When Is Building a Library Consortium Beneficial?*

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Abstract

This paper identifies strategies to build a library consortium from a long term point of view. Contrary to the conventional wisdom to build a consortium around groups of homogenous institutions (Davis, 2002), we find that libraries with similar preferences are likely to lose from building a consortium while libraries with opposite preferences almost always gain from it. Our results suggest a strong tension between a short-term strategy and a long-term strategy as long as the former dictates forming a consortium around libraries with homogenous preferences in order to gain from quantity discounts. This tension might create a "library consortium trap".

Keywords: Library Consortium, Academic Journals, Personalized Prices, Correlation, Multimarket Contact, Level-playing Field

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1 Introduction

Electronic publishing has brought fundamental changes in the market for academic journals. It allowed large publishers to practice 'Big Deal'[1] pricing strategies by bundling a large collection of journals. At the same time, it induced libraries to form consortia, whereby libraries of a given geographical area join forces in order to share acquisition of electronic academic journals licensed through the Big Deal.

Academic library consortia are widespread. Virtually every country or region has built or has the possibility of building a national or regional library consortium. North American examples include OhioLINK, the Triangle Research Libraries Network of North Carolina (TRLN), the Greater Western Library Alliance (GWLA), the Colorado Alliance of Research Libraries (CARL) and the Ontario Council of University Libraries (OCUL). Some well-known European groups include HEAL-LINK (Greek academic libraries including the National Library) and CBUC (academic libraries of Catalonia in Spain).[2] Moreover, existing consortia can decide to expand by forming a mega consortium.

In this paper, we aim at identifying strategies to make a library consortium beneficial from a long term point of view as is suggested by Thomas A. Peters (2001a), director of center for library initiatives,

"One challenge for academic library consortia is to shift gears and engage in more deliberate strategic planning with an eye to positive long-terms outcomes".

If one thinks that publishers propose menu of prices with quantity discounts based on the number of potential users, then it might be desirable to build consortia with libraries with similar preferences in terms of their preferred journals. Actually, this strategy is what Philip M. Davis (2002), a bibliographer at Cornell University, recommends.

"It is recommended that institutions consider their consortia membership and organize themselves into groups of homogenous institutions with similar missions".

Actually, Gatten and Sanville (2004) compute the Spearman's correlation coefficients between each pair of member institutions of OhioLINK,[3] and find that overall relative use of Big Deal titles between member institutions correlates highly. This might indicate that OhioLink adopted a strategy of building a consortium with libraries with similar

[1] Big Deal is defined as "any online aggregation of e-content that a publisher, aggregator, or vendor offers for sale or lease at prices and/or terms that substantially encourage acquisition of the entire corpus" (Peters, 2001b).

[2] Other examples include: CAUL CEIRC (Australia), ANSF (Brazil), CALIS (China), MALMAD (Israel), INFER (Italy).

[3] The coefficient varies between -1 and 1. To get it, they first compute the rank order of titles by each institution's total downloads and study how closely the rank orders of each pair of institutions correlate.

preferences. However, the reasoning based on quantity discounts implicitly assumes that publishers' price schedules do not change much after forming a consortium, which can be true in a short-run but cannot be true in a long-run. In fact, Dewatripont et al. (2006) point out that

"we may fear that consortia in fact strengthen the possibility for publishers to charge a high price for their electronic collection (p.52)."

In this paper, we take a long-term view in the sense that publishers change their prices after libraries form a consortium. Actually, publishers' price offers are tailored directly to individual characteristics of libraries or consortia.[4] Furthermore, it is now easy to estimate the value of a given journal to a library since its publisher and the library can observe the number of downloads of the journal (Gatten and Sanville, 2004 and Scigliano 2010).[5]

To describe the market for academic journals, we build on the framework of our previous papers (Jeon and Menicucci, 2006 and 2011) where each (for-profit) publisher competes by offering its bundle of journals at a personalized price to each different library (or consortium) under complete information about the library's preferences and budget.[6] When several libraries build a consortium, we assume that all their budgets are pooled and the consortium maximizes the sum of each member library's surplus. However, building the consortium triggers publishers' reactions since each publisher now offers a new personalized price of its bundle to the consortium, taking into account the preferences and budget of the consortium. In this setting, we study the conditions under which building a consortium is beneficial.

Since we consider that publishers make price offers (simultaneously) before libraries make purchase decisions, our model does not capture any gain from increase in the buyer power of libraries. However, Dewatripont et al. (2006) argue that "since researchers do not see the various publishers as good substitutes and need access to all journals, consortia only introduce a relatively weak 'buyer power' (p.8)." [7] In addition, in our framework,

[4] According to Edlin and Rubinfeld (2004), "Here, the price that a buyer is quoted depends upon the buyer's observable characteristics. ... Moreover, in practice, the price of the Big Deal is often individually negotiated with a given library or with groups of libraries called "consortia," offering further opportunities for the publisher to price based on individual characteristics."

[5] According to Derk Haank (2001), CEO of Elsevier Science "What we are basically doing is to say that you pay depending on how useful the publication is for you - estimated by how often you use it."

[6] Jeon and Menicucci (2006) show that bundling is dominant strategy for each publisher in this framework.

[7] Dewatripont et al. (2006) give another reason for which consortium is unlikely to increase buyer power. "This 'buyer concentration' remains however modest in comparison with publisher concentration: the largest library consortium represents 2 or 3% of global journal purchases, while the largest publisher represents more than 20% of journal sales (p.8)".

there is no gain from building a consortium in the case of a monopolist publisher since a monopolist charges a price equal to the budget (as long as the value of the bundle of the monopolist is not smaller than the budget, which we assume).

Therefore, we essentially focus on how forming a consortium affects the competition among publishers, which we think provides a long-term perspective since only competition can restrain the amount of surplus that each publisher can extract in a long run. More precisely, we focus on the question of whether a consortium should be formed by libraries with similar preferences (as Davis (2002) recommends) or by libraries with opposite preferences.

Contrary to some conventional wisdom to build consortium around groups of homogenous institutions (Davis, 2002), we find that (i) libraries with similar preferences have almost nothing to gain or lose from building a consortium; (ii) libraries with opposite preferences almost always gain from building a consortium; (iii) in general, building a consortium increases the total surplus only if the member libraries' preferences are heterogenous enough to create a level-playing field among different individually-preferred publishers.

