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Abstract

In this paper, two pairs of complementors have to decide whether to merge and eventually bundle their products. Depending on the degree of competitive pressure in the market, either both pairs decide to merge (with or without bundling), or only one pair merges and bundles, while rivals remain independent. The latter case can very harmful for consumers as it brings surge in prices. We also consider the case in which one pair moves first. Interestingly, we find a parametric region where first movers merge but refrain from bundling, to not induce rivals to merge as well.

Keywords: Bundling, Merger, Strategic Interaction, Antitrust.
JEL Classification: D43, L13; L41.

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1 Introduction

Recent antitrust decisions about proposed mergers explicitly considered the possibility that the merging parties may engage in bundling, especially when they produce complementary goods. This point is extremely delicate. On the one hand, based on the seminal contribution by Cournot (1838), vertical agreements involving complements tend to reduce prices, by which one could argue a merger between suppliers of complementary products should be allowed for. On the other hand, since Whinston (1990), bundling has been deemed as welfare reducing, especially when achieving foreclosure.[1] As a consequence, a vertical merger which involves bundling has to be carefully scrutinized, as it entails a trade-off between two forces which may have opposite effects on social welfare.

In one of the most controversial cases, the US and the EU severely disagreed on the proposed merger between General Electric (GE) and Honeywell in 2001. Although the two parties were US-based multinationals, the merger also fell under the European Merger Control Regulation (MCR) as their total turnover in the EU amounted to 29 billion euros.[2] The US Department of Justice (DOJ) was broadly in favour, while the European Commission decided to block the merger because of a possible bundle between GE's jet aircraft engines and Honeywell's avionics products.[3] The Commission raised also a second point of concern, which is of interest for this paper: the practical difficulty for rival suppliers of engines and avionics to respond appropriately, for example by merging or forming selling consortia and then offering their own competing bundle.[4]

Another interesting case was the merger between Comcast and NBC Universal (NBCU), approved in January 2011 by both the Federal Communication Commission (FCC) and the DOJ. The approval arrived under the condition that other providers maintained access to NBC programming, and that Comcast made affordable broadband available to its customers without forcing them to subscribe to a cable bundle. This decision has triggered a lot of criticism as it was argued that such a merger would certainly charge rivals, such as DirecTV or Verizon Fios, anticompetitive rates to access Comcast/NBC programming. Moreover, due to the size of the parties involved, it was clear that a real possibility for rivals to create a direct competitor by merging was extremely limited.[5]

In general, notwithstanding a growing interest for the impact on society of conglomerate mergers which may involve bundling, the focus has been directed to the study of market-foreclosure effects. Scanty attention has been devoted to the possibility that rivals may respond in a similar way, by

[1] The entry-deterrence use of bundling complement goods has been further investigated by Choi and Stefanadis (2001), Carlton and Waldman (2002), Nalebuff (2004) and Peitz (2008), *inter alii*.

[2] The turnovers of GE and Honeywell in the EU were respectively 23 billion euros 6 billion euros.

[3] For a brief history of the "transatlantic" divergence between US and EU regarding the GE/Honeywell case, see Morgan and McGuire (2004).

[4] The GE/Honeywell controversy reflects well the different views embraced by American and European regulators regarding bundling, with the former being more tolerant than the latter, since the Chicago School dismissed any form of leverage theory. In the European competition policy, on the contrary, bundling gained enormous prominence in a number of recent cases, *e.g.* Tetra Laval/Sidel, the already mentioned GE/Honeywell and the recent Microsoft case in which the European Commission ordered the unbundling of the Windows Media Player from Windows.

[5] The merger between Comcast's cable systems and NBC Universal's channels created a media giant as it combined a major producer of TV and movies with the dominant distributor of TV and movies in big media markets. NBCUniversal is now 51% owned by Comcast and 49% owned by GE.

creating their proper merged entity. The aim of our paper is to cover this gap.

In particular, we consider two pairs of complementors (producers of complementary products) that compete in the market by setting prices. In the preliminary stage of the game, the two producers of each pair have to decide whether to remain independent or merge. In the latter case, the merged entity decides whether to sell the two products separately or in a bundle.

Moreover, as casual observation suggests that mergers usually appear in sequence, we also investigate the case in which one pair of complementors moves before the other. It is worth remarking that we abstract from any synergies that may result from merging and/or bundling. Apart from the timing asymmetry in the sequential game, there are no additional factors which could artificially create an incentive to merge and to bundle.

The main message of our paper is that the strategic interaction between bundling and merging depends on the degree of competitive pressure in the market, which in our model is captured by the interplay between different degrees of product complementarity and brand substitutability.[6] In particular, the following results deserve attention:

1. When competitive pressure is relatively weak (sufficiently high degrees of product complementarity and/or brand differentiation), both pairs of complementors decide to merge. When this happens, bundling becomes ineffective.

2. For intermediate levels of competitive pressure in the market, in the simultaneous game both pairs of complementors bundle. This may give rise to a prisoner's dilemma, as firms would have obtained a higher profits by remaining independent. In the sequential game the strategic interaction between bundling and merging emerges in its true nature: first movers decide to merge but *not* to bundle, and this occurs as they want to avoid a profit-harming merging response by second movers, which remain independent in absence of bundling.

3. When brands are perceived as highly substitutes and/or product complementarity is very weak, first movers decide to merge and bundle, while second movers refrain from merging. Differently from the previous case, the latter gain as well from the merging and bundling strategy adopted by the formers. Co-opetion is therefore at work in such a scenario.

From a social welfare perspective, when both pairs of complementors merge social welfare is at its highest. All price externalities are internalized and society at large benefits from consuming at the lowest prices. Remarkably, this socially optimal outcome can be obtained also in presence of bundling, whose potential negative effect is completely neutralized when both pair of complementors merge. When only one pair merges without bundling, price externalities are only partially internalized and this represents the second best result in terms of social welfare.

The worst scenario occurs in the third case listed above. Bundling by one merged entity, when not accompanied by a second merger, leads to an overall surge in prices, thereby reducing social welfare.

[6] For terminological purposes, we use products when referring to complements and brands when referring to substitutes.

This situation occurs when market competition is very intense, and can be explained by the fact that bundling, by softening brand substitutability in a situation of low product complementarity, allows independent producers to gain as well. This may represent an interesting case also for the Antitrust agency, as it highlights a peculiar (and neglected) scenario in which firms strategically decide to not merge in response of a bundle proposed by rivals, even if they potentially could.

Literature review

Recent theoretical contributions tried to shed light on the interaction between bundling and mergers in presence of complementary goods. Dalkir et al. (2002) consider a model of quality differentiation in which there is a single quality leader in each market, with all other firms producing lower quality products. They demonstrate that a merger of quality leaders in the components has a negative effect on social welfare as it drives prices up and reduces the choice for consumers. However, they do not catch the strategic interaction between the merging entity and independent producers, which is the object of our paper. Evans and Salinger (2002) criticize the Commission's decision to prohibit the GE/Honeywell merger. However, their paper is mostly related to the legal controversy of the merger, and their economic theory does not allow to capture all the different forces at work.[7]

A paper with a direct economic reference to the GE/Honeywell case is the one by Choi (2008), who examines mergers in complementary system markets where the merging parties may engage in bundling. He shows that bundling may have both pro-competitive and anti-competitive effects; yet, in case of market foreclosure, bundling reduces unambiguously social welfare and the merger should then be prohibited. The main difference between his contribution and our paper is that we allow for different degrees of both product complementarity and brand substitutability. Moreover, we consider a representative consumer who is not forced to buy both products, as each of them is valuable even when consumed or used alone. It follows that our analysis applies to both mergers which require different components to be assembled together, like the GE/Honeywell case, and others which do not, like the Comcast/NBCU one.

Our paper is also related to the strategic incentives to bundle in oligopoly models. Carbajo *et al.* (1990) adopt a model with homogeneous goods in market B and valuations for goods A and B that are perfectly correlated and uniformly distributed across consumers, and demonstrate that bundling increases product differentiation. When firms compete in prices, bundling softens market competition and both firms gain; when they compete in quantities, on the contrary, only the bundling firm gains. In Martin (1999), a multiproduct firm enjoys a monopoly position in one market and faces competition in the other one. He shows that bundling changes the substitution relationships between goods to the advantage of the multiproduct firm. In so doing, he adopts a specific demand system which allows to consider only quantity competition, while we introduce competition in each horizontally differentiated market.

[7] They consider a simple model in which two complementary goods are provided by a monopolist and the other is provided by two firms selling differentiated products.

An alternative approach in which bundling is used to segment the market and relax price competition can be found in Chen (1997). In his model, two firms already produce a homogeneous good and have to decide whether to introduce a second good bundled with the former. He shows that bundling emerges as an equilibrium strategy for both firms given that it increases product differentiation. Gans and King (2006) model the interaction between four producers of two goods to investigate the consequences of bundled discount to encourage customer loyalty. They found that, even for unrelated products, a bundled discount has the effect of tying customers to particular product brands, thus improving the profitability of the firms involved.

The combination of complementary components into composite systems is another close field. Matutes and Regibeau (1988 and 1992) and Economides (1989) consider fully integrated firms and show that they prefer compatibility over incompatibility. Farrell *et al.* (1998) demonstrate that firms may prefer incompatibility with cost heterogeneity in presence of at least three different varieties of each component. Denicolò (2000) analyzes compatibility and bundling choices when a generalist firm offering both components competes against two specialist firms. He shows that incompatibility or pure bundling may be profitable for the generalist firm when one component is less differentiated than the other.

