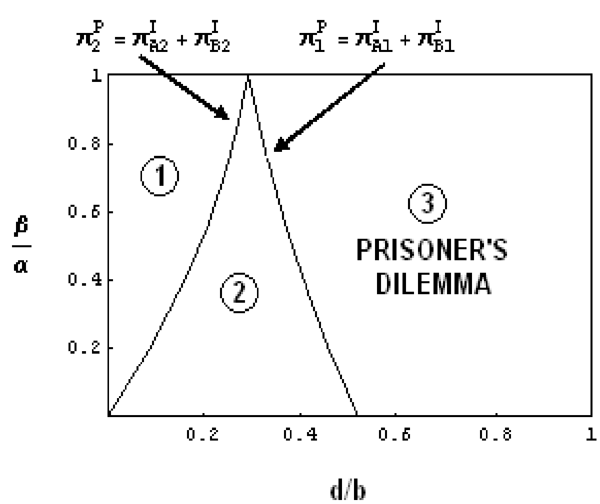

Figure 1: Profits

Therefore, depending on the values of $\frac{d}{b}$ and $\frac{\beta}{\alpha}$, it may occur that all firms end up better off (region 1, where $\pi_1^P > \pi_{A1}^I + \pi_{B1}^I$ and $\pi_2^P > \pi_{A2}^I + \pi_{B2}^I$); all worse off (region

3); only partners producing system 1 improve (region 2). We say that integration is "profitable per se" when all firms end up better off with respect to *independent ownership* (region 1). Thus, region 2 captures situations where only *single integration* is profitable but, since systems are sufficiently differentiated, integration is a dominant strategy. In order to improve with respect to *independent ownership*, firms require a high enough degree of product differentiation (integration processes have to be privately profitable) and a minimum absolute demand advantage, i.e. $\frac{\beta}{\alpha}$ sufficiently low for $A1$ and $B1$ (regions 1 and 2) and $\frac{\beta}{\alpha}$ sufficiently high for $A2$ and $B2$ (region 1). Market size asymmetry favoring partners producing system 1 explains the larger parameter space in which they end up better off.

For very high values of $\frac{d}{b}$, firms end up worse off giving rise to a prisoner's dilemma situation where absolute demand advantage does not play any role. Finally, one can check that when $\frac{\beta}{\alpha} \to 1$, either all firms improve or all them worsen (region 2 disappears).

3 Welfare Considerations and Policy Implications

Consumer surplus in each of the three considered scenarios is given by:

$$CS^I = \frac{b[(9b^2+4d^2)(\alpha^2+\beta^2)+24bd\alpha\beta]}{2\left(9b^2-4d^2\right)^2};\ CS^S = \frac{b[(9b^2+d^2)\alpha^2+16bd\alpha\beta+4(b^2+d^2)\beta^2]}{8\left(3b^2-d^2\right)^2} \tag{11}$$

$$\text{and } CS^P = \frac{b[(4b^2+d^2)\left(\alpha^2+\beta^2\right)+8bd\alpha\beta]}{2\left(4b^2-d^2\right)^2}. \tag{12}$$

Lemma 3 *Single integration is beneficial for consumers when it is privately profitable. However, the integration of the remaining system enhances consumer surplus only under certain circumstances. In any case, whenever parallel integration arises in equilibrium, consumers are better off than under independent ownership.*

It is easy to check that CS^S exceeds CS^I when *single integration* is privately profitable regardless of the degree of product differentiation and absolute demand advantage.[7]

[7] In fact, this statement also holds for $\alpha < \beta$, i.e. independently of whether the integrating system is the one with larger or smaller market size.

Although the comparison between CS^P and CS^S requires some qualifications (see Appendix), $CS^P > CS^I$ is always the case under a *parallel integration* equilibrium.