In our model, the value that a library obtains from a publisher's bundle is assumed to be independent from the value that it obtains from another publisher's bundle. Therefore, competition among bundles of journals in the market for a given library is generated by the library's budget constraint. In particular, if the library prefers too much the bundle of a certain publisher, this can induce a monopoly outcome in the sense that there is no budget left for other bundle(s) after paying for the preferred bundle.

In order to provide an intuition for our results, let us first consider the case of two identical libraries (i.e., the extreme case of perfectly positive correlation). Then, the consortium has no impact neither on libraries nor on publishers, since each library continues to consume the same bundles and bear the same expenses, as without the consortium. Consider now the other extreme case of perfectly negative correlation. Suppose that library 1 (2) likes so much bundle A (B) that library 1 (2) consumes only bundle A (B) in the absence of the consortium. Then, building a consortium creates a level-playing field between the two publishers such that no publisher monopolizes the market for the consortium and each library ends up consuming both bundles. Last, let us consider the intermediate case in which library 1 consumes only bundle A while library 2 consumes both bundles A and B without the consortium. Then, the consortium can either increase or decrease the total surplus depending on the size of its budget. If the budget is small enough, publisher A can export its residual monopoly power from library 1 to library 2 and monopolize the entire market of the consortium. This logic is similar to the one that multimarket contact allows firms to export residual collusive power from one market to another (Bernheim and Whinston, 1990). On the contrary, if the budget is large enough,

publisher A cannot monopolize the entire market of the consortium and the consortium consumes both bundles.

We show that our main insight is robust to making the budget of each library chosen in an endogenous way by a benevolent funding authority. Actually, the prediction becomes sharper in the case of endogenous budget since two libraries can never gain from building a consortium when their preferences are positively correlated no matter what the degree of correlation. In the case of negative correlation, the result obtained from the scenario of endogenous budget is remarkably similar to the result obtained from the scenario of exogenous budget: in both scenarios, the range of parameters for which building a consortium is beneficial increases with the absolute degree of correlation.

Finally, even if we focused on the market for academic journals, our results can be applied to other markets as long as buyers face budget constraint. For instance, in the market for drugs or vaccines sold to hospitals, hospitals often form a group for joint purchase and pharmaceutical firms offer personalized non-linear tariffs. More precisely, in the French antitrust case against GlaxoSmithKline France (Autorité de Concurrence, 2007), GlaxoSmithKline offered different non-linear prices to different hospitals or groups of hospitals. French antitrust authority condemned the firm's practice of bundling two different drugs by arguing that because of the budget constraint of hospitals, bundling a monopoly drug with another can allow the firm to leverage the monopoly power from one to another even if the two drugs are very different.

The paper is organized as follows. Section 1.1 reviews the related literature. Section 2 presents our model. Section 3 obtains a general result in the case of a consortium of n libraries. Section 4 provides more precise results focusing on correlation of preferences by considering a consortium of two libraries. Section 5 studies the scenario of endogenous budget. Section 6 provides concluding remarks.

1.1 Literature review

Our paper is related to the papers that study buyer group when sellers compete: Inderst and Shaffer (2007), Marvel and Yang (2008), Dana (2012), Chen and Li (2013). Among those paper, our paper is more closely related to Inderst and Shaffer (2007) and Dana (2012) since they assume that sellers have complete information on buyers' preferences and hence can offer personalized tariffs, regardless of whether or not buyers form a group.[8]

[8] For instance, in Marvel and Yang (2008) and Chen and Li (2013), buyers are located on the Hotelling line and each seller makes the same price offer to all buyers in the absence of buyer group. However, Marvel and Yang (2008) and our paper are similar in one aspect: when buyers form a group, sellers propose non-linear tariffs and the group can buy a positive quantity from both sellers.

Although the two papers differ in the way they generalize their results,[9] the main insight can be obtained by considering a two-seller-two-buyer setting in which each buyer buys one unit from only one of the two sellers. They assume that the buyer group makes exclusive purchase commitment and that sellers make a take-it-or-leave-it offer. In this setup, a buyer group never decreases its members' total payoffs: it strictly increases the members' total payoffs unless they have identical preferences; it has no impact on the members' payoffs in case of identical preferences. There are two main differences between our paper and Inderst and Shaffer (2007) and Dana (2012). In our paper, the buyer group (i.e., library consortium) does not make exclusive purchase commitment and each buyer (or buyer group) can buy journals from both sellers. Contrary to what happens in their papers, forming a buyer group can reduce the members' total payoffs.

Some papers study buyer coalition in a monopoly setting. Chipty and Snyder (1999) and Inderst and Wey (2007) consider some specific bargaining models and find that a convex cost function for the seller helps to make profitable the formation of a buyer group. This occurs because the incremental costs to serve the group is lower than the sum of the incremental cost to serve each member, and buyers are assumed to have some bargaining power. Since we consider digital good with take-it-leave-it offers from sellers, this effect is absent in our setting. Innes and Sexton (1993, 1994) analyze the case in which a monopolist is facing identical consumers who may form coalitions. They show that even though consumers' characteristics are homogeneous, the monopolist may price discriminate in order to deter the formation of coalitions, whereas price discrimination is unprofitable in the absence of coalitions. Alger (1999) studies a monopolist's optimal menu of price-quantity pairs when (a continuum of) consumers can purchase multiple times and/or jointly in a two-type setting. While the previous papers consider buyer coalition formation under complete information, Jeon and Menicucci (2005) study a monopolist's optimal menu of price-quantity pairs when buyers form a coalition under asymmetric information between themselves.

Our paper builds on the theoretical literature on the market for academic journals which studies issues raised by the move to electronic publishing.[10] The literature has studied bundling and/or price discrimination (McCabe, 2004, Jeon and Menicucci, 2006, Armstrong 2010), interoperability (Jeon and Menicucci, 2011), open access journals (McCabe and Snyder, 2007, Jeon and Rochet, 2010, Armstrong 2014). We contribute to the literature by studying the issue of library consortium.

