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# Bundled procurement☆

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ABSTRACT

When procuring multiple products from competing sellers, a buyer may choose separate purchase, pure bundling, or mixed bundling. We show that pure bundling maximizes buyer surplus when there are two sellers and trade for each good is likely efficient, whereas separate purchase can be optimal for the buyer when there are more sellers or one good has a low probability of trade. We explain how these results are related to the reduction of sellers' cost dispersion and the potential "adverse tying" under bundling. Remarkably, mixed bundling is dominated under procurement, in contrast to the finding under monopoly bundled sales.

## 1. Introduction

When purchasing multiple products from competing suppliers, what procurement strategy will maximize a buyer's (expected) surplus? This question arises in many economic situations. For example, the buyer could be an individual who desires to have a kitchen and a bathroom renovated, a public school that wishes to purchase some computers and printers, an airport in need of an elevator and an escalator, or a government agency procuring multiple public goods. The buyer may solicit competitive bids for each product separately (separate purchase), procure the multiple products as a package through competitive bidding (pure bundling), or solicit competitive bids simultaneously for individual products and for the package (mixed bundling). This paper examines the buyer's choice among these alternative procurement strategies.

Commodity bundling has been studied extensively from the perspective of a multiproduct monopoly seller. Because consumer values are less dispersed for a bundle than for individual goods, pure bundling potentially allows the seller to extract more consumer surplus than separate selling (e.g., Stigler, 1963; Schmalensee, 1984; Fang and Norman, 2006).[1] Mixed bundling, the practice of selling the products both separately and as a package, further endows the seller with the ability to price discriminate; consequently, it always weakly—and sometimes strictly—dominates pure bundling and separate selling (e.g., McAfee et al., 1989; Chu et al., 2011; Chen and Riordan, 2013). Our study of bundled purchase by a monopsony buyer is closely connected to this literature of bundled sales, despite that in the aforementioned literature on bundled sales there is usually no competition among buyers, whereas in procurement the buyer can typically solicit competitive bids from potential suppliers. As we shall demonstrate, while sharing some common intuition, the analysis of bundling differs substantially in these two different environments, and stronger results can be obtained, under more general conditions, in the procurement context. Strikingly, unlike for a monopoly seller, for a monopsony buyer mixed bundling can be strictly dominated by pure bundling. Moreover, as we shall discuss shortly, our analysis of bundled purchase is closely related to the literature on multi-object auction, particularly Palfrey (1983), Chakraborty (1999), and Jehiel et al. (2007).[2]

We consider a setting where a buyer has unit demand for each of

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[1] A multiproduct seller may also use bundling to leverage its market power in one product to foreclose competition in another (e.g., Whinston, 1990; Choi and Stefanadis, 2001).

[2] Also related are papers analyzing split-award auctions (e.g., Anton and Yao, 1989, 1992; Gong et al., 2012), but the models and the interests in these studies are rather different from those in the commodity bundling and the multi-object auction literatures.

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two products, for which her values are known to be $v_x$ and $v_y$, respectively. Both products can be produced by $N \geq 2$ competing firms. Each firm has private information about its production costs for the two goods, $c^x$ and $c^y$,[3] which are random draws from an arbitrary joint probability distribution on support $[0, \bar{c}]^2$. We allow the two costs to have any dependence relations except perfect positive dependence. As in the literature on bundled sales, we assume that the cost of producing two products jointly is equal to the sum of their individual costs, so that there is no complementarity or economies of scope. For ease of exposition, our main model will assume $N = 2$ and compare two procurement strategies: separate purchase vs. pure bundling, under each of which sellers compete through simultaneous sealed-bid second-price auctions. We then study the case where $N \geq 2$ and the case of mixed bundling. When it causes no confusion, we shall refer to pure bundling simply as bundling.

Our analysis of the main model starts with the base case where the buyer's value for each good is above its highest possible cost (i.e., $v_x, v_y \geq \bar{c}$), so that trade is always efficient. We show in this case that buyer surplus is always higher under bundling than under separate purchase. The reason for this result is closely related to the "dispersion reduction" under bundled sales, but for purchase from competing sellers: firms' costs are less dispersed for the package than for individual products, resulting in more competitive bidding and lower prices for the two goods under bundling than under separate purchase.[4] Notice that this result, invariant with the functional form of the cost distribution, is stronger than its counterpart under bundled sales, where (pure) bundling is sometimes less profitable than separate sales even when trade is always efficient (e.g., Fang and Norman, 2006).

When trade for a good may not be efficient (i.e., at least one of $v_x$ and $v_y$ is lower than $\bar{c}$) while maintaining $N = 2$, bundling can reduce buyer surplus for two possible reasons that we shall jointly term as the "adverse tying" effect. First, both firms' costs to supply the bundle may exceed the total value of the bundle, even when their costs for one of the goods are both lower than its value. This is analogous to the inefficient exclusion that may occur under bundled sales (e.g., Fang and Norman, 2006). Second, both goods will be purchased, but their total price could be lower under separate purchase, because when the value of a good is lower than the maximum of two firms' costs, it can force a lower bid on this good under separate purchase but not under bundling. This second adverse tying effect is more subtle and arises for bundled procurement but not for bundled sales. We show that the competition-enhancing effect dominates so that buyer surplus is higher under bundling than under separate purchase, if each product's value is likely to be higher than its cost; and the reverse is true if one of the values is sufficiently low.

