To Bundle or Not to Bundle: Determinants of the Profitability of Multi-Item Auctions

This article introduces and empirically tests a conceptual model of the key determinants of the profitability of bundling in auction markets. The model encapsulates hypotheses about how seller revenue from the combined (i.e., bundle) auction of component products relative to that from separate auctions of the components is influenced by the heterogeneity in bidders’ product valuations, the degree of complementarity between component products, the particular multi-item selling strategy, and the outside availability of the products. The results of three field experiments show that though bundle auctions tend to be less profitable for noncomplementary and substitute products, they are on average 50% more profitable than separate auctions when there is (even only moderate) complementarity between the component products. The latter effect is greater when the bundle and the separate components are offered at different times, and it is more pronounced for services than for tangible goods. The findings also identify conditions under which each of the essential multi-item selling strategies for fixed-price settings (pure components, pure bundling, and mixed bundling) tends to maximize seller revenue in auctions.

Keywords: auctions, bundling, bidding behavior, online shopping, complementarity

Retailers and wholesalers increasingly use Internet auctions to sell products. For example, more than 724,000 U.S. retailers use eBay as their major channel of distribution, and more than 1.5 million people use it to supplement their income (eBay 2005). This practice of selling items through auction marketplaces, which brings together a large number of buyers and sellers, has created new challenges to retailers (Cheema et al. 2005). For example, a store using a fixed-price format, either on- or offline, may carry thousands of products on its “shelves,” but practical considerations limit sellers’ ability to offer such a large number of auctions simultaneously. In particular, transaction costs are substantial for both buyers and sellers in online auctions. Buyers incur search and bidding costs as well as shipping and handling costs, whereas sellers pay listing and selling fees, handling costs, and the cost of creating the auctions.

One way for sellers to reduce transaction costs is to use bundling; that is, they can offer multiple component products as a package for a single, combined price. However, although the bundled sale of multiple goods entails economies of aggregation (Bakos and Brynjolfsson 2000), it can also result in the vendor forgoing the additional revenue that might be obtained by selling several component products separately, each to the highest bidder. This raises some important questions about how vendors should go about selling multiple products through auctions and, in particular, what factors determine the optimum selling strategy in this context. Is it better to sell a computer and a monitor in a single bundle auction or in two separate auctions? If they are sold separately, is it better to conduct the component auctions simultaneously or sequentially? Is it best to auction the two items both as a bundle and in separate component auctions? Finally, and critically, what factors determine which of these selling strategies maximizes revenue for the seller? These questions have received limited attention in the literature to date (see Haruvy et al. 2008) because the vast majority of research on auctions in economics has focused on individual auctions (for a review, see Milgrom 2004).

This article examines two key factors that, in addition to the selling strategy, influence the profitability of bundle auctions relative to separate component auctions—the degree of complementarity between the component products (Krishna and Rosenthal 1996; Subramanian and Venkatesh 2009) and heterogeneity in bidders’ valuations of these products (Adams and Yellen 1976; Stremersch and Tellis 2002). Complementarity is the additional value consumers derive from owning or consuming two related products, beyond the sum of their individual values (Venkatesh and Kamakura 2003). Following Stremersch and Tellis...
We conclude with a discussion of the implications of the findings for marketing theory and practice.

**Bundling and Bundle Auctions**

Bundling, a strategy of selling two or more separate products as a package for a single price, is widely practiced in today’s marketplace. Some examples are vacation packages that include flights and accommodations, product sets consisting of cameras and accessories, and sets of tickets for sporting or other events. Most prior research on bundling has characterized this selling strategy as one used by a fixed-price seller to engage in price discrimination, allowing the extraction of additional surplus from buyers with heterogeneous preferences (Adams and Yellen 1976; Schmalensee 1984). That work has considered the case of flexible product supply, with multiple units of a given product being available. In such a setting, the seller’s revenue depends not only on the prices of the components and/or bundles but also on how many units of these products are sold. The advantage of “unbundled” sales is the vendor’s ability to obtain the highest price for each component product from individual buyers, whereas bundling can increase seller profit by extracting more consumer surplus by reducing the heterogeneity in buyers’ reservation prices, thus serving as a second-degree price discrimination mechanism (see Adams and Yellen 1976; Schmalensee 1984).