In this framework, it is interesting to compute the total welfare to examine possible policy implications by taking into account both private profitability of firms and consumers welfare. As usual, total welfare is defined by the sum of consumer surplus and industry profits, and is denoted by W^P, W^S and W^I, for each corresponding scenario.

Proposition 2 *Complementary integration of a system is welfare-improving for sufficiently low values of* $\frac{d}{b}$ *combined with a minimum absolute demand advantage.*

Figure 2 below displays all the possible situations:

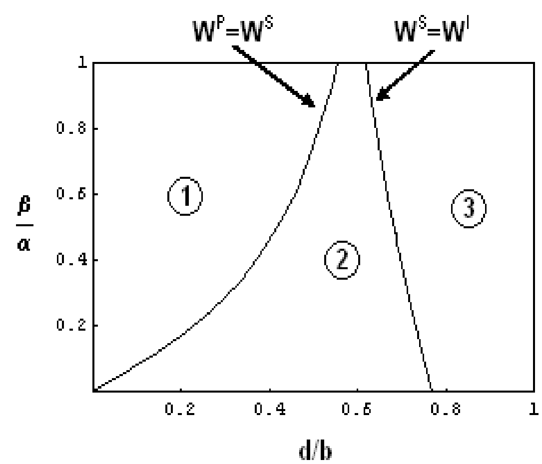

Figure 2: Welfare

In region 1, any integration decision is welfare-improving and therefore socially desirable ($W^S > W^I$ and $W^P > W^S$). The opposite occurs in region 3 where integration is welfare-harming, that is, *independent ownership* yields the highest welfare. In region 2, only the move from *independent ownership* to *single integration* induces a better social outcome, i.e. the integration of the firms producing the system with an absolute demand advantage.

As a consequence of this analysis, a major guideline for regulation of complementary integration processes in duopolistic markets can be drawn up. *Parallel* *integration* decisions should be allowed in region 1, i.e. when products are strongly differentiated (so that competition should not be too intense) and market size asymmetry across systems is not too large. On the other hand, if the latter is important and systems are sufficiently differentiated (region 2), then competition authorities should only favor *single integration* of the system with an absolute demand advantage.

There are cases for which *i)* integration processes that are welfare-reducing arise in equilibrium; *ii)* and some integration processes that are welfare-beneficial are not carried out.

In fact, *parallel integration* may be the equilibrium of the two-stage game played by firms (it is sufficient that $\frac{d}{b} < 0.66$) and yet social welfare be higher under *single integration*. Note for instance the case when there is a large enough degree of product differentiation and a large market size asymmetry. Then *parallel integration* is the equilibrium but welfare is the highest with *single integration*, which brings us to the controversial question of whether antitrust authorities should "correct" for wrong firms' decisions.

On the other hand, *independent ownership* is one of the equilibrium structures for $\frac{d}{b} \in (0.66, 0.77]$ and welfare is typically higher under *single integration*. As is obvious from inspection of Figures 1 and 2 above, by simply overlaying both figures, private and social incentives to integrate can run in opposite directions.

Furthermore, as must have been noted already, integration also entails a change in the pricing strategy of the integrated firms that now engage in pure bundling. Our analysis then puts forward that pure bundling need not be necessarily anti-competitive because *parallel integration* can be both privately profitable and socially desirable.

4 Some Extensions

We elaborate next on some extensions to investigate in more detail whether the main foregoing conclusions about endogenous integration of complementary products continue to hold.[8]

[8] The computations are available from the authors upon request.

Mixed bundling.