[9] Inderst and Shaffer (2007) consider competition in non-linear tariff between the two sellers and extend their result to a bargaining setup. They also make each seller's choice of product characteristics endogenous. Dana (2012) considers n sellers, a continuum of buyers, and allows that different buyer groups are formed. He proves that the grand coalition is a coalition-proof subgame perfect equilibrium when there are two sellers.

[10] See Bergstrom (2001) and Dewatripont et al. (2006) for an introduction.

Although we consider a common agency under complete information, (Bernheim and Whinston, 1986, 1998, Jeon and Menicucci, 2012), the well-known result that competition among sellers achieves the outcome that maximizes the joint payoff of all sellers and the buyer fails to hold in our setting because of the budget constraint. In contrast, Jeon and Menicucci (2012) show that the result holds if the buyer faces a slot constraint instead of a budget constraint.

Our result that libraries with opposite preferences (instead of libraries with similar preferences) should form a library consortium is reminiscent of a classic paper in the bundling literature, Adams and Yellen (1976), that shows that pure bundling of two products gives a monopolist a higher (resp. a lower) profit than independent pricing if buyers' valuations of the products are negatively correlated (resp. positively correlated). However, the two papers differ in many aspects. Adams and Yellen consider bundling of two products sold by a monopolist to a mass of heterogenous consumers whereas we study library consortium when publishers compete by offering personalized prices to each buyer.

Our paper also belongs to the emerging literature on personalized pricing (Chen and Iyer, 2002, Choudhary et al., 2005, Ghose and Huand, 2009, Shaffer and Zheng, 2002, Thisse and Vives, 1988). Personalized pricing refers to the practice that firms offer customized prices on a one-to-one basis to each customer (an individual or a firm), which has become possible since advances in information technologies and the Internet allow firms to identify each customer with greater accuracy and cost-effectiveness.

2 A simple model of the market for academic journals.

As we mentioned in the introduction, we build on the model of our previous papers (Jeon and Menicucci, 2006 and 2011) and accordingly assume that publishers have complete information about the value that a library attaches to each journal and about the library's budget, and offer personalized prices based on the information. In the baseline model, the budget of each library is exogenously given. In Section 5, we study the scenario in which the budget of each library is endogenously determined.

There are two (for-profit) publishers, A and B, and $n \geq 2$ libraries. Without loss of generality, we assume that each publisher offers only the pure bundle of its own journals.[11] Let B_j represent the bundle offered by publisher j $(= A, B)$. The monetary utility of library i $(= 1, ..., n)$ from consuming B_j is denoted by $U_j^i > 0$ (and is independent of

[11] Arguing as in the proof of Proposition 2(i) in Jeon and Menicucci (2006), we can prove that, for each publisher, pure bundling of its journals weakly dominates any alternative to pure bundling.

whether the library also consumes the other bundle) and the budget of library i is $M^i > 0$. The payoff of a library is given by the utility it obtains from the bundles of journals it buys minus the money it spends for the purchases.

Let C represent the consortium of the n libraries. The utility of the consortium C from consuming B_j and the budget of the consortium are given by:

$$U_j^C = \sum_{i=1}^{n} U_j^i, \qquad M^C = \sum_{i=1}^{n} M^i.$$

As for each member library, the payoff of the consortium is the utility it obtains from the bundles of journals it buys minus the money it spends for the purchases.

Let $P_j^i > 0$ represent the price that publisher j $(= A, B)$ charges to library i $(= 1, ..., n, C)$ for bundle B_j. We assume that the fixed cost of producing the first copy of each journal in B_j has already been incurred and that the marginal cost of distributing a journal is zero. Therefore, publisher j's profit is equal to publisher j's revenue.

Social welfare is equal, up to a constant, to the total payoff the libraries obtain from consuming bundles of journals, and therefore it is maximized when all libraries consume both bundles.

We consider the following two-stage game. At stage one, each publisher j simultaneously chooses $P_j^i > 0$ for $i = 1, ..., n$ $(P_j^C > 0)$ if there is no buyer group (if the buyer group is formed). At stage two, each library (the consortium) decides the bundle(s) to buy. Notice that we require $P_j^i > 0$, and exclude $P_j^i = 0$, because in some cases a publisher j earns a library's entire budget, and thus there is no money left for publisher $j' \neq j$. Then our assumption of positive prices rules out the possibility that publisher j' gives away $B_{j'}$ for free. Thus, in a sense we suppose that each publisher prefers not selling its bundle to selling it at zero price, which can be justified if there is an epsilon cost of contracting.

Consider competition in the market for a given library i $(= 1, ..., n, C)$. We eliminate the superscript i and without loss of generality we assume $U_A \geq U_B$. Then, from our previous papers, we have[12]

Lemma 1 *(Jeon and Menicucci, 2006 and 2011) Consider competition between two publishers in the market for a given library:*

(i) if $M \leq U_A - U_B$, then publisher A charges $P_A = M$, publisher B charges an arbitrary $P_B > 0$, and the library buys only B_A;

[12] In fact, in Jeon and Menicucci (2006, 2011) we assume that publishers play a three-stage game in which first each publisher simultaneously decides whether to be active or not, and then only active publishers compete in prices (libraries cannot buy from inactive publishers). However, when there are only two publishers, this three-stage game yields the same outcome that is described by Lemma 1 for our two-stage game.

(ii) if $U_A - U_B < M < U_A + U_B$, then publishers charge $P_A = \frac{1}{2}(M + U_A - U_B)$, $P_B = \frac{1}{2}(M + U_B - U_A)$, and the library buys both bundles;

(iii) if $U_A + U_B \leq M$, then publishers charge $P_A = U_A$, $P_B = U_B$, and the library buys both bundles.

Precisely, when $M \leq U_A - U_B$, only publisher A succeeds in selling its bundle because even when A charges $P_A = M$ (the highest feasible price), the library's payoff from buying only B_A, $U_A - M$, is larger than the payoff from buying only B_B, $U_B - P_B$, for any $P_B > 0$. On the other hand, if $M > U_A - U_B$ then the library buys both bundles and it is simple to see that $P_A = U_A$, $P_B = U_B$ when $M \geq U_A + U_B$: in this case the budget does not matter and each bundle is sold to the library at its full value. When instead $U_A - U_B < M < U_A + U_B$, prices are determined by the indifference condition

$$U_A - P_A = U_B - P_B \tag{1}$$

and by the binding budget constraint

$$P_A + P_B = M. \tag{2}$$

In particular, (1) implies that the library is indifferent between purchasing only B_A and purchasing only B_B. Thus no publisher j has an incentive to increase its price above P_j since then the library can not afford to buy both bundles (because of the binding budget constraint) and would buy only the bundle of the rival publisher.