Last, but not least, our paper contributes to the literature on 'Co-opetition', initially developed by Brandenburger and Nalebuff (1996). One of the most important results of our paper is that, when two complementors bundle, all firms increase prices, and there exists an interval region where individual producers enjoy a higher profit. Casadesus-Masanell *et al.* (2008) contribute to this branch or research by presenting Intel and Microsoft as a motivating example on the tension between cooperation and competition that characterizes relationships between complementors.

The paper is structured as follows. Section 2 presents the model and includes all the possible market equilibria resulting from the combinations of strategies adopted by firms. In Section 3 we solve the simultaneous game, while in Section 4 we consider the more realistic sequential game. In Section 5 we discuss implications for social welfare and provide policy indications. Section 6 concludes.

2 The model

We consider four firms (A_1, A_2, B_1 and B_2), two complementary markets (α and β) and four goods (α_1, α_2, β_1 and β_2). Firms A_1 and A_2 operate in market α and produce respectively α_1 and α_2, while B_1 and B_2 respectively provide β_1 and β_2 in market β. Goods are considered as imperfect substitutes within the same market and as imperfect complements between the two markets. As already mentioned, we refer to brands when considering substitutes and to products when complements. Moreover, it is assumed that *(i)* goods α and β are valuable even if consumed alone, and *(ii)* any combination of α and β is perceived as equally valuable by the representative consumer.[8] As the level of the demand intercept has no effect on relative prices and quantities, we normalize it to 1.

[8] Recent decisions taken by the Antitrust agencies impeded the producer to bundle two complements that are mutually dependent. This is particularly true in high-tech sectors, such as computers (see the Microsoft case).

The social welfare function that represents such consumer preference takes the following form:

$$\begin{aligned} U &= m + (q_{\alpha_1} + q_{\alpha_2} + q_{\beta_1} + q_{\beta_2}) - \frac{1}{2}(q_{\alpha_1}^2 + q_{\alpha_2}^2 + q_{\beta_1}^2 + q_{\beta_2}^2) + \\ & -\delta(q_{\alpha_1}q_{\beta_1} + q_{\alpha_1}q_{\beta_2} + q_{\alpha_2}q_{\beta_1} + q_{\alpha_2}q_{\beta_2}) - \gamma(q_{\alpha_1}q_{\alpha_2} + q_{\beta_1}q_{\beta_2}), \end{aligned} \tag{1}$$

where m is the amount of the numeraire good, whose price is normalized to 1, q_{α_1} and q_{α_2} (resp. q_{β_1} and q_{β_2}) are the quantities of good α (resp. β) produced by firm A_1 and A_2 (resp. B_1 and B_2). Parameter $\delta \in (-1, 0)$ measures the degree of complementarity between each combination of a α and β product, while $\gamma \in (0, 1)$ measures the brand substitutability both between α_1 and α_2 and between β_1 and β_2. The implied inverse demand functions are:

$$p_{\alpha_i} = 1 - q_{\alpha_i} - \gamma q_{\alpha_j} - \delta \sum_{l=1}^{2} q_{\beta_l}, \tag{2}$$

$$p_{\beta_i} = 1 - q_{\beta_i} - \gamma q_{\beta_j} - \delta \sum_{l=1}^{2} q_{\alpha_l}, \tag{3}$$

with $i, j = 1, 2$, $i \neq j$, and $l = 1, 2$.[9] This notation will be used henceforth. The above demand system can be easily inverted to obtain direct demand functions:

$$q_{\alpha_i} = \frac{(1-\gamma)(1+\gamma-2\delta) - (1+\gamma-2\delta^2)p_{\alpha_i} + \left[\gamma(1+\gamma) - 2\delta^2\right] p_{\alpha_j} + \delta(1-\gamma)\sum_{l=1}^{2} p_{\beta_l}}{(1-\gamma)\left[(1+\gamma)^2 - 4\delta^2\right]}, \tag{4}$$

$$q_{\beta_i} = \frac{(1-\gamma)(1+\gamma-2\delta) - (1+\gamma-2\delta^2)p_{\beta_i} + \left[\gamma(1+\gamma) - 2\delta^2\right] p_{\beta_j} + \delta(1-\gamma)\sum_{l=1}^{2} p_{\alpha_l}}{(1-\gamma)\left[(1+\gamma)^2 - 4\delta^2\right]}, \tag{5}$$

Lemma 1 *Substitutability and complementarity relationships are preserved in the direct demand system iff* $\gamma > \frac{1}{2}(\sqrt{1+8\delta^2} - 1) \equiv \underline{\gamma}$.

Proof. see the Appendix. ■

Therefore, we limit our attention to the interval region where $\gamma > \frac{1}{2}(\sqrt{1+8\delta^2} - 1) \equiv \underline{\gamma}$. Regarding the cost structure, we assume that the two goods are independent in production and that neither merging nor bundling yield any cost synergies. Moreover, the constant unit cost of production each good is supposed to be symmetric across firms and equal to 0.

As for profit functions, (4)-(5) have to be respectively inserted into: *(i)*

$$\pi_{A_l} = p_{\alpha_l} q_{\alpha_l},\ \pi_{B_l} = p_{\beta_l} q_{\beta_l}, \tag{6}$$

when firms A_i and B_i is independent; *(ii)*

$$\pi_{AB_i} = p_{\alpha_i} q_{\alpha_i} + p_{\beta_i} q_{\beta_i}, \tag{7}$$

when A_i and B_i merge (but do not bundle), and the merged entity is labeled AB.

[9] A similar demand structure can be found in Choi (2008) and Economides and Salop (1992). However, both papers consider four composite products which are substitutes for one another.

When the merged entity decides to sell the two products in a package, the bundle is called $\alpha\beta_l$. We assume that each bundle consists of one unit of the α and one unit of the β good.[10] In order to obtain the demand functions, the following relation between the number of bundles ($q_{\alpha\beta_l}$) and the quantities of the different products need to be inserted in the utility function (see Martin, 1999):

$$q_{\alpha\beta_l} = q_{\alpha_l} = q_{\beta_l}. \tag{8}$$

Hence, when only one pair of complementors, say i, merges and bundles, while pair j remains independent or merges without bundling, the social welfare function (1) becomes:

$$U = m+(2q_{\alpha\beta_i}+q_{\alpha_j}+q_{\beta_j})-\frac{1}{2}(2q^2_{\alpha\beta_i}+q^2_{\alpha_j}+q^2_{\beta_j})-\delta\left[(q_{\alpha\beta_i}+q_{\alpha_j})(q_{\alpha\beta_i}+q_{\beta_j})\right]-\gamma q_{\alpha\beta_i}(q_{\alpha_j}+q_{\beta_j}). \tag{9}$$

The implied direct demand curves are:

$$q_{\alpha\beta_i} = \frac{2(1-\gamma)-(1+\delta)p_{\alpha\beta_i}+(\gamma+\delta)(p_{\alpha_j}+p_{\beta_j})}{2(1-\gamma)(1+\gamma+2\delta)}, \tag{10}$$

$$q_{\alpha_j} = \frac{2(1-\gamma)(1-\delta)-\left[2(1-\delta)-(\gamma+\delta)^2\right]p_{\alpha_j}-\left[\gamma(\gamma+2\delta)-\delta(2+\delta)\right]p_{\beta_j}+(1-\delta)(\gamma+\delta)p_{\alpha\beta_i}}{2(1+\gamma+2\delta)(1-\gamma)(1-\delta)} \tag{11}$$

$$q_{\beta_j} = \frac{2(1-\gamma)(1-\delta)-\left[2(1-\delta)-(\gamma+\delta)^2\right]p_{\beta_j}-\left[\gamma(\gamma+2\delta)-\delta(2+\delta)\right]p_{\alpha_j}+(1-\delta)(\gamma+\delta)p_{\alpha\beta_i}}{2(1+\gamma+2\delta)(1-\gamma)(1-\delta)} \tag{12}$$

Turning to profit functions, we have to insert (10) in firm i's profit

$$\pi_{AB_i} = p_{\alpha\beta_i}q_{\alpha\beta_i} \tag{13}$$

and (12)-(11) in rivals' profit functions, which are respectively given by (**??**) if they remain independent, and by

$$\pi_{AB_j} = p_{\alpha_j}q_{\alpha_j} + p_{\beta_j}q_{\beta_j}, \tag{14}$$

if they merge.

Finally, when both pairs of complementors merge and bundle their products, the social welfare function (1) writes:

$$U = m + 2(q_{\alpha\beta_i} + q_{\alpha\beta_j}) - (q^2_{\alpha\beta_i} + q^2_{\alpha\beta_j}) - \delta(q_{\alpha\beta_i} + q_{\alpha\beta_j})^2 - 2\gamma q_{\alpha\beta_i}q_{\alpha\beta_j}. \tag{15}$$

Direct demand curves are:

$$q_{\alpha\beta_i} = \frac{2(1-\gamma)-(1+\delta)p_{\alpha\beta_i}+(\gamma+\delta)p_{\alpha\beta_j}}{2(1-\gamma)(1+\gamma+2\delta)},\ \ i,j=1,2,i\neq j, \tag{16}$$

and they enter into symmetric profit functions:

$$\pi_{AB_l} = p_{\alpha\beta_l}q_{\alpha\beta_l}. \tag{17}$$

Notice that bundling affects the perceived substitutability and complementarity relations. In particular:

[10] See Mantovani (2011) for a thorough discussion.