The model that we have developed above has assumed that firms that integrate engage in pure bundling. In other words, integration also entails a change in their pricing strategy. Suppose then that, once integration occurs, the integrated firm can sell each product separately as well as the bundle or composite good. In this case, the integrated firm would practise mixed bundling. Hence, we have to distinguish between the market for the components (monopolies) and the market for systems (duopoly). We keep on assuming potentially different market sizes for the two system producers.[9] Now integration enables partner firms to price-discriminate consumers willing to buy just separate components from those interested in the composite good by pricing separately and independently the integrated good. Under *independent ownership*, the price for the systems are just the sum of the prices of components and integration processes allow to offer a lower price to consumers buying the system. When integration occurs, the integrated firms must ensure an equilibrium price lower than the sum of the equilibrium prices of the separate components but higher than the equilibrium price of just one of the components; these guarantee that the composite good (the bundle) and the separate components both have positive demand.[10]

Though computations are rather more elaborate, the main results regarding the market for systems remain valid and, from the point of view of private profitability, the only disparity is that the multiple equilibria case that appeared in the previous sections disappears. That is, part *iii)* of Proposition 1 does not show up and *parallel integration* arises for enough product differentiation whereas *independent ownership* is the equilibrium for little product differentiation. Additionally, profits of outsiders

[9]More precisely, demand functions for separate components are given by $q_{A1} = \alpha - bp_{A1}$, $q_{B1} = \alpha - bp_{B1}$, $q_{A2} = \beta - bp_{A2}$, $q_{B2} = \beta - bp_{B2}$; whereas in the case of systems they take the form specified in equation (1). We assume that market sizes are the same both for the components and the systems demands. It must however be noted that the analysis is consistent (i.e. equilibrium prices suppose positive demands in all the scenarios) as long as these market sizes do not differ much.

[10]In this framework, one must take into account the so called *non-arbitrage conditions* ensuring the separability between component and system markets. These conditions take the form $p_1^S > p_{A1}^S, p_{B1}^S$ and $p_1^S < p_{A1}^S + p_{B1}^S$ in the *single integration* framework; and $p_1^P > p_{A1}^P, p_{B1}^P$; $p_2^P > p_{A2}^P, p_{B2}^P$; $p_1^P < p_{A1}^P + p_{B1}^P$and $p_1^P < p_{A1}^P + p_{B1}^P$ in the *parallel integration* framework.

Compliance with *non-arbitrage conditions* determine a subset in $(\frac{d}{b}, \frac{\beta}{\alpha})$ where results are comparable under the three considered scenarios.

decrease and prices of composite goods go down once integration occurs. It is also the case that a prisoner's dilemma arises. Furthermore, by comparing equilibrium profits under pure and mixed bundling, we observe that firms are typically better off under mixed bundling since they can as well exploit the markets for the individual components.

As for the potential anti-competitive effects of mixed bundling, the main results are affected by the interaction between the markets for components and the market for systems. More precisely our analysis unveils that, although *single integration* is socially desirable when integration is privately profitable, *parallel integration* (which can be indeed the equilibrium outcome of the proposed two-stage game) always induces a worse social outcome. This is explained by the fact that a *single integration* process entails a decrease in the prices of the non-integrated firms (as pointed out in Lemma 1), and this effect concerns both the components (i.e. p^S_{A2} and p^S_{B2}) and the system market (i.e. $p^S_{A2}+p^S_{B2}$). Nevertheless, when a *parallel integration* process takes place, the mentioned effect over the prices of the previously integrated firms (as pointed out in Lemma 2) only affects the system market (i.e. p^P_1), having no effect on the components markets (i.e. p^P_{A1} and p^P_{B1}) that are now priced independently. Therefore, the positive effect for consumers that a *single integration* process had over the components market vanishes in the case of a *parallel integration* process, turning it into welfare harming.

Consequently, the policy recommendations in a duopolistic market for systems where components are also sold separately, would be that a *single integration* process should be permitted but not a *parallel integration* of both systems. This situation raises a dilemma for competition authorities that have to determine which of the two possible integration processes has to be allowed. In such a framework, transparency of policy procedures becomes especially relevant.

Compatibility.