Bundling strategies in fixed-price settings have been widely studied in both marketing and economics (for a review, see Stremersch and Tellis 2002). Most prior research on the profitability of bundling has been based either on theoretical models or on simulation analyses. An important exception is a field study by Kannan, Pope, and Jain (2009), which examines the bundling of different product forms (i.e., books in print and electronic formats), in which bundle discounts led to increased seller profit.

A seller that auctions multiple component items separately can do so either simultaneously or sequentially. According to prior research, differences in revenue between these two selling strategies are influenced by informational effects and by the degree of complementarity between the items (Hausch 1986; Milgrom and Weber 2000; Rosenthal and Wang 1996). Theoretical work by Milgrom and Weber (2000) shows that in the absence of complementarity between the offered products, revenues from sequential auctions exceed those from simultaneous auctions because bidders may gain new information from early auctions and then bid more aggressively in subsequent auctions. However, when there is complementarity between the items, simultaneous auctions tend to produce higher revenues (Krishna and Rosenthal 1996; Rosenthal and Wang 1996). Finally, analytical work by Feng and Chatterjee (2008) shows that the relative profitability of simultaneous versus sequential auctions (for identical items) depends on the ratio of the number of bidders to the number of items.

A substantial body of literature exists on combinatorial auctions, in which prospective buyers can submit bids for sets—or “packages”—of items (Cramton, Shoham, and Steinberg 2006; Rothkopf, Pekek, and Harstad 1998). An example of a combinatorial auction is one for airport take-off and landing slots, in which an airline’s demand for the two types of slots is interdependent (Rassenti, Smith, and Bullfin 1982). By allowing bidders to place package bids for sets of items, the seller can eliminate bidders’ risk of winning some, but not all, of a desired set of complementary items—that is, their “exposure risk” (Bykowsky, Cull, and Ledyard 2000; Chakraborty 2004; Rothkopf, Pekek, and Harstad 1998). The design and implementation of combinatorial auctions is a complex process, and a wide range of research has been devoted to developing efficient algorithms for finding optimal solutions.

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1Hausch (1986) also proposes a deception effect that opposes the information effect (i.e., bidders who are aware of the information effect tend to bid lower in the first auctions). Therefore, the optimality of sequential auctions depends on the net effect of these two opposing influences.
Hypotheses and Conceptual Model

We consider a firm that intends to sell two items either (1) in a single bundle auction or (2) in two separate component auctions. We focus on second-price auctions with incremental bidding—the predominant auction format in current practice, particularly in consumer-targeted Internet auctions (Lucking-Reiley 2000), though our conceptual model generalizes to other auction formats. In such a second-price auction, the participant who submits the highest bid emerges as the buyer, and the amount he or she pays is the second-highest bid plus the bid increment (Vickrey 1961).

Our aim is to examine what factors influence seller revenue from bundle auctions relative to separate component auctions. Thus, the dependent variable of interest is the ratio of the revenue from the bundle auction to the sum of the revenues from the corresponding separate component auctions. In what follows, we develop six hypotheses pertaining to the key drivers of the relative profitability of these two selling formats. The first three hypotheses reflect theoretical predictions that are tested empirically for the first time in the studies presented here; the other three are original hypotheses.

2 An advantage of using this ratio is that it removes any spurious effect due to the inherent differences in product values (Popkowski Leszczyc, Qiu, and He 2009).