The main model further investigates how the *relative surplus* of bundling, which we define as the change in buyer surplus from separate to bundled purchase (and can thus be negative), may vary with the dependence relations between the two costs and with the cost correlations across firms. For general cost distributions satisfying certain conditions, we prove that the relative surplus of bundling is higher when the costs for two goods are more negatively or less positively dependent. Furthermore, these results extend to a setting where the two firms have correlated costs, so that the costs have both private value and common value components. Interestingly, while the relative surplus of bundling depends importantly on the cost relations between the two products, it is invariant with the cost correlation between the two firms.

We next extend the main model to the case where there may be more than two suppliers.[5] The comparison of buyer surplus under S and B for $N > 2$ will again be related to the possible reduction of cost dispersion due to bundling, but potentially in quite different ways, and bundling can reduce buyer surplus for a reason different from adverse tying. With the assumption of $v_x, v_y \geq \bar{c}$, the equilibrium average price for each product is the second smallest order statistics of $r \equiv (c^x + c^y)/2$ under bundling and of $c^k$ for $k = x,y$ under separate purchase, among the $N$ sellers. For large $N$, the second smallest cost realization tends to occur at the left tail of the respective cost distribution. When $r$ is less dispersed than $c^k$, it is likely that the left tail of the pdf is heavier for $c^k$ than for $r$. Hence, the equilibrium price could be higher under bundling than under separate purchase for large $N$.[6]

We finally extend our analysis to include the procurement strategy of mixed bundling, where the buyer solicits supply prices both for individual products and for the two goods as a package. In contrast to bundled sales, we find that mixed bundling can lead to lower buyer surplus than pure bundling for bundled purchase. When sellers are invited to bid on the price for the two goods as a package, the option for them to also bid on the prices of individual goods changes their strategic bidding incentives, motivating them to refrain from submitting bids on the package (or to raise bids on the package) so as to increase the chance to be selected as the winning bidder for an individual good. Consequently, the equilibrium outcome under separate purchase can always be supported as an equilibrium outcome under mixed bundling, which means that if the buyer prefers pure bundling to separate purchase, she could be worse off under mixed bundling.[7] In this sense, mixed bundling is weakly dominated, and this justifies our focus on the comparison of separate purchase with pure bundling.

Besides the product bundling literature, our paper is closely related to the literature on multi-object auction, most notably Palfrey (1983) and Chakraborty (1999),[8] which find that the seller prefers bundling to separate selling, or the reverse, when the number of bidders is sufficiently small or large, respectively. We complement these important contributions in several aspects. Unlike these two papers, we allow the possibility that the buyer's value for a good may be below the firms' costs, so that the adverse tying effect may arise, and bundling can be inferior even when there are only two bidders. Furthermore, we clarify that the benefit of bundling comes from the reduction of cost dispersion, show how the distribution of costs may affect the potential bundling advantage, and further find that this potential advantage is invariant with the cost correlation between firms. Also related are Jehiel et al. (2007) and Tang and Sandholm (2012), which analyze mixed bundling using VCG mechanisms under which truth-telling is the bidders' dominant strategy; Krishna and Rosenthal (1996), which characterizes equilibrium in simultaneous sealed-bid second-price auctions where some bidders can submit a package bid for multiple homogeneous objects or separate bids for individual objects and winning multiple objects together generates a synergy for these bidders. In addition to having more extensive analysis comparing separate and pure bundling, we complement these contributions with the result that mixed bundling is a weakly dominated strategy in a procurement

[3] All of our main results will continue to hold if firms observe each other's costs.

[4] This is closely related to Dana (2012), where heterogenous consumers with different preferences towards competing firms may form a buyer group that is indifferent between the firms, which eliminates product differentiation and reduces equilibrium prices. By comparison, our model has no consumer heterogeneity, and bundling boosts suppliers' competition by reducing their cost asymmetry for the two goods.

[5] Our analysis of bundled procurement complements Zhou (2017)'s study of competitive bundled sales for any number of firms.

[6] In contrast, when $N = 2$, the second lowest cost realization is the highest cost realization, for which the right tail of the respective cost distributions would be more relevant, and hence the lower dispersion of the average cost under bundling leads to a lower equilibrium price.

[7] When competing sellers offer bundles to consumers, they may also collectively prefer pure bundling to mixed bundling, but for strategic reasons different from ours. See, for example, Chen (1997), Armstrong and Vickers (2010), and Zhou (2017).

[8] See also the more recent work of Li and Yao (2013), who compare the revenue achieved in separate purchase with a seller's optimal revenue when k-objects are sold simultaneously.