Lemma 1 applies both to each library without the consortium, and also to the consortium. In the next sections, we compare the outcome without the consortium and the outcome with the consortium.

3 Consortium of n libraries for exogenous budgets

In this section, we consider the model of n libraries introduced in Section 2. We assume

Assumption 1: $M^i \leq U_A^i + U_B^i$ for $i = 1, ..., n$.

If Assumption 1 is not satisfied for library i, there is no competition between the two publishers in the market for library i since each publisher extracts the full surplus. Hence, this assumption implies that the two publishers compete, because of the budget constraint, in the market for any given library $i = 1, ..., n$. As a consequence, every library i ends up spending its whole budget to purchase the journals of the two publishers.[13] Assumption 1 also implies that $M^C \leq U_A^C + U_B^C$, and thus also the consortium spends its whole budget

[13] In Section 5 in which we make the budget endogenous, Assumption 1 is always satisfied

to buy bundle(s). Therefore, in order to determine the effects of building a consortium on libraries' payoffs, we only need to study how libraries' consumption of bundles is affected.

Without loss of generality, we assume that $\Delta^C \equiv U_A^C - U_B^C$ is non-negative and that there exists an n' between 1 and n such that $\Delta^i \equiv U_A^i - U_B^i \geq 0$ for $i = 1, ..., n'$ and $\Delta^i < 0$ for $i = n'+1, ..., n$. Libraries $1, ..., n'$ are called *type* A libraries (there is a non-empty set of type A libraries since $U_A^C \geq U_B^C$); the other libraries (if any) are called *type* B libraries.

Lemma 1 makes clear that the only characteristics of library i which matter are Δ^i and M^i. Without the consortium, library i of type j buys only B_j if $M^i \leq |\Delta^i|$, buys both bundles if $M^i > |\Delta^i|$, for $j = A, B$. Likewise, the consortium buys only B_A if $M^C \leq \Delta^C$ (recall that $\Delta^C \geq 0$), buys both bundles if $M^C > \Delta^C$. These remarks deliver the following results.

Proposition 1 *(exogenous budget) Suppose Assumption 1 and (without loss of generality) $\Delta^C \equiv U_A^C - U_B^C \geq 0$. Consider the consortium of $n(\geq 2)$ libraries.*

(i) When $\Delta^C < M^C$, the consortium buys both bundles and hence the payoff of each library is weakly larger than without the consortium. The consortium strictly increases the total payoff of the libraries unless each library buys both bundles without the consortium.

(ii) When $M^C \leq \Delta^C$, the consortium buys only B_A and hence the payoff of each library is weakly smaller than without the consortium. The consortium strictly reduces the total payoff of the libraries unless each library buys only B_A without the consortium.

It is simple to see why this proposition is true. Without the consortium, each library with type j either buys only B_j or both bundles. When the consortium is formed and $M^C \leq \Delta^C$, each library consumes only B_A and therefore (i) a type B library is worse off; (ii) a type A library is unaffected if it buys only B_A without consortium, otherwise is worse off. On the other hand, when the consortium buys both bundles, each library enjoys maximal consumption and this strictly increases the payoff of each library which does not buy both bundles without the consortium.

Proposition 1 implies that a key issue is whether or not the inequality $\Delta^C < M^C$ holds. This condition is most easily satisfied when the preferences of libraries over bundles are quite heterogenous, that is in the consortium the intensity of the preferences of type A libraries for B_A over B_B are more or less counterbalanced by the intensity of the preferences of type B libraries for B_B over B_A. The ideal case is such that $\Delta^1 + ... + \Delta^{n'} = -(\Delta^{n'+1} + ... + \Delta^n)$, that is $\Delta^C = 0$, which makes $\Delta^C < M^C$ hold for any level of budget of the consortium. For instance, when $n = 2$ this occurs if $\Delta^1 = -\Delta^2$. If instead $\Delta^1 + ... + \Delta^{n'}$ is much larger than $-(\Delta^{n'+1} + ... + \Delta^n)$, then Δ^C is much larger than zero and the consortium buys only B_A if its budget is small. Therefore, forming a consortium is more likely to be beneficial for libraries the more they are heterogeneous in terms of preferences for bundles.

To some extent, the forces identified by Inderst and Shaffer (2007) and Dana (2012) are at work here since they find that forming a group among heterogenous buyers increases the total payoffs of the buyers. However, in their framework with commitment to exclusive purchase, buyers never lose anything from forming a group whereas they can strictly lose in our model without commitment to exclusive purchase.

4 Consortium of two libraries for exogenous budgets

In this section we analyze our model for the case of $n = 2$ in order to obtain more precise results by focusing on the correlation between the two libraries' preferences. We maintain Assumption 1 and, to reduce the number of cases to consider, assume $M^1 = M^2 \equiv M$.

As in the previous section, we define $\Delta^i \equiv U_A^i - U_B^i$ for $i = 1, 2$, and without loss of generality we assume $\Delta^1 \geq |\Delta^2| \geq 0$ (with at least one strict inequality). In words, library 1 prefers B_A to B_B. If also library 2 prefers B_A, then library 1 prefers B_A more than library 2. If conversely library 2 prefers B_B, then library 1 prefers B_A more than library 2 prefers B_B.

In order to simplify notation, let $\rho \equiv \Delta^2/\Delta^1 \in [-1, 1]$ and $\Delta \equiv \Delta^1$. Notice that ρ is a measure of the correlation between the two libraries' preferences. With this notation we have

$$U_A^1 - U_B^1 = \Delta, \qquad U_A^2 - U_B^2 = \rho\Delta, \qquad U_A^C - U_B^C = (1 + \rho)\Delta(\geq 0).$$

From Lemma 1 and Proposition 1, in the absence of the consortium, library 1 buys both bundles if and only if $M > \Delta$, library 2 buys both bundles if and only if $M > |\rho|\Delta$, and the consortium buys both bundles if and only if $M > (1 + \rho)\Delta/2$. Hence, we have:

Observation: If every single library buys both bundles in the absence of the consortium (i.e., if $M > \Delta$), then the consortium buys both bundles and thus the consortium has no effect.