| TABLE 1 | Studies Comparing Auction Formats for Multiple Products |
|-----------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **Auction formats** | Bundled versus separate        | Combinatorial, sequential, and simultaneous | Bundled versus separate        | Bundled, sequential, and combinatorial | Bundled, sequential, and simultaneous |
| **Complementarity and substitutability of components** | Neither                        | Complementarity only            | Neither                        | Complementarity and substitutability | Complementarity and substitutability |
| **Heterogeneity in bidders’ valuations** | Independently distributed      | Independently distributed or perfectly positively correlated | Independently distributed      | Independently distributed        | Asymmetry and variation (negatively and positively correlated) |
| **Outside product availability** | No                             | No                             | No                             | No                             | Yes                             |
| **Bundle offered in isolation (effect of bundle on components)** | No                             | No                             | No                             | No                             | Yes                             |
| **Empirical/theoretical** | Theoretical                    | Theoretical                    | Theoretical                    | Theoretical                    | Empirical and theoretical        |
| **Conclusions about relative profitability of bundle auction versus separate component auctions** | Relative profitability of component auctions increases as the number of bidders increases. | Competition increases exposure risk resulting in less aggressive bidding for separate auctions for complements. | When the number of bidders is greater than a unique critical number, component auctions are more profitable. | Separate auctions are more profitable for moderate complements, and pure bundling for strong complements or with too few bidders. | Bundle auctions are more profitable even for moderate complements. Heterogeneity and selling strategy influence bundle profitability. |
**Revenue of a Bundle Auction Relative to Separate Component Auctions**

Economic theory suggests that consumer valuations of bundles consisting of functionally unrelated products are strictly additive such that a person’s valuation of a given bundle is equal to the sum of his or her valuations of the components (Adams and Yellen 1976; Schmalensee 1984). However, given our focus on the relative profitability of bundle auctions, the relevant units of analysis are auctions rather than bidders.

Inherent to bundling in auctions is an allocative inefficiency, whereby bundle auctions tend to yield lower revenue than corresponding separate component auctions. The rationale behind this is that when there are separate auctions, each component product can be assumed to be sold to the bidder who has the highest valuation for that individual item, whereas this is not the case when there is a single auction for a bundle consisting of multiple component products. In line with this, Palfrey’s (1983) theoretical analysis suggests that a profit-maximizing seller should conduct separate component auctions unless there are only two bidders, in which case a bundle auction weakly dominates separate auctions (i.e., bundle auction revenues are higher in most, but not all, cases). Similarly, Chakraborty (1999) shows that separate component auctions are more profitable than a bundle auction as long as the number of bidders is greater than some (small) critical number. However, the allocative inefficiency of bundle auctions may be offset by their greater transactional efficiency and also by the influence of complementarity between component products and the associated exposure risk.

**Heterogeneity in Bidders’ Valuations**

Bidders differ in their product valuations. All prior work on bundling in auctions has treated heterogeneity in valuations as a unidimensional construct (Chakraborty 1999; Krishna and Rosenthal 1996; Palfrey 1983; Subramanian and Venkatesh 2009). In contrast, in line with Stremersch and Tellis (2002), we decompose this heterogeneity into two aspects—asymmetry and variation. Greater asymmetry implies a lower (more negative) correlation between bidders’ valuations of the components (Adams and Yellen 1976; Schmalensee 1984), which in turn reduces the profitability of bundle auctions relative to separate component auctions (McAfee, McMillan, and Whinston 1989; Subramanian and Venkatesh 2009). An example of high asymmetry is the case of two event tickets, one for a hockey game and one for a classical concert, with consumers having a high valuation for either the hockey game or the concert but not for both. In this case, the seller is better off auctioning these items separately rather than as a bundle. Conversely, greater variation across bidders in their valuation of the bundle (consisting of tickets for both events) implies a higher or more positive correlation between component valuations (Stremersch and Tellis 2002), which increases the relative profitability of bundle auctions. Therefore, asymmetry (variation) has a negative (positive) effect on the profitability of bundle auctions relative to separate component auctions.

Disentangling these two aspects of heterogeneity is critical because the two influence bundle profitability in different ways (Stremersch and Tellis 2002). Failure to do so may lead to erroneous conclusions about the effects of heterogeneity in bidders’ valuations on the relative profitability of bundle auctions.

Thus, we hypothesize the following about the influence of the two aspects of heterogeneity in bidders’ valuations on revenue from a bundle auction relative to the combined revenue from separate auctions of the same component items:

- **H1:** Asymmetry in bidders’ valuations of the bundle components has a negative effect on revenue from a bundle auction relative to separate component auctions.
- **H2:** Variation in bidders’ valuations of the bundle has a positive effect on revenue from a bundle auction relative to separate component auctions.