Thus far we have been assuming that only two systems (systems 1 and 2) were possible since combinations $A1+B2$ or $B1+A2$ reported no utility to consumers and therefore had no demand. Under compatibility we would have four possible systems. Consistently with the above analysis, we assume that "hybrid" systems (systems 12 and 21) are characterized by a market size that is the average of the market size of its components.[11] For tractability reasons, we consider that the degree of product differentiation between any pair of systems is the same.[12] In this framework, there exists a unilateral incentive to integrate which makes *independent ownership* not to arise at equilibrium. Besides, *parallel integration* (either system 1 or system 2) is typically the equilibrium of the proposed two-stage game. As in the main model, it is also the case that non-integrating firms (outsiders) are almost always harmed by an integration decision. To be more precise, outsiders can only profit from integration of other systems when product differentiation is strong and there is a high enough absolute demand advantage of the integrating system. As for the welfare and policy implications, the considerations made under incompatible systems stand true when systems are composed of compatible products. In our four-firm setting, product compatibility improves upon the situation under incompatibility both from a private and a social point of view when compatibility is enforceable and has no implementation costs, just as in the the two-firm setting depicted in Matutes and Regibeau (1988). This result is mainly explained by the fact that product compatibility increases the number of systems from which consumers can choose.

Competition from another system.

Now suppose that there are two more firms, one producing component A_3 and another one producing component B_3 so that, when combined, system (composite good) 3 is formed. One wonders whether the main results of the model are robust to the introduction of more competition.[13] By solving the proposed two-stage game we

[11] Specifically, $Q_1 = \alpha - b(p_{A1} + p_{B1}) + d(p_{A1} + p_{B2}) + e(p_{A2} + p_{B1}) + f(p_{A2} + p_{B2})$, $Q_2 = \beta - b(p_{A2} + p_{B2}) + d(p_{A2} + p_{B1}) + e(p_{A1} + p_{B2}) + f(p_{A1} + p_{B1})$, $Q_{12} = \frac{\alpha+\beta}{2} - b(p_{A1} + p_{B2}) + d(p_{A1} + p_{B1}) + e(p_{A2} + p_{B2}) + f(p_{A2} + p_{B1})$ and $Q_{21} = \frac{\alpha+\beta}{2} - b(p_{A2} + p_{B1}) + d(p_{A2} + p_{B2}) + e(p_{A1} + p_{B1}) + f(p_{A1} + p_{B2})$, where $b > d + e + f$.

[12] That is, $d = e = f$. By defining $g = 3d$, we can measure pairwise differentiation across systems by $\frac{g}{b}$ (that ranges between 0 and 1). It would be equivalent to keeping $\frac{d}{b}$ as the product differentiation indicator, knowing that $\frac{d}{b}$ would range now between 0 and $\frac{1}{3}$.

[13] Specifically, demand functions are assumed as follows: $Q_1 = \alpha - b(p_{A1} + p_{B1}) + d(p_{A2} + p_{B2}) + e(p_{A3} + p_{B3})$, $Q_2 = \beta - b(p_{A2} + p_{B2}) + d(p_{A1} + p_{B1}) + f(p_{A3} + p_{B3})$ and $Q_3 = \gamma - b(p_{A3} + p_{B3}) + e(p_{A1} + p_{B1}) + f(p_{A2} + p_{B2})$, where $b > d + e$, $b > d + f$ and $b > e + f$. As we did in the robustness analysis under compatibility we consider that the degree of product differentiation between any pair of systems is the same, i.e. $d = e = f$. Thus, by defining $g = 2d$, we can measure pairwise differentiation across systems by $\frac{g}{b}$ (that ranges between 0 and 1). In addition, we assume that $\gamma = \frac{\alpha+\beta}{2}$ to have comparable results.