Lemma 2 *When at least one pair of complementors resorts to bundling, the bundle and the rivals' products are perceived as substitutes (complements) when* $\gamma > -\delta$ $(\gamma < -\delta)$.

Proof. see the Appendix. ■

The above lemma simply indicates that, in presence of at least one pair of bundling complementors, it is the relative strength of brand differentiation *vis à vis* product complementarity that determines whether the bundle and either the two stand-alone rival products or the alternative bundle are considered as substitutes or complements by the representative consumer. Consider, for example, $\gamma > -\delta$: brands are relatively highly substitutable and/or product complementarity is low: the bundle is perceived as a substitute either to the bundle proposed by rivals or to their alternative separate products. The opposite holds, *mutatis mutandis*, when $\gamma < -\delta$.

3 The simultaneous game

Players interact simultaneously in the market by setting prices. However, there exists a preliminary stage of the game where each pair of complementors selects a strategy from the following set {*Remain Independent (I), Merging without bundling (M), Merging with bundling (B)*}.

The preliminary stage of the game is represented in Table 1, where the first (resp. second) superscript denotes the strategy of pair i (resp. pair j). Moreover, we use symmetry to simplify the notation by removing the firm type. As an illustrative example, $\pi_i^{MI} = \pi_{A_i}^{MI} = \pi_{B_i}^{MI}$ indicates the profit that each firm in pair i obtains by merging without bundling, when firms in pair j remain independent, and so on.

Table 1: Payoff matrix

		Pair j					
		I		M		B	
Pair i	I	π_i^{II}	π_j^{II}	π_i^{IM}	π_j^{IM}	π_i^{IB}	π_j^{IB}
	M	π_i^{MI}	π_j^{MI}	π_i^{MM}	π_j^{MM}	π_i^{MB}	π_j^{MB}
	B	π_i^{BI}	π_j^{BI}	π_i^{BM}	π_j^{BM}	π_i^{BB}	π_j^{BB}

The game is solved backwards and we start from the market stage. Equilibrium values for prices and profits are reported in Table 2.[11] Two remarks: first, for the sake of comparability, we consider *per firm* profits.[12] Second, we include only cases II, MI, MM, BI, BM and BB, given that IB and MB are respectively symmetric to BI and BM.

[11] It is relatively easy to verify that in the interval region of interest ($\gamma > \underline{\gamma}$, see Lemma 1), the system is stable and equilibrium prices and profits are always positive.

[12] When one pair merges and bundles, per firm profit is half of the profit of the merged entity.

Table 2: Market stage equilibrium prices and profits

Case	EQUILIBRIUM PRICES	PER FIRM EQUILIBRIUM PROFITS
II	$p^{II}_{\alpha_i} = p^{II}_{\beta_i} = \frac{(1-\gamma)(2\delta-\gamma-1)}{(2\delta-\gamma)(1-\gamma)-2\left(1-\delta^2\right)}$	$\pi^{II}_i = \frac{\left(2\delta^2-\gamma-1\right)(1-\gamma)(2\delta-\gamma-1)}{(2\delta+\gamma+1)\left[(2\delta-\gamma)(1-\gamma)-2\left(1-\delta^2\right)\right]^2}$
	$p^{II}_{\alpha_j} = p^{II}_{\beta_j} = \frac{(1-\gamma)(2\delta-\gamma-1)}{(2\delta-\gamma)(1-\gamma)-2\left(1-\delta^2\right)}$	$\pi^{II}_j = \frac{\left(2\delta^2-\gamma-1\right)(1-\gamma)(2\delta-\gamma-1)}{(2\delta+\gamma+1)\left[(2\delta-\gamma)(1-\gamma)-2\left(1-\delta^2\right)\right]^2}$
MI	$p^{MI}_{a_i} = p^{MI}_{\beta_i} = \frac{(1-\gamma)\left[2+\gamma(3+\gamma)-6\delta^2\right]}{\Psi}$	$\pi^{MI}_i = \frac{(1-\gamma)(1+\delta)\left[2+\gamma(3+\gamma)-6\delta^2\right]^2}{\Psi^2(1+\gamma+2\delta)}$
	$p^{MI}_{a_j} = p^{MI}_{\beta_j} = \frac{(1-\gamma)(1+\gamma-2\delta)(2+\gamma+3\delta)}{\Psi}$	$\pi^{MI}_j = \frac{(1-\gamma)(1+\gamma-2\delta)(1+\gamma-2\delta^2)(2+\gamma+3\delta)^2}{\Psi^2(1+\gamma+2\delta)}$
MM	$p^{MM}_{\alpha_i} = p^{MM}_{\beta_i} = \frac{1-\gamma}{2+\delta-\gamma}$	$\pi^{MM}_i = \frac{(1-\gamma)(1+\delta)}{(2\delta+\gamma+1)(2+\delta-\gamma)^2}$
	$p^{MM}_{\alpha_j} = p^{MM}_{\beta_j} = \frac{1-\gamma}{2+\delta-\gamma}$	$\pi^{MM}_j = \frac{(1-\gamma)(1+\delta)}{(2\delta+\gamma+1)(2+\delta-\gamma)^2}$
BI	$p^{BI}_{\alpha\beta_i} = \frac{(1-\gamma)[4-\gamma(\gamma-2+4\delta)+\delta(4-5\delta)]}{2\left[2-\gamma(\gamma+2\delta)+\delta(3-\delta-\delta^2)\right]}$	$\pi^{BI}_i = \frac{(1-\gamma)(1+\delta)[4-\gamma(\gamma-2+4\delta)-\delta(4-5\delta)]^2}{16(1+\gamma+2\delta)\left[2-\gamma(\gamma+2\delta)+\delta(3-\delta-\delta^2)\right]^2}$
	$p^{BI}_{\alpha_j} = p^{BI}_{\beta_j} = \frac{(1-\gamma)(1-\delta)(2+\gamma+3\delta)}{2\left[2-\gamma(\gamma+2\delta)+\delta(3-\delta-\delta^2)\right]}$	$\pi^{BI}_j = \frac{(1-\gamma)(1+\delta)(2+\gamma+3\delta)^2\left[2(1+\delta)-(\gamma+\delta)^2\right]}{8(1+\gamma+2\delta)\left[2-\gamma(\gamma+2\delta)+\delta(3-\delta-\delta^2)\right]^2}$
BM	$p^{BM}_{\alpha\beta_i} = \frac{2(1-\gamma)}{2+\delta-\gamma}$	$\pi^{BM}_i = \frac{(1-\gamma)(1+\delta)}{(2\delta+\gamma+1)(2+\delta-\gamma)^2}$
	$p^{BM}_{\alpha_j} = p^{BM}_{\beta_j} = \frac{1-\gamma}{2+\delta-\gamma}$	$\pi^{BM}_j = \frac{(1-\gamma)(1+\delta)}{(2\delta+\gamma+1)(2+\delta-\gamma)^2}$
BB	$p^{BB}_{\alpha\beta_i} = \frac{2(1-\gamma)}{2+\delta-\gamma}$	$\pi^{BB}_i = \frac{(1-\gamma)(1+\delta)}{(1+2\delta+\gamma)(2+\delta-\gamma)^2}$
	$p^{BB}_{\alpha\beta_j} = \frac{2(1-\gamma)}{2+\delta-\gamma}$	$\pi^{BB}_j = \frac{(1-\gamma)(1+\delta)}{(1+2\delta+\gamma)(2+\delta-\gamma)^2}$

where $\Psi = 4 - \gamma^2(1+\gamma) + \delta(2+\delta)(1-6\delta) + \gamma\left[4+\delta(4+5\delta)\right]$.

We can now proceed by solving the simultaneous game and obtain:

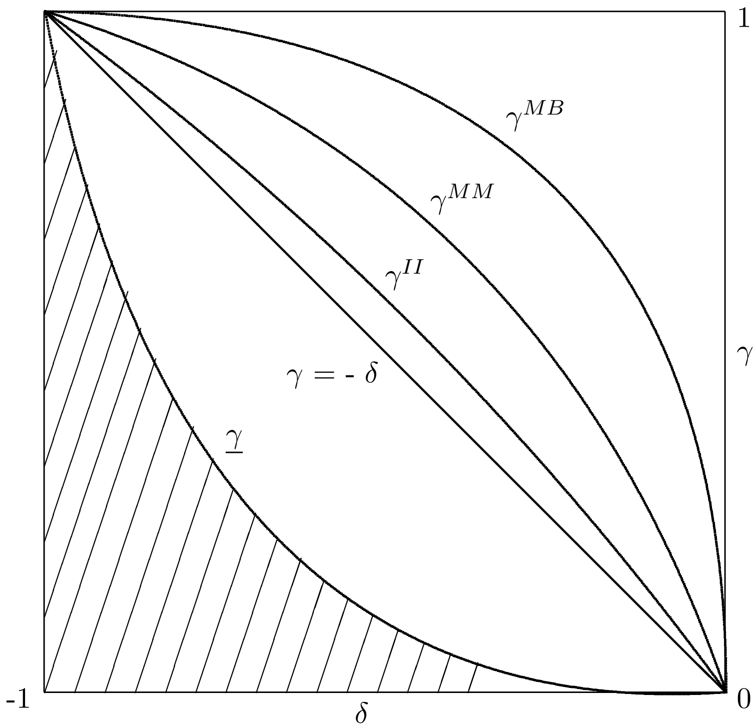
Proposition 1 *Depending on the interaction between product complementarity and brand substitutability, the following holds:*