**Complementarity and Substitutability of Component Products**

In line with prior work, we conceptualize complementarity as the additional value to a consumer, beyond the sum of his or her valuations of two products, that results from owning or consuming both products (Guiltinan 1987; Harlam et al. 1995; Stremersch and Tellis 2002; Venkatesh and Kamakura 2003). In contrast, substitutability renders the valuation of a bundle lower than the sum of its components’ valuations. Thus, complementarity and substitutability represent the opposite ends of a single dimension, which we refer to as the degree of complementarity. Greater complementarity (i.e., either an increase in complementarity or a reduction in substitutability) leads to higher bundle valuations.

To illustrate how complementarity influences bidding behavior in separate component auctions, consider the example of a pair of shoes. While one of the shoes alone has little or no value to a consumer, the complete pair may be of substantial value. A bidder’s strategy in a (second-price) bundle auction is straightforward—the consumer should bid up to his or her valuation of the bundle, which is the sum of valuations of the component products plus the complementarity between them or minus an equivalent term reflecting their substitutability (Cramton 1998).

However, bidding in separate simultaneous component auctions for these two products is considerably more complicated. Here, a bidder must decide how much of the complementarity and substitutability

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3Stremersch and Tellis (2002) distinguish between price bundling and product bundling. They define price bundling as the bundling of separate products sold at a discount and product bundling as the integration of two or more functionally related goods at a single price.

4This does not imply that bundle auctions are more profitable than separate component auctions when variation is high. Instead, high variation may merely reduce the difference in revenue between the two.

5For each of the bundles used in the field studies, we measured the amount of complementarity or substitutability between the two component products in a separate survey.
plementarity (substitutability) he or she should add to (deduct from) the valuations of the individual items when submitting bids for the separate component auctions, and he or she must do so in the face of exposure risk (i.e., the possibility of winning only one of the two auctions). This risk results in less aggressive bidding in the separate auctions for two complementary components than in the corresponding bundle auction, and the size of this gap should be a function of the degree of complementarity between the components (Benoit and Krishna 2001; Krishna and Rosenthal 1996; Levin 1997; Subramanian and Venkatesh 2009). This leads to the following hypothesis:

H³: The degree of complementarity between component products has a positive effect on revenue from a bundle auction relative to separate component auctions.

Different Multi-Item Selling Strategies

Table 2 provides a typology of the different selling strategies for auctioning two component products both as a bundle and separately. These multi-item strategies differ in terms of (1) whether the bundle is offered in isolation, without either of the components being offered at the same time, and (2) whether the components are offered simultaneously or sequentially. Our typology subsumes the three strategies that are commonly considered in the analysis of bundling in fixed-price settings (Adams and Yellen 1976; Stremersch and Tellis 2002): “pure components,” when the firm only offers the component products separately (Cell 4, Line 2); “pure bundling,” when it only offers them as a bundle (Cells 2 and 4, Line 1); and “mixed bundling,” when the bundle and the separate component products are offered at the same time (Cell 3). However, the two-dimensional classification has the advantage that it identifies the essential differences between the various multi-item strategies while explicitly capturing the temporal dimension, which is critical in the context of auctions.

We first consider whether the bundle is offered in isolation as opposed to at least one of the components also being available separately at the same time. In line with the notion that bidding behavior in an auction can be influenced by another, “adjacent” auction (Dholakia and Simonson 2005), when the bundle is not offered in isolation, bidders may use observed bid amounts for the bundle as an indicator of the value of the component products, and vice versa. Moreover, the joint availability of bundles and separate components may make it easier for consumers to evaluate all the items involved (e.g., Hsee 1996). Thus, offering the bundle along with its components should reduce the difference between the revenue from the bundle auction and the combined revenue from the separate component auctions. However, we hypothesize that this depends on the degree of complementarity (substitutability) between the items. Specifically, we propose that for highly complementary products, the presence of the bundle auction highlights the complementarity between the separately offered components, thus increasing bid amounts in the component auctions and, in turn, revenue from these. We predict the following interaction effect between the degree of complementarity and whether the bundle is offered in isolation:

H₅: The positive effect of complementarity on the revenue of a bundle auction relative to separate component auctions (i.e., H³) is greater when the bundle is offered in isolation than when it is offered along with the separate component auctions.