find that all the results previously stated stand valid in the case of a triopoly with the nuance that private profitability integration now requires softer conditions in terms of the degree of product differentiation; in particular, *single integration* is profitable for a degree of product differentiation below 0.80 (with two systems this value is 0.66) while that value is 0.87 for *parallel integration* to be privately profitable (it was 0.77). The same conclusions about prices and that outsiders are harmed by integration continue to hold. Concerning welfare, similar results and policy implications to the main model are obtained. The consideration of more competition provides the following interesting insight. As long as systems competing in the market differ from each other in the same degree, integration processes are more likely to arise when there are more composite products available for consumers. That is, the range of values for the degree of product differentiation under which *parallel integration* is an equilibrium enlarges when there is a third competing system. The main reason underlying this rather surprising result is that the differentiated goods model that we have used has the property that aggregate market size varies with the number of products. Thus, there is more competition but there also arises a "creation of demand" effect.

5 Concluding Remarks

We have developed a simple model with complementary goods competition to answer some well-established research questions in the literature as to whether socially detrimental mergers may occur in equilibrium and whether some socially beneficial mergers may fail to occur. One rationale behind the merging of two firms is that it can lead to cost savings. The foregoing analysis has assumed away the presence of any efficiency gains so that one must expect that, because market power increases, consumers and society at large must be worse off. Yet a merger can rationalize production when there are complementary products involved, as in our setting.

Basically, antitrust merger policy evaluates whether the merging parties can exercise market power, raise prices and indeed lessen competition. Our setting is a modest contribution to the analysis of integration between complements, that would lead to lower prices, when integration entails the use of bundling. Competition authorities are of course concerned with concentration operations but it must also be noted that bundling is a marketing tactic that may have anti-competitive effects if employed e.g. for price discrimination purposes or entry deterrence reasons. The growth in the so called economics of information as well as many recent antitrust cases have renewed interest in the economic effects of vertical and complementary product integration, and bundling.[14] The *General Electric/Honeywell* case precisely exemplifies the issues at stake. But there are other cases, such as *ABB/Daimler-Benz* (M.580), *T-Online International/TUI/C&N Touristic* (M.2149), and *Flying-J et al v. Comdata Network, Inc.*[15] The economic issues in these cases are not exclusively about integration with complementary products and bundling practises but certainly these features figure rather prominently and emphasize the interest of the analysis undertaken.

Despite its simplicity, and with the necessary qualifications, several lessons can be extracted from our study. Firstly, integration of complementary products combined with bundling is not necessarily privately profitable in a setting with strategic interaction. Firms have a unilateral incentive to integrate for a sufficiently high degree of product differentiation. Secondly, a conflict may arise between private and social incentives to integration. It has been shown that rival non-integrating firms are typically harmed whereas consumer surplus improves when the absolute demand advantage of the integrating product is sufficiently large. Consequently, integration of a system is welfare-improving for a high enough degree of product

[14] Specifically, concentrations in the European Union are evaluated on the basis of Regulation 4064/89, amended by Council Regulation 139/2004; in the United States the ruling is under the 1992 Horizontal Merger Guidelines, later amended in 1997.

As for bundling, it is a business strategy that allows a seller to sort out consumers of different types. Price discrimination in the European Union is ruled under Article 82 of the Treaty while in the United States it is judged according to Section 2 of the Clayton Act amended by the Robinson-Patman Act (1936). See Motta (2004) for a treatment of competition policy. Also, the recent report by Church (2004) provides a detailed review of the literature, which can be used by antitrust agencies, on vertical and conglomerate mergers and the opportunities these create to engage in bundling and foreclosure.