- *When $\gamma \in (\underline{\gamma}, -\delta)$, we have one Nash Equilibrium in (weakly) dominant strategies given by (M, M), which is also Pareto efficient.*
- *When $\gamma \in (-\delta, \gamma^{II})$, we have one Nash Equilibrium in (weakly) dominant strategies given by (B, B), which is also Pareto efficient.*
- *When $\gamma \in (\gamma^{II}, \gamma^{MB})$, the game is a Prisoner's Dilemma as the unique Nash Equilibrium (B, B) is Pareto dominated by (I, I).*
- *When $\gamma \in (\gamma^{MB}, 1)$, we have two Nash Equilibria given by (B, I) and (I,B).*

Proof. see the Appendix. ■

As the analytical expressions of the above threshold values of γ are rather complicated, the parametric regions of interest in the bidimensional space, delimited by $\delta \in (-1, 0)$ and $\gamma \in (0, 1)$, is represented in Figure 1. For future reference, γ^{MM} is also depicted. The dashed area in $\gamma \in (0, \underline{\gamma})$ has no economic meaning, following Lemma 1.

Figure 1



Our results deserve additional explanations. In particular, we need to focus on the incentives to merge with respect to those to bundle. Let us neglect for the moment the possibility to bundle and focus on the decision to merge. As already established, two merging complementors end up by setting lower prices as they internalize the positive externality that a price reduction of each product has on the demand of the other. Considering pair i, it is easy to verify that a merger results in lower prices both, when rivals remain independent and when they merge:

$$p_{x_i}^{MI} < p_{x_i}^{II} \text{ and } p_{x_i}^{MM} < p_{x_i}^{IM},\ x = \alpha, \beta. \tag{18}$$

Yet, the effectiveness of such price internalization depends on the relative strength of δ and γ, as we can infer from Proposition 1. In particular: *(i)* $\pi_i^{MI} > \pi_i^{II}$ when $\gamma < \gamma^{MI}$, *(ii)* $\pi_i^{MM} > \pi_i^{IM}$ when $\gamma < \gamma^{MM}$, and *(iii)* $\pi_i^{MM} > \pi_i^{II}$ when $\gamma < \gamma^{II}$. Moreover $\underline{\gamma} < \gamma^{II} < \gamma^{MI} \lesssim \gamma^{MM} < \gamma^{MB}$, as can be observed in Figure 1, where we also notice that such threshold values are decreasing in δ.[13] Moreover, we find that:

$$p_{x_j}^{MI} > p_{x_j}^{II} \text{ and } p_{x_j}^{MM} > p_{x_j}^{IM} \text{ when } \gamma < -\delta,\ x = \alpha, \beta. \tag{19}$$

When $\gamma < -\delta$, producers in pair j set a higher price in response to a merger in pair i.

Starting in $\gamma < -\delta$ and supposing that A_1 and B_1 merge, prices for α_1 and β_1 decrease substantially and so quantities increase. Moreover, A_2 and B_2, either independently or in a merger, respond

[13] See the Proof of Proposition 1 in the Appendix, with particular reference to espressions (A3), (A4), (A8) and (A9).

by charging higher prices, as their goods, α_2 and β_2 are still sufficiently *differentiated from* α_1 and β_1 and/or sufficiently *complementary to* β_1 and α_1, respectively, whose sales have significantly increased. Product complementarity is therefore stronger than brand substitutability. The merger between A_1 and B_1 would allow to lower prices and gain in quantities without eliciting an aggressive answer by rivals, which would also raise prices if they cannot merge. Obviously, the same incentive holds for the other pair, thus explaining why they both merge.

The picture changes when $\gamma > -\delta$, especially when we proceed northeastward on Figure 1. On the one hand, the intensity of the Cournot effect diminishes as products are perceived as less and less complementary. On the other hand, brand substitutability increases, and rivals respond to a merger by lowering their price. This exacerbates price competition without a compensating increase in sales: firms prefer to not merge. When the degree of brand substitutability exceeds the threshold value γ^{II}, both pairs of complementors would be better off by remaining independent, but their dominant strategy is still merging. Only when $\gamma > \gamma^{MI} \simeq \gamma^{MM}$ they would both decide to refrain from merging. Absent bundling, therefore, we would have a prisoner's dilemma in $\gamma \in (\gamma^{II}, \gamma^{MM})$.

Now we introduce bundling. First of all, from Table 1, notice that:

$$\pi_y^{MM} = \pi_y^{BM} = \pi_y^{BB}, y = i, j \tag{20}$$

Remark 1 *When both pairs of complementors merge, bundling becomes ineffective.*

When two complementors merge, they have no incentive to bundle their products if the other complementors decide to merge as well. The reason lies in the fact that, when both pairs of complementors merge, we start from a symmetric "coordinated" position in which firms charge the same prices and sell the same quantity. It comes therefore as no surprise that at equilibrium $p_{\alpha\beta_i}^{BM} = p_{\alpha\beta_i}^{BB} = p_{\alpha_i}^{MM} + p_{\beta_i}^{MM}$: the bundling pair plugs in the package the same amount of units of each product and charges for it a price which is the sum of the prices charged for each stand-alone product. As a consequence the profit does not change with respect to the no bundling case.

The situation is different when one pair of complementors remains independent.

Lemma 3 *If rivals remain independent, the price of the bundle is different from the sum of the prices of the stand-alone products . In particular:*

- *When* $\gamma \in (\underline{\gamma}, -\delta)$: $p_{\alpha\beta_i}^{BI} < p_{\alpha_i}^{MI} + p_{\beta_i}^{MI} < p_{\alpha_i}^{II} + p_{\beta_i}^{II}$.
- *When* $\gamma \in (-\delta, \gamma^P)$: $p_{\alpha_i}^{MI} + p_{\beta_i}^{MI} < p_{\alpha\beta_i}^{BI} < p_{\alpha_i}^{II} + p_{\beta_i}^{II}$.
- *When* $\gamma \in (\gamma^P, 1)$: $p_{\alpha_i}^{MI} + p_{\beta_i}^{MI} < p_{\alpha_i}^{II} + p_{\beta_i}^{II} < p_{\alpha\beta_i}^{BI}$.

Proof. see the Appendix. ■

The results of Lemma 3 are very interesting as they confirm that (pure) bundling can be used to revert the price drop induced by the merger. In particular, bundling yields a price increase when $\gamma > -\delta$ where, recalling Lemma 2, the bundle is a substitute for the alternative goods produced by rival complementors. Absent bundling, rivals would respond to a merger by lowering prices, as we know from (19). Selling the two products in a bundle can therefore be used by pair i to soften price competition, given that $p^{BI}_{\alpha\beta_i} > p^{MI}_{\alpha_i} + p^{MI}_{\beta_i}$ when $\gamma > -\delta$. Independent rivals in j now respond by charging higher prices: $p^{BI}_{x_j} > p^{MI}_{x_j}$. Hence, it is no surprise that $\pi^{BI}_i > \pi^{MI}_i$ and bundling is thus preferred to only merging when $\gamma > -\delta$, as we know from Proposition 1.[14]

In addition, in $\gamma \in (\gamma^P, 1)$, when brands become almost homogeneous (and/or product complementary tends to fade away), pair i can even charge for the bundle a price that is higher than the sum of the prices it would have charged for the two independently produced goods: $p^{BI}_{\alpha\beta_i} > p^{II}_{\alpha_i} + p^{II}_{\beta_i}$.[15] Independent producers in j respond again by charging higher prices ($p^{BI}_{x_j} > p^{II}_{x_j}$) and $\pi^{BI}_i > \pi^{II}_i$ in our interval region.[16] As a consequence:

$$p^{BI}_{\alpha\beta_i} < p^{BI}_{\alpha_j} + p^{BI}_{\beta_j} \ . \tag{21}$$

Remark 2 *When rival complementors remain independent, the bundling entity charges a price for the bundle which is lower than the sum of the prices charged by the two rivals.*

The previous discussion has two implications. On the one hand, it spells out the incentives for each pair of complementors to bundle in $\gamma > -\delta$. On the other hand, it opens up the possibility for independent rivals to gain as well, as prices rise. There exists therefore a trade-off for independent complementors in j when pair i decides to (merge and) bundle: re-activating price competition via (merging and) bundling, thus recouping market shares, or remaining independent and charging higher prices in a smaller portion of the market. The trade-off can be easily navigated:[17]

$$\pi^{BI}_j < \pi^{BM}_j \Longleftrightarrow \gamma < \gamma^{MB}; \text{ moreover, } \gamma^{MB} \simeq \gamma^P. \tag{22}$$

In $\gamma \in (-\delta, \gamma^{MB} \simeq \gamma^P)$ both pairs of complementors opt for bundling. By doing so, they obtain the same profits as if they would have merged without bundling, as highlighted in Remark 1. This also explains the prisoner's dilemma in $\gamma \in (\gamma^{II}, \gamma^{MB})$, where $\pi^{BB}_i = \pi^{MM}_i > \pi^{II}_i$ and both pairs would obtain a higher profit by remaining independent.