From now on we restrict attention to the case of $M \leq \Delta$ and therefore library 1 buys only B_A in the absence of the consortium. We can further simplify notation by considering a normalized budget $M' \equiv M/\Delta \in (0, 1]$. Hence, in what follows, the model has only two parameters: $M' \in (0, 1]$ and $\rho \in [-1, 1]$. For instance, in the absence of the consortium, if $\rho = 1$ then both libraries buy only B_A; if $\rho = -1$, library 1 buys only B_A and library 2 buys only B_B; if $\rho = 0$, library 1 buys only B_A and library 2 buys both bundles. From these remarks and Proposition 1 we obtain the next lemma.

Lemma 2 *Suppose Assumption 1 and $M' \equiv M/\Delta \leq 1$. Then library 1 buys only B_A in the absence of the consortium. Consider now the consortium of two libraries.*

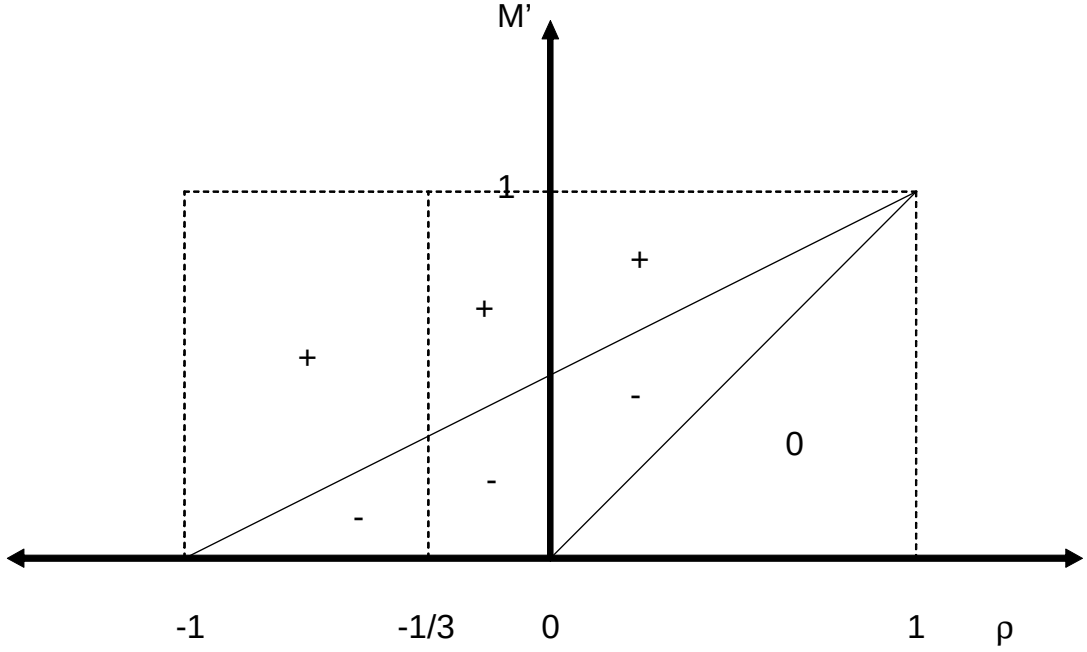

Figure 1: $A^+(\rho)$, $A^-(\rho)$ and $A^0(\rho)$.

(i) If $M' > (1+\rho)/2$, the consortium buys both bundles, which strictly increases the libraries' aggregate payoff.

(ii) If $M' \leq (1+\rho)/2$, the consortium buys only B_A. This reduces the libraries' total payoff if $M' > \rho$, but it does not affect neither any library's consumption nor its payoff if $M' \leq \rho$.

Figure 1 represents the sets of (ρ, M') which satisfy the conditions in Lemma 2(i) and Lemma 2(ii). The region denoted by + is such that $M' > (1+\rho)/2$; the region denoted by – is such that $\rho < M' \leq (1+\rho)/2$; the region denoted by 0 is such that $M' \leq \rho < (1+\rho)/2$. For each $\rho \in [-1, 1]$, let $L^+(\rho) \in [0, 1]$ represent the length of the interval of values of M' such that the consortium strictly increases the total payoff of the libraries. Similarly, let $L^-(\rho) \in [0, 1]$ (resp., $L^0(\rho) \in [0, 1]$) represents the length of the interval of values of M' such that the consortium strictly reduces the libraries' total payoff (resp., does not affect the total payoff). Using Lemma 2 it is possible to compute each length, and thus we obtain:

Proposition 2 *(exogenous budget and correlation) Suppose that the two libraries form a consortium, and that $M' \equiv M/\Delta \leq 1$. Under Assumption 1:*

(i) The length of the interval of values of M' such that the consortium strictly increases the libraries' total payoff, $L^+(\rho)$, satisfies $L^+(-1) = 1$, $L^+(1) = 0$ and linearly decreases with ρ, that is $L^+(\rho)$ linearly shrinks as the degree of correlation increases.

(ii) The length of the interval of values of M' such that the consortium strictly reduces the libraries' total payoff, $L^-(\rho)$, satisfies $L^-(0) = 1/2$, $L^-(1) = L^-(-1) = 0$ and linearly decreases with $|\rho|$, that it $L^-(\rho)$ linearly shrinks as the absolute degree of correlation increases.

Corollary 1 *Suppose Assumption 1 and $M' \leq \Delta$. Consider the consortium of two libraries.*

(i) In the case of perfectly negative correlation, $\rho = -1$, the consortium always strictly increases the libraries' total payoff.

(ii) In the case of perfectly positive correlation, $\rho = 1$, the consortium has no impact on the libraries' total payoff.