Next, we turn to the second dimension of our classification of multi-item selling strategies—namely, whether the two component products are offered simultaneously or sequentially. Milgrom and Weber (2000) show that in the case of sequential auctions for identical goods, consumers bid more aggressively in later auctions because of the additional information they obtain from the outcomes of earlier auctions, which results in higher total revenue from sequential auctions than from simultaneous auctions. However, this effect is weaker for component products that are not identical—and, more generally, for less similar items—because earlier auctions become less informative about subsequent ones as the similarity of the products decreases.

The construct of product similarity is linked to asymmetry in bidders’ valuations of the bundle components such that lower asymmetry tends to be associated with greater similarity between the component products. Thus, in light of Milgrom and Weber’s (2000) result, we hypothesize that separate component auctions that are conducted sequentially produce greater (combined) revenue than simultaneous component auctions when asymmetry in bidders’ valuations of the bundle components is low, but this difference vanishes as asymmetry increases. Therefore, we predict an interaction effect between the degree of asymmetry in component valuations and component simultaneity, which we express formally as the moderating influence of component simultaneity on the effect asymmetry:

H₆: The negative effect of asymmetry on the revenue of a bundle auction relative to separate component auctions (i.e., H₁) is smaller when the separate components are offered sequentially than when they are offered simultaneously.

Outside Product Availability and the Effect of Complementarity

Finally, we hypothesize that the effect of complementarity between component products on revenue from bundle auctions relative to component auctions depends on how easy or difficult it is for consumers to buy the individual items from another vendor. To illustrate the predicted moderating
influence of outside product availability, we return to the example of a pair of shoes. Given that neither shoe is particularly useful without the other, separate auctions for the two shoes tend to result in lower (combined) revenue than a single auction of the pair, because of the risk of winning only one of these two highly complementary items in the case of separate component auctions. However, an abundant supply of component products reduces this exposure risk because it enables consumers to easily buy one of the components elsewhere, if necessary. Consequently, when component products are widely available from other sellers, the difference between the combined revenue from separate component auctions and the revenue from a bundle auction should be small. Thus, we predict the following interaction relationship among selling strategy, heterogeneity in valuations, complementarity, and outside product availability on the revenue of a bundle auction relative to separate component auctions. In what follows, we present evidence from three studies designed to test the hypotheses. A common aspect

\[ R(A + B) = \frac{R(A) + R(B)}{2} \]

of these studies is that a particular pair of component products is always offered twice—once as a bundle and once separately—to allow for a direct assessment of the relative profitability of bundle auctions. We systematically manipulated the timing of these different auctions (i.e., simultaneous versus sequential).

**Study 1**

*Pretest of Stimuli (Survey of Stamp Collectors)*

To pretest the stimuli—sets of collectable stamps—used in Studies 1 and 2, we conducted an Internet-based survey of 157 stamp collectors, who were recruited through stamp-related online communities and were paid $10 for their participation. After successfully completing a set of questions that tested their knowledge regarding collectable stamps, participants were presented with descriptions of sets of stamps, one at a time. For each of the sets (which represented either an individual component or a bundle), participants stated their valuation (i.e., how much they would be willing to pay for it) in U.S. dollars. We used these valuations as a basis for constructing indicators of complementarity, asymmetry, and variation for each of the bundles. We operationalized complementarity (or substitutability) as the ratio of the valuation of the bundle to the sum of the valuations of its components. We operationalized asymmetry as the (Pearson) correlation coefficient between participants’ valuations of the two components of a bundle, with more negative values indicating greater asymmetry. We measured variation as the variance in valuations of a bundle across individuals. In addition, participants rated how well they thought the two components in each bundle fit together on an 11-point scale, with endpoints “very poor” (0) and “excellent” (10). Each participant completed this task for one quarter, selected at random, of the combined pool of 208 sets of stamps used in Studies 1 and 2.