Only in $\gamma \in (\gamma^{MB} \simeq \gamma^P, 1)$, hence in presence of a significant surge in prices driven by bundling adopted by one pair, rival complementors prefer to remain independent. This happens when the competitive pressure is very strong as the degree of brand substitutability is very high and/or the degree of product complementarity is low. In such circumstances, bundling allows to increase prices without eliciting an aggressive answer by rivals, which prefer to raise prices as well instead of exacerbating price competition in a market where brands are almost homogeneous. These asymmetric equilibria can be interpreted in terms of co-opetition: the merging-bundling strategy adopted by one pair generates a positive effect also on rivals which prefer to produce separately.

[14] In particular, see (A6) in the Appendix and remember that $\pi^{BM}_i = \pi^{MM}_i = \pi^{MB}_i = \pi^{BB}_i$ (Remark 1).

[15] In the literature, a form of bundling in which the bundle price is higher than the sum of separate prices is known as 'premium bundling' (since Cready, 1991).

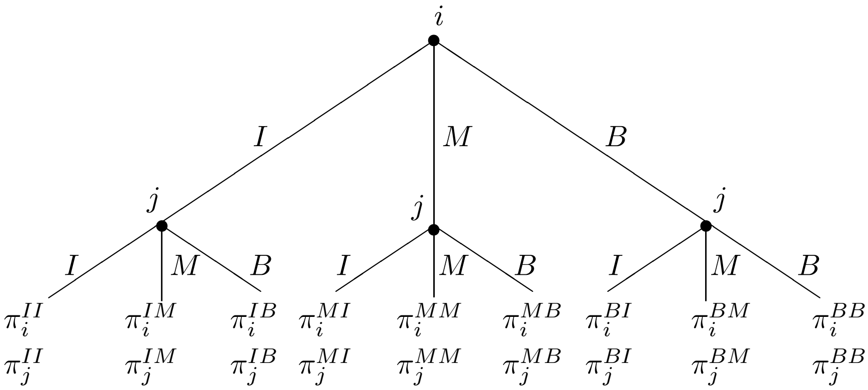
[16] As we can see from (A7) in the Appendix.

[17] In particular, see (A5) in the Appendix and remember that, by symmetry, $\pi^{BM}_j \equiv \pi^{MB}_i$

4 The sequential game

In this section we consider the more realistic situation in which one pair of complementors moves before the other in the preliminary stage of the game. We have therefore two substages in the preliminary stage of the game. Without loss of generality, we assume that pair i moves first and selects a strategy from the set $\{I, M, B\}$. The other pair of complementors j faces the same decision in the second sub-stage, after having observed the strategy selected by pair i. The preliminary stage of the game is represented in extensive form in Figure 2.

Figure 2



For notational purposes, recalling Remark 1, we denote as M/B the strategy of the firm when it is indifferent between merging with bundling and merging without bundling. Equilibrium results of the market stage for different combinations of strategies selected by the two pairs of complementors are in Table 1, where the first (resp. second) superscript now denotes the strategy of first-mover pair i (resp. second-mover j). By proceeding backwards and comparing the appropriate equilibrium profits, we find that:

Proposition 2 *when one pair of complementors moves first, the following holds:*

- *when $\gamma \in (\underline{\gamma}, \gamma^{MM})$, both pairs of complementors merge (with or without bundling) and the resulting SPNE is (M/B, M/B);*
- *when $\gamma \in (\gamma^{MM}, \gamma^{MB})$, the first mover opts for merging without bundling, while the other pair of complementors remains independent and the SPNE is (M,I);*
- *when $\gamma \in (\gamma^{MB}, 1)$, the first pair of complementors merges and bundles, while rivals remain independent; the SPNE is therefore given by (B,I).*

Proof. see the Appendix. ■

We can still refer to Figure 1 to visualize the areas of interest. The interaction between product complementarity and brand substitutability plays again a crucial role in determining which strategies are selected at equilibrium by the two pairs of complementors.

The first and the third interval region do not require further attention. As has been carefully explained in the previous section, when $\gamma \in (\underline{\gamma}, \gamma^{MM})$, the first pair of complementors merge thereby inciting a merger between the second pair. There is only one caveat with respect to the previous section. As, in this region, remaining independent is not a profitable option for either pair, the decision to bundle becomes ineffective, as is known from Remark 1. Therefore, as merging with or without bundling entails the same profit level, M/B is the strategy adopted by both pairs at the subgame Nash Equilibrium. As for $\gamma \in (\gamma^{MB}, 1)$, first movers can now merge *and* bundle, while rivals prefer to remain independent to not activate a relatively fierce price competition.

On the contrary, the region $\gamma \in \left(\gamma^{MM}, \gamma^{MB}\right)$ is extremely interesting as it represents a situation in which the strategic interplay between merging and bundling emerges in its true nature. In particular:

Corollary 1 *In $\gamma \in \left(\gamma^{MM}, \gamma^{MB}\right)$, pair i refrain from bundling to not induce rivals to merge.*

As has been clearly shown in the simultaneous game, when $\gamma > -\delta$ each pair of complementors would (merge and) bundle if the other pair remained independent. Nonetheless, when $\gamma \in \left(\gamma^{MM}, \gamma^{MB}\right)$, if first-mover pair i adopts bundling, then complementors belonging to j would merge (with or without bundling) as well, thus intensifying price competition.[18] The alternative for pair i is to merge without bundling, as this strategy would induce the others to remain independent. Combining the results from Lemma 3 with $p^{BM}_{\alpha\beta_i}$ *vs.* $p^{MI}_{\alpha_i} + p^{MI}_{\beta_i}$, it is possible to demonstrate that, in the region of interest:

$$p^{BM}_{\alpha\beta_i} < p^{MI}_{\alpha_i} + p^{MI}_{\beta_i} < p^{BI}_{\alpha\beta_i}. \tag{23}$$

Pair i prefers therefore to avoid the aggressive response by pair j as this would imply a price for the bundle which would turn out to be lower than the sum of the prices for unbundled goods when it merges. This provides a valid support to justify the result that $\pi^{MI}_i > \pi^{BM}_i$ in $\gamma \in \left(\gamma^{MM}, \gamma^{MB}\right)$, as we know from Proposition 2. In other words, when market pressure is intermediate, the first movers merge but refrain from bundling in order to avoid a profit deteriorating contra merger by the second pair of complementors in the second stage.

5 Welfare considerations and policy indications

A very crucial point of our paper is the strategic interaction between bundling and merging. The beneficial effect of a merger between complementors has to be evaluated *vis à vis* the negative effect that can arise when the merging entity resorts to bundling. As we have demonstrated, the bundling strategy, when adopted by only one pair of complementors, drives prices up and reduces consumer surplus. On the other hand, the bundling pair can resort to bundling to dampen the negative effects of lower levels of both brand differentiation and product complementarity:

$$\left|\frac{\partial \pi^{BI}_i}{\partial \gamma}\right| < \left|\frac{\partial \pi^{II}_i}{\partial \gamma}\right| \text{ and } \left|\frac{\partial \pi^{BI}_i}{\partial \delta}\right| < \left|\frac{\partial \pi^{II}_i}{\partial \delta}\right| \text{ when } \gamma > -\delta. \tag{24}$$

[18] For this and the following statements, see the demonstration of Proposition 2 in the Appendix.

Moreover, independent rivals may gain as well, as we highlighted in $\gamma \in (\gamma^{MB}, 1)$. Bundling increases therefore producer surplus.

It follows that the potential effect of bundling on social welfare, defined as the sum of consumer surplus and firms' profits, is at least ambiguous. By comparing social welfare in the different combinations of strategies available for players, we find:

Proposition 3 *In the relevant parametric region defined by Lemma 1:* $SW^{BB} = SW^{MM} = SW^{BM} > SW^{MI} > \max\left\{SW^{II}, SW^{BI}\right\}$. *Moreover,* $SW^{II} > SW^{BI}$ *when* $\gamma > \gamma^{SW}$, *where* $\underline{\gamma} < \gamma^{SW} < \gamma^{MM} < \gamma^{MB}$.

Proof. see the Appendix. ■

Moreover, as we considered two different time sequences that characterize the preliminary stage of the game, we have to show how this may affect social welfare. In Figure 3 we summarize the most important equilibrium results and the respective parametric regions that we found in the previous sections. This will be useful to describe the welfare analysis that emerges from Proposition 3.