In order to provide an intuition, let us first consider the extreme case of two identical libraries. Then, the consortium has no impact since the payment and the consumption of each library (and each publisher's profit) are just like in the absence of the consortium. More generally, Lemma 2(ii) and Figure 1 show that the consortium has no impact as long as the degree of positive correlation is strong enough with respect to the budget, i.e. if $M' \leq \rho$. Then, every library consumes only B_A regardless of whether the two libraries form the consortium or not.

Let us now consider the other extreme case of perfectly negative correlation (i.e., $\rho = -1$). Then, in the absence of the consortium, each library consumes only its preferred bundle: library 1 consumes only B_A and library 2 consumes only B_B. On the contrary, after they form the consortium, the consortium buys both bundles. This occurs because the opposite preferences of the libraries make the market power of each publisher symmetric in the case of the consortium, and this creates a level-playing field for the two publishers (without affecting the profit of any publisher).

Now let us consider the middle case of no correlation (i.e. $\rho = 0$). Then, in the absence of the consortium, library 1 consumes only B_A and library 2 consumes both bundles. In this case, the consortium increases (respectively, reduces) the libraries' payoff if its budget is large enough, i.e., if $M' > 1/2$ (respectively, small enough, i.e. $1/2 \geq M'$). If the budget is small, publisher A can export its residual monopoly power from library 1 to library 2 in order to monopolize the market for the consortium (and increase its profit). On the contrary, if the budget is large enough, publisher A's market power is not strong enough to monopolize the entire market of the consortium and therefore the consortium buys both bundles (but the profit of publisher A still increases).[14]

[14] As the analysis of the three cases $\rho = -1, \rho = 0, \rho = 1$ suggests, under the consortium the profit of A (the profit of B) is weakly higher (weakly smaller) than without the consortium, for any $M' \leq 1$ and any $\rho \in [-1, 1]$, because the consortium allows A to export its residual monopoly power from library 1 to library 2.

Another way to see that a lower ρ makes it more likely that a consortium is beneficial consists in noticing that in order to buy both bundles, the consortium needs to have a budget larger than $(1+\rho)\Delta$, which is increasing in ρ. Therefore, if for instance each library buys only one bundle without consortium and the libraries form a consortium aimed at buying both bundles, the required budget for the consortium is smaller the smaller is ρ in $[-1, 1]$.

5 Endogenous budget

Up to now, we assumed that each library's budget is given. In this section, we continue to analyze the case of two libraries but relax this assumption. Instead, we assume that a public authority perfectly internalizing each library's payoff determines each library's budget before publishers choose prices. For instance, a state authority determines the budget of the libraries of the state's public universities. The timing of the game we consider is as follows:

- Stage 1: A public authority determines the budget for each library i (or the budget for the consortium).
- Stage 2: Each publisher simultaneously chooses a personalized price for its bundle of journals to each library (or the consortium).
- Stage 3: Each library i (or the consortium) decides which bundle(s) to buy.

Consider the market for library i, for instance, with $U_A^i \geq U_B^i$. According to Lemma 1, any positive M^i smaller than $U_A^i - U_B^i$ allows the library to consume B_A and any M^i higher than $U_A^i - U_B^i$ allows the library to consume both bundles. The library's payoff is $U_A^i - M^i$ in the first case, is $U_A^i + U_B^i - M^i$ in the second case. Since the authority wants to minimize the payment to publishers given the consumption of the library, the Supremum of the library's payoff when its budget is endogenous is given by U_A^i in the first case, and by $2U_B^i$ in the second case. Therefore, we have:

Lemma 3 *Consider competition between two publishers in the market for a given library when its budget is endogenously chosen by an authority who perfectly internalizes the library's payoff. Assume $U_A \geq U_B$ without loss of generality. Then, the Supremum of the library's payoff is* $\max\{U_A, 2U_B\}$.

In the equilibrium without consortium, each library consumes only its preferred bundle or both bundles. Let (M,D),[15] for instance, represent the situation in which the authority

[15] M refers to monopoly and D refers to duopoly.

induces library 1 to consume only one bundle (i.e., B_A) and library 2 to consume both bundles in the absence of consortium; (M,M), (D,M) and (D,D) are similarly defined. As in the previous section, we define $\Delta \equiv U_A^1 - U_B^1 > 0$, $\rho \equiv \frac{U_A^2 - U_B^2}{\Delta}$, and without loss of generality we assume $\rho \in [-1, 1]$.

In next lemma we consider the case of $\rho \geq 0$ (positive correlation). We have:

Lemma 4 *(positive correlation) Consider the case of endogenous budget with positive correlation between the two libraries' preferences (i.e., $\rho > 0$).*

(i) In the case of (M,M) or (D,D), building a consortium has no effect on the bundle(s) consumed and on the payoffs of the libraries.

(ii) In the case of (M,D) or (D,M), building a consortium affects the bundle(s) consumed and strictly reduces the total payoffs of the libraries.

Consider first the case of (M,M): $U_A^i \geq 2U_B^i$ holds for $i = 1, 2$. Therefore $U_A^C \geq 2U_B^C$. As a consequence, the authority induces the consortium to consume only B_A and thus building a consortium has no effect on the bundle consumed and on the libraries' payoffs. The same logic applies to the case of (D,D), since then $U_A^i \leq 2U_B^i$ holds for $i = 1, 2$ and $U_A^C \leq 2U_B^C$.

Consider now for instance the case of (M,D). Note first that the authority cannot achieve this pattern of consumption through a consortium, since under a consortium both libraries consume either the single bundle B_A or both bundles. Moreover, given B_A or $(B_A,\ B_B)$ that the consortium consumes in equilibrium, the authority can achieve the same consumption pattern without the consortium *at the same total price.* This implies that under the consortium the authority chooses between the alternatives (M,M) and (D,D), a subset of the alternatives available without the consortium. Since the authority chooses (M,D) in the absence of the consortium, a revealed preference argument implies that (M,D) gives a higher payoff than (M,M) or (D,D). Therefore building a consortium reduces the total payoffs of the libraries.

Now we consider the case of $\rho < 0$ (negative correlation). In order to reduce the number of cases, we assume that both libraries obtain the same total utility from consuming both bundles:

Assumption B: $(U_A^1 + U_B^1)/2 = (U_A^2 + U_B^2)/2 \equiv U$.