**Experimental Design and Procedure**

A total of 168 auctions were run on eBay over a three-week period. The products sold were sets of collectable stamps. The selling format was either a single bundle auction consisting of two components or two separate auctions for these components. Two identical replicates of each of 112 components were sold—one separately and once as part of a two-component bundle. Thus, the study involved 112 component auctions and 56 corresponding bundle auctions. We ran the two component auctions for a given bundle sequentially. For example, the bundle auction may have been in Week 1, followed by the first component auction in Week 2 and by the second one in Week 3. We counterbalanced the order of these across bundles. The 56 bundles were constructed such that the degree of complementarity between their components varied from positive to negative

\[ \text{Complementarity} = \frac{V(A) + V(B)}{V(A + B)} \]

6 We thank an anonymous reviewer for suggesting this example. 7 In addition to counterbalancing, we tested whether treatment order had any influence on revenue from bundle auctions relative to combined revenue from separate component auctions in any of the three studies. The effect of order was not significant in any of them (Study 1: \( p = .67 \); Study 2: \( p = .33 \); Study 3: \( p = .95 \)).
(i.e., substitutability). Examples of component items that are substitutes—in that the survey results indicate that collectors’ joint valuation of the bundle is well below the sum of the valuations of the individual components—are two separate sets of 100+ mint United Nations stamps of which collectors typically want one but not both (for details on the design and stimuli, see Table A1 in the Web Appendix at http://www.marketingpower.com/jmjuly10).

All auctions ran for five days. They had predetermined ending times (all on Sunday evening North American time), and no reserve prices were specified. All auctions were conducted through an experienced eBay seller account (with more than 200 feedbacks). For each auction, a picture and a verbal description of the set of stamps were provided.

Results

All 168 auctions resulted in a sale. For each auction, we observed the winning bid (in U.S. dollars), the number of bids submitted, and the number of unique bidders, and we augmented these with the measures of complementarity/substitutability, asymmetry, and variation obtained from the survey. Across the 56 bundles used in this study, the average ratio of bundle valuation to (combined) component valuations is .77, with ratios for individual bundles ranging from .39 to 1.24, suggesting a tendency toward substitutability rather than complementarity for these particular stimuli.

Overall, separate component auctions turned out to be more profitable. The average (combined) revenue from the component auctions was $14.68, while that from the bundle auctions was only $10.99 ($t_{55} = 3.441, p < .01$). This is not surprising, given that the bundles used in this study were skewed toward substitutability, but it is also consistent with what would be expected from the allocative inefficiency of bundle auctions. Furthermore, we estimated a general linear model with the natural logarithm of the ratio of the revenue from the bundle auction to the combined revenue from the component auctions as the dependent variable and asymmetry, variation, and complementarity/substitutability as independent variables ($R^2 = .30$). To facilitate comparisons between the effects of the two aspects of heterogeneity in valuations, we standardized asymmetry and variation. In line with $H_1$, asymmetry in component valuations has a negative effect on revenue from bundle relative to component auctions ($\beta = -1.42, p < .05$). Moreover, consistent with $H_2$, variation in bundle valuations across bidders has a positive effect on this outcome variable ($\beta = .153, p < .05$). Asymmetry and variation are only mildly negatively correlated ($r = -0.18$), suggesting that multicollinearity is not a concern in these data. Finally, a positive coefficient for the degree of complementarity ($\beta = 1.353, p < .01$) reveals that the relative profitability of bundle auctions increases as the complementarity of the component products increases (or as their substitutability decreases), which provides support for $H_3$.

Discussion

The results of Study 1 reveal that for a set of bundles, most of which consist of components that are substitutes, bundling tends to be less profitable for sellers than separate auctions. On average, revenue from bundle auctions was 25.1% lower than the combined revenue from corresponding separate auctions. For 44 of the 56 bundles, the separate component auctions produced higher revenue than a single auction for the bundle. In 22 of these 44 instances, revenue from one of the component auctions was actually higher than that from the bundle auction.

Moreover, the findings of this study show that asymmetry, variation, and complementarity influence the relative profitability of bundle auctions as predicted. Notably, the opposing effects of asymmetry and variation are of approximately equal magnitude (as indicated by their standardized coefficients). Because these influences roughly offset each other, neglecting to disentangle the two aspects of heterogeneity might lead to the false conclusion that the relative profitability of bundle auctions is not affected by heterogeneity.