Figure 3a : the simultaneous game

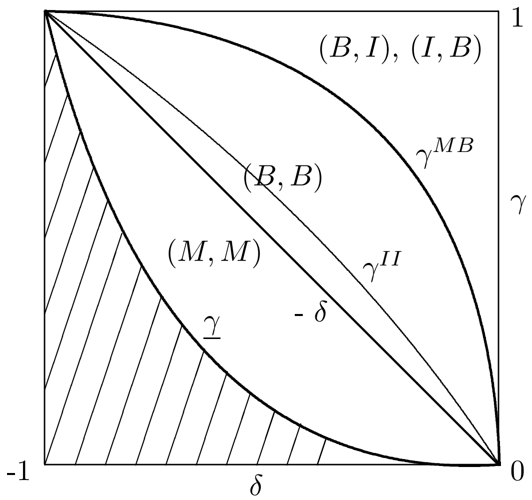
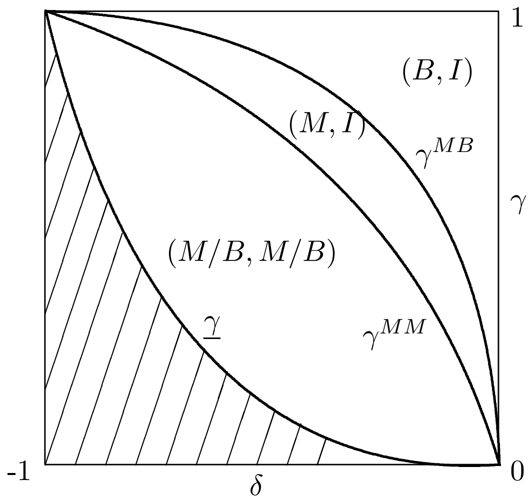


Figure 3b : the sequential game



First of all, social welfare is highest when both pairs merge. As already established, this is due to the fact that the overall price level decreases when complementors internalize the price externality. Moreover, as is known from Remark 1, bundling becomes ineffective in presence of coordinated price decisions made by rivals. This explains why $SW^{BB} = SW^{MM} = SW^{BM}$. From the welfare standpoint, this confirms that the potential negative impact of bundling is completely neutralized when alternative producers can merge (and bundle) as well.

The equilibrium analysis reveals that the simultaneous game provides a larger area in which social welfare is maximized, given that $SW^{BB} = SW^{MM}$ in $\gamma \in (\underline{\gamma}, \gamma^{MB})$. The sequential game reproduces such a favorable result only in $\gamma \in (\underline{\gamma}, \gamma^{MM})$. In $\gamma \in (\gamma^{MM}, \gamma^{MB})$, as stated in Corollary 1, the first-mover pair merges without bundling, and rivals prefer to produce separately in order to not exacerbate price competition. From welfare standpoint, this implies a social welfare loss equal to $SW^{MM} - SW^{MI}$, as only the second best solution is reached.

On the contrary, social welfare is at its lowest either when both pairs of complementors remain independent, or when one engages in bundling, and the other remain independent. The latter case deserves specific attention as it implies a specific action, taken by two complementors, which has a negative impact on society. In particular, the price increase due to bundling and the concomitant negative effect on consumer surplus is not offset by a sufficient profit gain for producers. It follows that a policy maker should prohibit bundling when the other pair has *no incentive* to merge as well. Notice that our theoretical model leaves open the possibility for each pair of complementors to merge. It is therefore a strategic decision, and not a *de facto* imposition, to remain independent.

This finding is very interesting and it may, at first sight, even seem counterintuitive, given that it involves a situation in which the merged firm bundles two products which are considered as very similar to those provided by two alternative producers ($\gamma > \gamma^{SW}$). A consumer who is only interested in good α can still buy α_j, which characteristics are are very similar to those of α_i. However, as we know from the analysis of the interval region $\gamma \in (\gamma^{MB}, 1)$, bundling increases *both* the price of the bundle *and* that of α_j and the consumer would unambiguously suffer. Bundling should therefore be prohibited in such a parametric region.

One would be tempted to think that in our framework pure bundling, in absence of cost synergies, is always socially detrimental and should therefore be prohibited tout court. This is not true. Following our previous analysis, one can easily verify that, without bundling, both in the simultaneous and in the sequential game, the equilibrium would be (*I*, *I*) in $\gamma \in (\gamma^{MM}, 1)$. While this reduces the welfare loss in $\gamma \in (\gamma^{MB}, 1)$, where (*B*, *I*) would be selected otherwise, prohibiting bundling would *generate* a welfare loss when $\gamma \in (\gamma^{MM}, \gamma^{MB})$, by not allowing to reach first best (*B*, *B*) in the simultaneous game, or second best (*M*, *I*) in the sequential game.[19]

One last remark. In the cases presented in the introduction, one of the major concern was the difficulty for rivals to be able to merge and compete with such a conglomerate as Comcast/NBC, for example. In our paper we assumed that individual producers decide whether to merge or not, and this option is costless. In presence of a costly, long or simply very difficult merging processes, the negative effect of bundling on social welfare would be even more evident, as the merged entity would decide to bundle in the large parametric region where $(\gamma + \delta) > 0$.

6 Conclusions and extensions

In this paper, the strategic interplay between the merging and bundling decisions by two pairs of complementors is analyzed. This strategic interaction is shown to depend on the intensity of market pressure and on the nature of the game. The latter depends on whether producers play simultaneously or sequentially in the preliminary stage of the game. Competitive pressure is measured by the combination between brand differentiation within the same market and product complementarity be-

[19] See also Figure A in the Appendix for a graphical representation of social welfare ranking.

tween markets. This represents one of the most important novelty of our paper, given that we admit different degrees of *both* product complementarity and brand substitutability. Although strongly inspired by recent antitrust decisions, the predictions of our model are not therefore confined to the study of composite systems that require both complements to work.

When competitive pressure is low (brands are very differentiated and/or product complementarity is relatively high), both pairs of complementors decide to merge and bundling becomes ineffective. This happens in both the simultaneous and the sequential game, and hence the first move does not convey any significant advantage. Social welfare is at its highest, as a double merger favours consumers by lowering prices.

On the contrary, when market competition is very intense, first movers opt for merging and bundling, while second mover remain independent as they can increase their prices. The surge in the overall price level results in the lowest possible level of social welfare. Bundling in this parametric region should therefore be prohibited by the antitrust agency.

The region where competitive pressure is intermediate deserves special attention, as it shows the strategic interplay between bundling and merging at its full force. In the simultaneous game both pairs of complementors bundle, and this may result in a Prisoner's dilemma as remaining independent would yield a higher payoff. In the more realistic sequential game, first movers merge without engaging in bundling. They do so in order to avoid a profit-harming merger by second movers, which prefer therefore to remain independent. Without bundling, however, in this region both pairs would stay independent, thus reducing social welfare. Hence, for an intermediate degree of market competition, one could, with caution, argue that bundling has a positive effect on social welfare.

Of course, this paper is not without some caveats. In particular, we used a simple scenario in which firms are *a priori* identical and where we assumed symmetry concerning the degree of brand substitutability and the degree of product complementarity. Moreover, we limit our attention to pure bundling. The theoretical model that we adopt may give rise to algebraic complications when studying mixed bundling. However, we believe that this does not alter the quality of our results, as it allows to examine the strategic interplay between the incentive to merge and bundle *vis-à-vis* an analogous decision by rivals, which was the object of our paper.

Appendix

Proof of Lemma 1

Due to the symmetric structure of the system, it suffices to verify that: *(i)* $\frac{\partial q_{\alpha_i}}{\partial p_{\alpha_i}} < 0$ *(ii)* $\frac{\partial q_{\alpha_i}}{\partial p_{\alpha_j}} > 0$, and *(iii)* $\frac{\partial q_{\alpha_i}}{\partial p_{\beta_i}} = \frac{\partial q_{\alpha_i}}{\partial p_{\beta_j}} < 0$. In the parametric region delimited by $\delta \in (-1, 0)$ and $\gamma \in (0, 1)$, we find that the binding condition derives from $\frac{\partial q_{\alpha_i}}{\partial p_{\alpha_j}} > 0$,which is satisfied when $\gamma > \frac{1}{2}(\sqrt{1 + 8\delta^2} - 1)$.

Proof of Lemma 2

From (10)-(11) we find that:

$$\frac{\partial q_{\alpha\beta_i}}{\partial p_{\alpha_j}} = \frac{\partial q_{\alpha\beta_i}}{\partial p_{\beta_j}} = \frac{\partial q_{\alpha_j}}{\partial p_{\alpha\beta_i}} = \frac{\partial q_{\beta_j}}{\partial p_{\alpha\beta_i}} = \frac{\gamma+\delta}{2(1-\gamma)(1+\gamma+2\delta)}; \tag{A1}$$

similarly, from (16):

$$\frac{\partial q_{\alpha\beta_i}}{\partial p_{\alpha\beta_j}} = \frac{\gamma+\delta}{2(1-\gamma)(1+\gamma+2\delta)}. \tag{A2}$$

The two expressions are equivalent, and their sign only depends on the numerator, which is positive when $\gamma + \delta > 0$, and negative otherwise. Indeed, looking at the denominator, we know that $2(1-\gamma)(1+\gamma+2\delta) > 0 \Leftrightarrow \gamma > (-2\delta - 1)$ but $\underline{\gamma} = \frac{1}{2}(\sqrt{1+8\delta^2} - 1) > (-2\delta - 1)$ by which the sign of $2(1-\gamma)(1+\gamma+2\delta)$ is always positive in $\gamma > \underline{\gamma}$.