In the assumption, U represents the average utility from the two bundles. Hence, we have

$$\begin{aligned}
(U_A^1, U_B^1) &= (U + \Delta/2, U - \Delta/2), \quad (U_A^2, U_B^2) = (U - |\rho|\,\Delta/2, U + |\rho|\,\Delta/2), \\
\left(U_A^C, U_B^C\right) &= (2U + (1 - |\rho|)\Delta/2, 2U - (1 - |\rho|)\Delta/2).
\end{aligned}$$

Then, we can normalize the utilities by dividing them by Δ. Let $U' \equiv U/\Delta$, which must be larger than $1/2$ since $U_B^1 > 0$. Let $U_j^{i\prime} = U_j^i/\Delta$ for $i = 1, 2, C$ and $j = A, B$. Hence

$$\begin{aligned}(U_A^{1\prime}, U_B^{1\prime}) &= (U' + 1/2, U' - 1/2), \quad (U_A^{2\prime}, U_B^{2\prime}) = (U' - |\rho|/2, U' + |\rho|/2), \\ \left(U_A^{C\prime}, U_B^{C\prime}\right) &= (2U' + (1 - |\rho|)/2, 2U' - (1 - |\rho|)/2).\end{aligned}$$

Given this normalization, we have only two parameters: $U' > 1/2$ and $\rho \in [-1, 0)$. We have:

Lemma 5 *(negative correlation) Suppose that Assumption 2 holds, and consider the case of endogenous budget with negative correlation between the two libraries' preferences (i.e., $\rho < 0$).*

(i) Case of $U' \geq \frac{3}{2}$. For any $\rho < 0$, both bundles are consumed (i.e., (D, D) arises) in the absence of the consortium. Under the consortium, the libraries still consume both bundles but at strictly lower prices.

(ii) Case of $3/2 > U' > 1/2$.

(a) For $-1/3 \leq \rho < 0$: In the absence of the consortium, only (M,D) arises. Under the consortium, the libraries consume both bundles if and only if $U' \geq 3(1 - |\rho|)/4$. The consortium strictly increases the total payoffs of the libraries if and only if $U' > (3 - 4|\rho|)/2$.

(b) For $-1 \leq \rho < -1/3$: In the absence of the consortium, (M,D) arises if $U' > 3|\rho|/2$ and (M,M) arises otherwise. Under the consortium, the libraries always consume both bundles. The consortium strictly increases the total payoffs of the libraries if and only if $U' > \frac{1}{2}\max\{3 - 4|\rho|, \frac{3-|\rho|}{2}\}$.

This lemma reveals first that, for any $\rho < 0$, whenever the average value of the bundles is large enough (i.e. $U' \geq 3/2$) such that (D,D) arises without consortium, then the consortium strictly increases the total payoffs of the libraries. This is because building the consortium does not affect consumption but reduces the gap between the willingness to pay for bundle of A and the one for bundle of B; this in turn increases competition between the two publishers and allows the libraries to consume both bundles at a lower total price. Precisely, without the consortium the total price paid is $1 + |\rho|$ but the consortium pays only $1 - |\rho|$.

When the average value of the bundles is not large (i.e. $3/2 > U' > 1/2$), either (M,D) or (M,M) occurs without consortium. To sharpen the intuition, let us consider the two extreme cases of perfect negative correlation and no correlation. Under perfect negative correlation, building a consortium always strictly increases the total payoffs of the libraries. In this case, only (M,M) arises in the absence of the consortium: library 1 consumes only the bundle of A and library 2 consumes only the bundle of B. Then, building a consortium creates a level playing field between the two publishers such that the

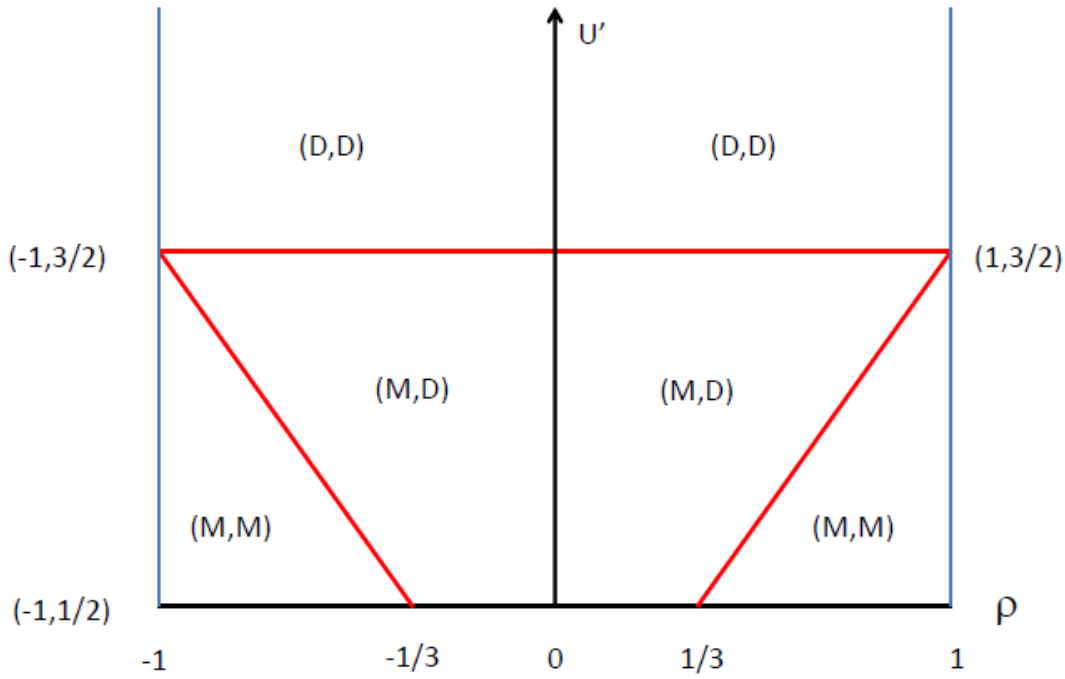

Figure 2: The consumption patterns without consortium under Assumption 2 when the budget is endogenous

consortium can consume both bundles *at almost zero price*. In contrast, in the extreme case of no correlation, only (M,D) occurs without consortium. Then, for the revealed preference argument explained right after Lemma 4, building a consortium always strictly reduces the total payoffs of the libraries. For the general case of negative correlation (i.e. $0 > \rho > -1$), there exists a cut-off value of $U' \equiv U/\Delta$ above which building a consortium strictly increases the sum of the libraries' payoffs. This cut-off strictly decreases with the degree of the negative correlation $|\rho|$.