[15] The former two cases are European cases; they include relations of complementary between rolling stock (rail vehicles) and stationary equipment, and the joint operation of the leading German internet service provider with tour operators activities, respectively. The latter case is a U.S. case that is expressly referred by Garmon (2004) to develop a theoretical framework and analyze the incentive to integrate (and foreclose) by two complementary producers, Comdata, a provider of fleet card services for trucks, and Trendar, a supplier of fuel desk devices for trucks.

differentiation combined with a minimum demand advantage relative to the competing system; otherwise, a conflict may arise. Thirdly, and in connection with the latter conclusion, bundling need not be per se anti-competitive. As catalogued by Gans and King (2004), bundling can be socially efficient since we have just seen that there are conditions under which private and social interests coincide. Indeed, our results abound on some of the arguments given by Nalebuff (2002), who expresses his doubts about the potential anti-competitive effects of bundling, specially in the presence of systems competition. Last but not least, the analysis uncovers some different policy implications; such differences depend not only on absolute demand advantages and the degree of product differentiation but also on the type of bundling, the presence of more competition and the question of compatibility. The main message is that a *parallel integration* process can only lead to welfare gains in rather particular circumstances.

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A Appendix: Proofs

Proof of Lemma 1.

The price of the integrating system decreases since the difference $(p_{A1}^I + p_{B1}^I) - p_1^S$ yields $\frac{3b^2(3b\alpha+2d\beta)}{54b^4-42b^2d^2+8d^4}$, which is clearly positive provided that $b > d$. Since prices are strategic complements it follows that p_{A2}^S and p_{B2}^S are now lower, and so are profits by the way equilibrium profits are written. Finally, the difference $\frac{\pi_1^S}{2} - \pi_{A1}^I$ yields $\frac{(\frac{b}{4})(3b\alpha+2d\beta)^2(9b^4-24b^2d^2+8d^4)}{(9b^2-4d^2)^2(3b^2-d^2)^2.}$. The sign of this expression is given by the sign of $9b^4 - 24b^2d^2 + 8d^4$. Therefore, $\frac{\pi_1^S}{2} - \pi_{A1}^I$ is positive for $\frac{d}{b} < 0.66$.■

Proof of Lemma 2.

The price of the integrating system decreases since the difference $(p_{A2}^S + p_{B2}^S) - p_2^P$ results in $\frac{b^2(2b\beta+d\alpha)}{12b^4-7b^2d^2+d^4}$, which is positive given that $b > d$. The difference $\frac{\pi_2^P}{2} - \pi_{A2}^S$ yields $\frac{(\frac{b}{2})(2b\beta+d\alpha)^2(2b^4-4b^2d^2+d^4)}{(4b^2-d^2)^2(3b^2-d^2)^2}$. The sign of this expression is given by the sign of $2b^4 - 4b^2d^2 + d^4$. Therefore, $\frac{\pi_2^P}{2} - \pi_{A2}^S$ is positive for values of $\frac{d}{b}$ below 0.77.■

Proof of Proposition 1.

Straightforward given Lemmas 1 and 2.■

Proof of Corollary 1.

The difference $\pi_1^P - (\pi_{A1}^I + \pi_{B1}^I)$ yields $\frac{b(2\alpha b+\beta d)^2(9b^2-4d^2)^2-2b(3\alpha b+2\beta d)^2(d^2-4b^2)^2}{(9b^2-4d^2)^2(d^2-4b^2)^2}$ whose sign is given by the numerator that is positive for $\frac{\beta}{\alpha} < \frac{30(\frac{d}{b})+48(\frac{d}{b})^3-20(\frac{d}{b})^5-\sqrt{2}\sqrt{1296(\frac{d}{b})^2-1800(\frac{d}{b})^4+913(\frac{d}{b})^6-200(\frac{d}{b})^8+16(\frac{d}{b})^{10}}}{8(\frac{d}{b})^6-8(\frac{d}{b})^4-47(\frac{d}{b})^2}$ which is the decreasing function plotted in Figure 1.