Proof of Proposition 1

From Table 2, notice that $\pi_y^{MM} = \pi_y^{BM} = \pi_y^{BB}$, $y = i, j$. Focusing on pair i (pair j is symmetric), the other relevant profit comparisons are:

$$\begin{aligned} \pi_i^{MI} &> \pi_i^{II} \Longleftrightarrow \gamma < \gamma^{MI}; && \text{(A3)} \\ \pi_i^{MM} &> \pi_i^{IM} \equiv \pi_j^{MI} \Longleftrightarrow \gamma < \gamma^{MM}; && \text{(A4)} \\ \pi_i^{MB} &> \pi_i^{IB} \equiv \pi_j^{BI} \Longleftrightarrow \gamma < \gamma^{MB}; && \text{(A5)} \\ \pi_i^{BI} &> \pi_i^{MI} \Longleftrightarrow \gamma + \delta > 0,\ i.e. \gamma > -\delta; && \text{(A6)} \\ \pi_i^{BI} &> \pi_i^{II} \text{ always in } \gamma \in (\underline{\gamma}, 1). && \text{(A7)} \\ \pi_i^{MM} &> \pi_i^{II} \Longleftrightarrow \gamma < \gamma^{II}; && \text{(A8)} \end{aligned}$$

The explicit algebraic expressions of the above threshold values of γ are not reported in order to avoid tedious algebraic formulas. Moreover, in the parametric region under investigation, it is possible to verify that

$$\underline{\gamma} < -\delta < \gamma^{II} < \gamma^{MI} \lesssim \gamma^{MM} < \gamma^{MB} < 1. \tag{A9}$$

We then have to consider six subintervals:

1. In $\gamma \in (\underline{\gamma}, -\delta)$, merging without bundling (M) is dominant strategy for pair i given that: $\pi_i^{MI} > \pi_i^{BI} > \pi_i^{II}$, $\pi_i^{MM} = \pi_i^{BM} > \pi_i^{IM}$ and $\pi_i^{MB} = \pi_i^{BB} > \pi_i^{IB}$. The same obviously holds for symmetric pair j. Moreover, $\pi_i^{MM} = \pi_i^{BB} > \pi_i^{II}$. The unique Nash equilibrium in (weakly) dominant strategies is (M, M), which is also Pareto dominant.

2. In $\gamma \in (-\delta, \gamma^{II})$, the important change with respect to the previous case is that bundling becomes the dominant strategy as $\pi_i^{BI} > \pi_i^{MI}$; it follows that $\pi_i^{BI} > \pi_i^{MI} > \pi_i^{II}$, and similarly for player j. The Nash equilibrium in (weakly) dominant strategies is therefore (B, B), which is also Pareto dominant as $\pi_i^{BB} = \pi_i^{MM} > \pi_i^{II}$.

3. In $\gamma \in (\gamma^{II}, \gamma^{MI})$, the only difference with respect to the previous case is that $\pi_i^{MM} = \pi_i^{BB} < \pi_i^{II}$. Bundling is still dominant strategy for both players, but the game is a prisoner's dilemma given that the Nash equilibrium (B, B) is Pareto dominated by (I, I).

4. The subinterval $\gamma \in (\gamma^{MI}, \gamma^{MM})$ is very small as the two threshold values tend to coincide. Now $\pi_i^{II} > \pi_i^{MI}$, but this does not alter the dominance given that $\pi_i^{BI} > \pi_i^{II} > \pi_i^{MI}$. The Nash equilibrium in (weakly) dominant strategies is still represented by (B, B) and the game is again a prisoner's dilemma.

5. In $\gamma \in (\gamma^{MM}, \gamma^{MB})$ the situation is more complicated. As in the previous interval, $\pi_i^{BI} > \pi_i^{II} > \pi_i^{MI}$. Differently from before, however, now $\pi_i^{MM} = \pi_i^{BM} < \pi_i^{IM}$, and bundling is not anymore a dominant strategy for i: when rival pair j opts for merging, complementors in i would prefer to remain independent. Nonetheless, (I, M) is not a Nash equilibrium, as rivals in j would respond by bundling when observing that complementors in i remain independent (by symmetry, $\pi_j^{IB} > \pi_j^{II} > \pi_j^{IM}$). But given that it continues to hold that $\pi_i^{MB} = \pi_i^{BB} > \pi_i^{IB}$, i would prefer to bundle as well when j bundles. The unique Nash equilibrium is represented again by (B, B), which is Pareto dominated by (I, I), as we already know.

6. Finally, in $\gamma \in (\gamma^{MB}, 1)$, $\pi_i^{IB} > \pi_i^{MB} = \pi_i^{BB}$ (and obviously $\pi_j^{BI} > \pi_j^{BM} = \pi_j^{BB}$) This, combined with the fact that $\pi_i^{BI} > \pi_i^{II} > \pi_i^{MI}$ (and $\pi_j^{IB} > \pi_j^{II} > \pi_j^{IM}$), demonstrates the existence of two Nash equilibria: (B, I) and (I, B). In this region we have therefore a chicken game with two asymmetric equilibria along the secondary diagonal.

As a consequence, considering that subintervals 3, 4 and 5 provide the same outcome, we find the four relevant parametric regions that are reported in Proposition 1.

Proof of Lemma 3

Consider pair of complementors i and the equilibrium prices which appear in Table 2. When rivals in j remain independent, we find that:

$$p_{\alpha\beta_i}^{BI} > p_{\alpha_i}^{II} + p_{\beta_i}^{II} \iff \gamma > \gamma^P; \tag{A10}$$

$$p_{\alpha\beta_i}^{BI} > p_{\alpha_i}^{MI} + p_{\beta_i}^{MI} \iff \gamma + \delta > 0, \ i.e. \gamma > -\delta. \tag{A11}$$

Moreover, we already know that $p_{\alpha_i}^{MI} + p_{\beta_i}^{MI} < p_{\alpha_i}^{II} + p_{\beta_i}^{II}$ due to the Cournot effect. For the reasons explained before, the explicit expressions of γ^P is omitted. However, it is relatively simple to find that

$$\underline{\gamma} < -\delta < \gamma^P < 1. \tag{A12}$$

By combining the above ranking with the results in (A10) and (A11), we obtain the price inequalities reported in the three different regions of interest.

Proof of Proposition 2

Let us proceed backwardly and analyze the decision of player j in response to the strategy selected by player i:

(i) If i remains independent (I), then j compares π_j^{II} with π_j^{IM} and π_j^{IB}. From Table 1 we know the value of π_j^{II} and, by symmetry, $\pi_j^{IM} = \pi_i^{MI}$ and $\pi_j^{IB} = \pi_i^{BI}$. Considering (A3), (A6) and (A7), respectively, we find then that $\pi_j^{IM} > \pi_j^{II} \iff \gamma < \gamma^{MI}$, $\pi_j^{IB} > \pi_j^{II}$ always and $\pi_j^{IB} > \pi_j^{IM} \iff \gamma > -\delta$. From (A9), the following ranking applies: $\underline{\gamma} < -\delta < \gamma^{MI} < 1$. This, combined with the previous profit comparisons, indicates that j responds by merging (M) in $\gamma \in (\underline{\gamma}, -\delta)$, while it merges *and* bundles (B) in $\gamma \in (-\delta, 1)$. Player j gets π_j^{IM} in the former parametric region and π_j^{IB} in the latter one.

(ii) If i decides to merge (M), then j compares π_j^{MI} with $\pi_j^{MM} = \pi_j^{MB} (= \pi_j^{BM})$. From (A4) we know that $\pi_j^{MM} = \pi_i^{MM} > \pi_j^{MI} \iff \gamma < \gamma^{MM}$, where $\gamma^{MM} > \underline{\gamma}$. It follows that j opts for merging (with or without bundling, hence M/B) in $\gamma \in (\underline{\gamma}, \gamma^{MM})$, obtaining $\pi_j^{MM} = \pi_j^{MB}$, while it remains independent (I) in $\gamma \in (\gamma^{MM}, 1)$ and gets π_j^{MI}.

(iii) If i merges and adopts bundling (B), rival pair j contrasts π_j^{BI} and $\pi_j^{BB} = \pi_j^{BM}$. From (A5) we easily obtain that $\pi_i^{MB} = \pi_j^{BB} > \pi_i^{IB} \equiv \pi_j^{BI} \iff \gamma < \gamma^{MB}$, where $\gamma^{MB} > \underline{\gamma}$. Hence, player j merges (with or without bundling, M/B) in $\gamma \in (\underline{\gamma}, \gamma^{MB})$ and gets $\pi_j^{BB} = \pi_j^{BM}$, while it remains independent (I) in $\gamma \in (\gamma^{MB}, 1)$, where its profit is given by π_j^{BI}.

We can now consider the strategy adopted by player i, which anticipates the best response of the rival. From (A9) we know that, in $\delta \in (-1, 0)$ the γ-threshold values of interest can be ranked as follows: $\underline{\gamma} < -\delta < \gamma^{MM} < \gamma^{MB} < 1$. We then have to consider four subintervals:

1. In $\gamma \in (\underline{\gamma}, -\delta)$, the follower j opts for M when it observes that i remains independent (I), while it plays M/B otherwise. First mover i compares therefore π_i^{IM} with $\pi_i^{BM} = \pi_i^{MB} = \pi_i^{MM} = \pi_i^{BB}$. We already know that $\pi_j^{MM} = \pi_i^{MM} > \pi_j^{MI} = \pi_i^{IM} \iff \gamma < \gamma^{MM}$, with $-\delta < \gamma^{MM}$. It follows that in this first region player *i* decides to merge (with or without bundling), and as a consequence player *j* does the same. The subgame perfect equilibrium is (*M/B, M/B*)

2. In $\gamma \in (-\delta, \gamma^{MM})$, the only difference is that player j decides to bundle (B) if i selects *I*, while it continues to play M/B otherwise. Player *i* now confronts π_i^{IB} with $\pi_i^{BM} = \pi_i^{MB} = \pi_i^{MM} = \pi_i^{BB}$. Again, we know that $\pi_j^{MM} = \pi_i^{MM} > \pi_j^{BI} = \pi_i^{IB} \iff \gamma < \gamma^{MB}$. Given that $\gamma^{MM} < \gamma^{MB}$, also in this region player *i* merges (with or without bundling), and the same does player *j*. The subgame perfect equilibrium is therefore the same as in region 1.