Figure 2 describes the consumption patterns in the absence of the consortium under Assumption 2. Figure 3 shows the region (marked with +) in which building the consortium strictly increases the sum of the libraries' payoffs, the region (marked with 0) in which building the consortium does not affect it, and the region (marked with -) in which building the consortium strictly reduces it. Summarizing, we have:

Proposition 3 *(endogenous budget and correlation) Consider the case of endogenous budget.*

(i) When the two libraries' preferences are positively correlated (i.e. $\rho \geq 0$), building a consortium either has no effect on the sum of the libraries' payoffs, or strictly reduces

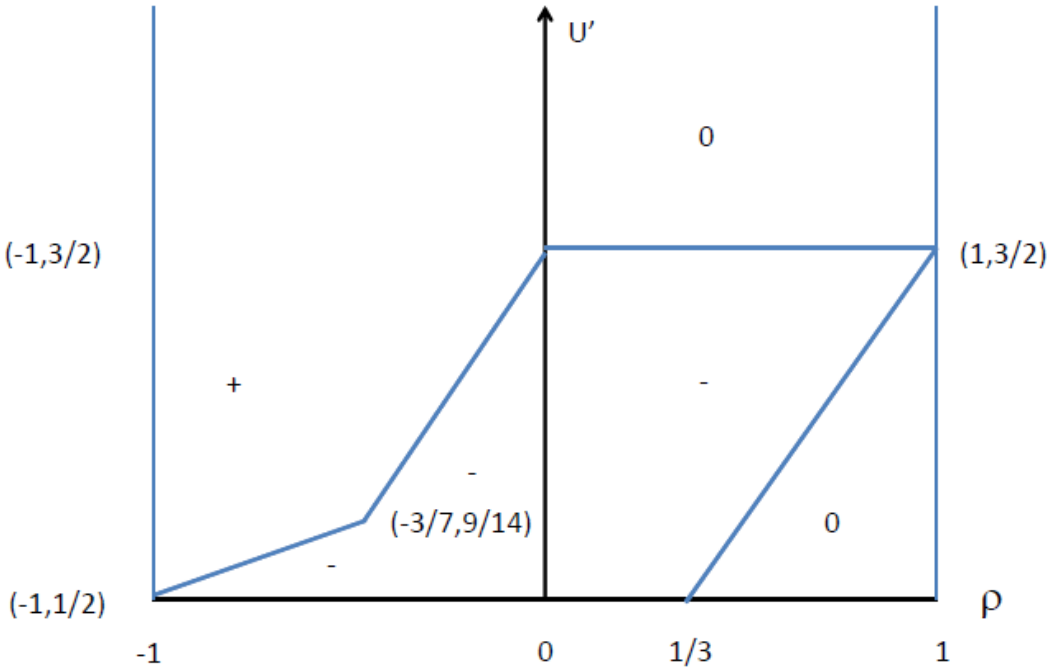

Figure 3: The effect of the consortium under A2 when the budget is endogenous

it. Under Assumption 2, the range of U' for which the consortium is harmful shrinks with the degree of correlation such that it disappears for perfect positive correlation.

(ii) When the two libraries' preferences are negatively correlated (i.e. $\rho < 0$), under Assumption 2 there exists a cut-off value of $U' \equiv U/\Delta$ above which building a consortium strictly increases the sum of the libraries' payoffs. This cut-off strictly decreases with the absolute degree of the correlation $|\rho|$ such that the consortium certainly increases the sum of libraries' payoffs for perfect negative correlation.

Corollary 2 *Consider the case of endogenous budget and suppose Assumption B.*

(i) In the case of perfectly negative correlation, $\rho = -1$, the consortium always strictly increases the libraries' total payoff;

(ii) In the case of perfectly positive correlation, $\rho = 1$, the consortium has no impact on the libraries' total payoff.

When we compare Figure 1 of exogenous budget and Figure 3 of endogenous budget, it is remarkable that they share a number of features even if the parameter represented on the vertical axis is different in the two figures. First, Corollary 1 and Corollary 2 have the identical predictions for the two extreme cases of perfect positive and perfect negative correlation. Second, given negative correlation, the parameter range for which consortium

is beneficial increases with the absolute degree of correlation both in Proposition 2(i) and Proposition 3(ii). Third, given positive correlation, the parameter range for which consortium is harmful decreases with the degree of correlation both in Proposition 2(ii) and Proposition 3(i). The key differences arise for the case of positive correlation: while building a consortium is strictly beneficial in a certain parameter range when the budget is exogenously given, it can never be strictly beneficial in the case of endogenous budget.

6 Policy implications

Our results show that what determines whether libraries gain or lose from forming a consortium is not the mere size of the consortium but its composition, as is emphasized by Dana (2012) in his theory of buyer group. We find that libraries with similar preferences are likely to lose from building a consortium whereas libraries with opposite preferences are likely to gain from building a consortium.

These results suggest that there could be a strong tension between a short-term strategy and a long-term strategy as long as the former dictates forming a library consortium among libraries with similar preferences to benefit from quantity discounts. If publishers are strategic and have foresight while buyers are myopic, publishers with strong market power might have incentives to provide quantity discounts to libraries of similar preferences in order to induce them to form a consortium. In particular, if forming a group requires to incur some sunk cost, which in turn makes undoing the group very costly, publishers could have an incentive to subsidize such cost through quantity discounts only in order to extract more surplus in the long run when they can adjust their tariffs. Hence, we cannot exclude such possibility of "consortium trap". This calls for an empirical study about long term effect of library consortium. For instance, the finding of Gatten and Sanville (2004) that overall relative use of Big Deal titles between member institutions of OhioLink correlates highly might indicate that OhioLink adopted a strategy of building a consortium with libraries with similar preferences.

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