The difference $\pi_2^P - (\pi_{A2}^I + \pi_{B2}^I)$ yields $\frac{b(2\beta b+\alpha d)^2(9b^2-4d^2)^2-2b(3\beta b+2\alpha d)^2(d^2-4b^2)^2}{(9b^2-4d^2)^2(d^2-4b^2)^2}$ whose sign is given by the numerator that is positive for $\frac{\beta}{\alpha} > \frac{30(\frac{d}{b})+48(\frac{d}{b})^3-20(\frac{d}{b})^5-\sqrt{2}\sqrt{1296(\frac{d}{b})^2-1800(\frac{d}{b})^4+913(\frac{d}{b})^6-200(\frac{d}{b})^8+16(\frac{d}{b})^{10}}}{2(18-72(\frac{d}{b})^2+23(\frac{d}{b})^4)}$ which is the increasing function plotted in Figure 1.

The three different regions delimited by this two functions are thoroughly commented in the main text.■

Proof of Lemma 3.

The difference $CS^S - CS^I$ yields $\frac{b(3\alpha b+2\beta d)(135\alpha b^5-165\alpha b^3d^2+44\alpha bd^4+54\beta b^4d-82\beta b^2d^3+24\beta d^5)}{8(27b^4-21b^2d^2+4d^4)^2}$ whose sign is given by the numerator that is positive for $\frac{\beta}{\alpha} < \frac{165(\frac{d}{b})^2-44(\frac{d}{b})^4-135}{2(\frac{d}{b})(27-41(\frac{d}{b})^2+12(\frac{d}{b})^4)}$

which is always the case when *single integration* is privately profitable (i.e. $\frac{d}{b} < 0.66$).

The difference $CS^P - CS^S$ yields $\frac{b(\alpha d+2\beta b)(-4\alpha b^4 d-9\alpha b^2 d^3+3\alpha d^5+40\beta b^5-46\beta b^3 d^2+10\beta b d^4)}{8(12b^4-7b^2d^2+d^4)^2}$ whose sign is given by the numerator that is positive for $\frac{\beta}{\alpha} > \frac{4(\frac{d}{b})+9(\frac{d}{b})^3-3(\frac{d}{b})^5}{2(20-23(\frac{d}{b})^2+5(\frac{d}{b})^4)}$. The latter inequality is respected for sufficiently low values of $\frac{d}{b}$ combined with sufficiently high values of $\frac{\beta}{\alpha}$.

$CS^P - CS^I$ yields $\frac{b((180b^6-199b^4d^2+15b^2d^4+12d^6)\alpha^2+(264b^5d-384b^3d^3+104bd^5)\alpha\beta+(180b^6-199b^4d^2+15b^2d^4+12d^6)\beta^2)}{2(9b^2-4d^2)^2(4b^2-d^2)^2}$ and the sign of this expression is given by the numerator which is always positive when *parallel integration* is privately profitable (i.e. $\frac{d}{b} < 0.77$).■

Proof of Proposition 2.

The difference $W^S - W^I$ yields $\frac{b(3\alpha b+2\beta d)(189\alpha b^5-393\alpha b^3 d^2+124\alpha b d^4-54\beta b^4 d-122\beta b^2 d^3+56\beta d^5)}{8(27b^4-21b^2d^2+4d^4)^2}$ whose sign is given by the numerator that is positive for $\frac{\beta}{\alpha} < \frac{393(\frac{d}{b})^2-124(\frac{d}{b})^4-189}{2d(28(\frac{d}{b})^4-61(\frac{d}{b})^2-27)}$ which is the decreasing function plotted in Figure 2.

The difference $W^P - W^S$ yields $\frac{b(\alpha d+2\beta b)(-44\alpha b^4 d-11\alpha b^2 d^3+7\alpha d^5+56\beta b^5-106\beta b^3 d^2+26\beta b d^4)}{8(12b^4-7b^2d^2+d^4)^2}$ whose sign is given by the numerator that is positive for $\frac{\beta}{\alpha} > \frac{44(\frac{d}{b})+11(\frac{d}{b})^3-7(\frac{d}{b})^5}{2(28-53(\frac{d}{b})^2+13(\frac{d}{b})^4)}$ which is the increasing function plotted in Figure 2.

The three different regions delimited by this two functions are thoroughly commented in the main text.■