3. In $\gamma \in (\gamma^{MM}, \gamma^{MB})$ the situation is more complicated, as player j respectively: bundles (B) when i plays I; remains independent (I) when i selects M; merges with or without bundling

(M/B) when i opts for B. First mover i then compares π_i^{IB}, π_i^{MI} and $\pi_i^{BM} = \pi_i^{BB}$. From the previous point $\pi_i^{MM} = \pi_i^{BM} > \pi_i^{IB} \iff \gamma < \gamma^{MB}$; moreover, we find that $\pi_i^{MI} > \pi_i^{MM} \iff \gamma > -\delta$. These results, combined with the previous ranking of threshold values of γ, imply that in this third interval region $\pi_i^{MI} > \pi_i^{MM} = \pi_i^{BM} > \pi_i^{IB}$. Player i hence opts for merging without bundling, and as a consequence j remains independent. The subgame perfect equilibrium is (M, I).

4. In $\gamma \in (\gamma^{MB}, 1)$, player j continues to bundle (B) when i selects I, while it decides to remain independent (I) when i opts for either M or B. Player i now compares π_i^{IB}, π_i^{MI} and π_i^{BI}. Algebraic calculations confirm that $\pi_i^{BI} > \pi_i^{MI} \iff \gamma > -\delta$ and $\pi_i^{BI} > \pi_i^{IB} \iff \gamma > -\delta$. As $\gamma^{MB} > -\delta$, in our last interval region player i chooses bundling, and j remains independent. The subgame perfect equilibrium is (B, I).

Proof of Proposition 3

When both pairs of complementors remain independent, consumer surplus can be easily computed:

$$CS^{II} = \frac{2\left(1+\gamma-2\delta^2\right)^2}{(1+\gamma+2\delta)\left[\gamma^2-\gamma(1+2\delta)-2(1-\delta-\delta^2)\right]^2} \tag{A13}$$

By summing up consumer surplus and the profit of the four producers (see Table 1), social welfare amounts to:

$$SW^{II} = \frac{2\left(1+\gamma-2\delta^2\right)\left[3-2\gamma^2-2\delta(2+\delta)+\gamma(1+4\delta)\right]}{(1+\gamma+2\delta)\left[\gamma^2-\gamma(1+2\delta)-2(1-\delta-\delta^2)\right]^2}. \tag{A14}$$

When both merge without bundling, consumer surplus and social welfare are respectively given by:

$$CS^{MM} = \frac{2\,(1+\delta)^2}{(1+\gamma+2\delta)\,(2+\delta-\gamma)^2}, \tag{A15}$$

$$SW^{MM} = \frac{2\,(1+\delta)\,(3-2\gamma+\delta)}{(1+\gamma+2\delta)\,(2+\delta-\gamma)^2}. \tag{A16}$$

In the asymmetric case where one pair merges (without bundling) and the other remains independent:

$$CS^{MI} = \frac{\Gamma}{(1+\gamma+2\delta)\left\{4-\gamma^2(1+\gamma)+\delta(2+\delta)(1-6\delta)+\gamma\left[4+\delta(4+5\delta)\right]\right\}^2}, \tag{A17}$$

where

$$\begin{aligned}\Gamma \;=\;& 2(1+\gamma)^2(2+\gamma)^2+2\delta(1+\gamma)^2(2+\gamma)(5+\gamma)-3\delta^2(1+\gamma)\left[9+(4-\gamma)\gamma\right]+\\ & -\delta^3\left\{97+\gamma\left[145+\gamma(43+3\gamma)\right]\right\}-2\delta^4(5+\gamma)(1+5\gamma)+24\delta^5+72\delta^6,\end{aligned}$$

and:

$$SW^{MI}=\frac{\Theta}{(1+\gamma+2\delta)\left\{4-\gamma^2(1+\gamma)+\delta(2+\delta)(1-6\delta)+\gamma\left[4+\delta(4+5\delta)\right]\right\}^2} \tag{A18}$$

where

$$\begin{aligned}\Theta &= 2(1+\gamma)^2(2+\gamma)^2(3-\gamma)+2\delta(1+\gamma)(2+\gamma)\left\{9+\gamma\left[9-\gamma(5+\gamma)\right]\right\}+\\ &\quad -\delta^2(1+\gamma)\left\{121-\gamma\left[36+\gamma(45+4\gamma)\right]\right\}-\delta^3\left\{197+\gamma\left[193-\gamma(65+37\gamma)\right]\right\}+\\ &\quad +2\delta^4\left[61-\gamma(86+11\gamma)\right]+24\delta^5(11-5\gamma)+72\delta^6.\end{aligned}$$

Now we can consider bundling: when one pair (merges) and bundles, while the other remain independent, we find:

$$CS^{BI}=\frac{(1+\delta)\cdot\Delta}{16(1+\gamma+2\delta)\left[2-\gamma(\gamma+2\delta)+\delta(3-\delta-\delta^2)\right]^2} \tag{A19}$$

where:

$$\begin{aligned}\Delta &= 32+3\gamma^5+\gamma^4(1+24\delta)+2\gamma^2\left\{\delta\left[\delta(56\delta-27)-52\right]-8\right\}+\gamma^3(74\delta^2-20-8\delta)+\\ &\quad +\delta\left\{112+\delta(76+\delta\left[\delta(32\delta-55)-80\right]\right\}+\gamma\left[32-\delta(2-\delta)(87\delta^2+78\delta-4)\right],\end{aligned}$$

$$SW^{BN}=\frac{(1+\delta)\left[2(1-\gamma)\Upsilon+\Delta\right]}{16(1+\gamma+2\delta)\left[2-\gamma(\gamma+2\delta)+\delta(3-\delta-\delta^2)\right]^2} \tag{A20}$$

where:

$$\Upsilon=\left\{\left[4-\gamma(\gamma-2+4\delta)-\delta(4-5\delta)\right]^2+2(2+\gamma+3\delta)^2\left[2(1+\delta)-(\gamma+\delta)^2\right]\right\}$$

Finally, consumer surplus and total welfare in *BM* an *BB* are the same as in *MM*, as we know from Remark 1. Hence:

$$CS^{BM}=CS^{BB}=CS^{MM};\ SW^{BM}=SW^{BB}=SW^{MM}. \tag{A21}$$

Using Mathematica, it is possible to demonstrate that, in the admissible interval region defined by Lemma 1:

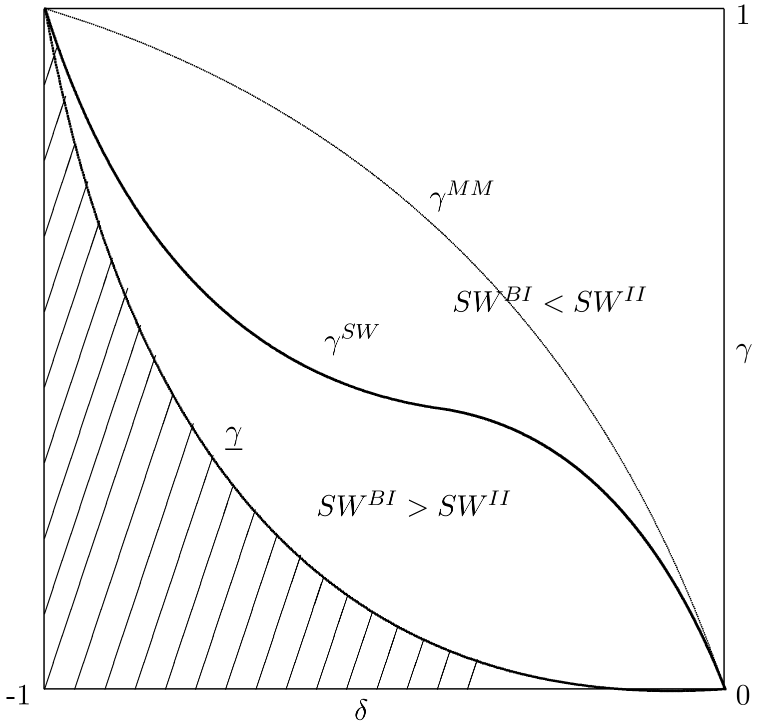
$$SW^{BM}=SW^{BB}=SW^{MM}>SW^{MI}>SW^{II}. \tag{A22}$$

The last comparisons involves SW^{BI}. We find that $SW^{MI}>SW^{BI}$ and:

$$SW^{II}>SW^{BI}\iff\gamma>\gamma^{SW}. \tag{A23}$$

Moreover, $\underline{\gamma}<\gamma^{SW}<\gamma^{MM}<\gamma^{MB}$. Additional calculations are available upon request. However, as they imply algebraic expressions which have been evaluated through Mathematica, we decided not to write their explicit expression in the text. To help the reader, however, we represent in Figure A the threshold value γ^{SW} together with γ^{MM} in the parametric region of interest.

Figure A : Social welfare ranking



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