Finally, we examined the possibility that complementarity/substitutability has an indirect effect on revenue from bundle auctions relative to separate component auctions through the number of bidders who choose to participate. In particular, a bundle auction for complementary components may attract more bidders than separate auctions. However, the results of a mediation analysis provide no evidence of such an indirect effect (Sobel test, $p > .3$).

Study 1 considered only one of the multi-item selling strategies shown in Table 2 (i.e., Cell 2). In Study 2, we examine the profitability of the remaining strategies and focus on complementary products to investigate bidders’ response to exposure risk in greater depth.

Study 2

Experimental Design and Procedure

Study 2 uses the same basic procedure as Study 1. The main difference is that in Study 2, we manipulate the selling strategy in terms of (1) whether the bundle is offered in isolation (i.e., with neither of its components being offered separately at the same time) and (2) whether the two component auctions are held simultaneously (Cells 1, 3, and 4 of Table 2). Two identical replicates of each of 96 components were sold—once separately and once as part of a two-component bundle. Each of the 48 bundles consisted of a complete series of stamps (or a small collection of completed series). Splitting these bundles into two parts resulted in pairs of complementary components. We randomly divided the 48 bundles into three groups of 16 to be assigned to the three treatment conditions (i.e., selling strategies). A total of 144 auctions (48 bundle auctions and 96 component auctions) were run on eBay over a period of two weeks using the same protocol as in Study 1. We counterbalanced the order of bundle and component auctions within selling strategy (for details on the design and stimuli, see Table A2 in the Web Appendix at http://www.marketingpower.com/jmjuly10).

Results

All 144 auctions resulted in a sale. Again, we augmented the auction outcomes with the measures of complementar-
ity, asymmetry, and variation from the survey. Across the 48 bundles used in this study, the average ratio of bundle valuation to (combined) component valuations is 1.19, with ratios for individual bundles ranging from .83 to 1.78, suggesting a tendency toward complementarity rather than substitutability for these particular stimuli.

Overall, bundle auctions were more profitable for these (mostly) complementary goods. The average revenue from the bundle auctions was $24.87, while the combined revenue from the component auctions was only $16.52 on average ($t_{47} = 3.19, p = .0025). We also estimated a general linear model, similar to that for Study 1, with the log of the ratio of the revenue from the bundle auction to the combined revenue from the component auctions as the dependent variable ($R^2 = .46$). We summarize the results in Table 3. Consistent with the findings of Study 1, the degree of complementarity between the component products has a strong positive effect on the relative profitability of bundle auctions, providing further support for $H_3$.

With respect to the different selling strategies, the main effects of offering the bundle in isolation and of offering the two components simultaneously are not significant.\(^9\) (Note that we did not have any directional predictions for these.) Critically, however, the two hypothesized interaction effects involving aspects of the selling strategy are significant. First, the interaction between complementarity and bundle in isolation demonstrates that the positive effect of product complementarity on the revenue of a bundle auction relative to separate component auctions is greater when neither of a bundle’s components is offered separately along with the bundle, in line with $H_4$. Second, although the main effects of asymmetry and variation (which are almost perfectly independent; $r = -.004$) are not significant, the significant interaction between asymmetry and simultaneous components shows that asymmetry has a less negative impact on revenue from bundle auctions than on that from separate auctions when the two component auctions are held in sequence rather than simultaneously. This provides support for $H_5$.

The results of this study also enable us to compare the multi-item selling strategies commonly considered in connection with fixed-price bundling. We held a bundle auction (1) along with the separate auctions for both of its components (“mixed bundling”); (2) by itself, but with both components being offered separately at a different time (“pure bundling and pure components”); or (3) with one of its components being available simultaneously but the other one being offered at a different time (“partial mixed bundling and sequential components”); e.g., Choi and Stefanidis (2006).

In all three cases, revenue from bundle auctions was higher than the combined revenue from separate component auctions—by 11% for mixed bundling, by 69% for pure bundling and pure components, and by 56% for partial mixed bundling and sequential components. Although this difference was not statistically significant for mixed bundling ($p > .25$), it was significant in the other two scenarios ($p < .05$). This suggests that for complementary products, bundle auctions can produce substantially higher revenue than separate component auctions, particularly when the set of component products is not offered in separate auctions at the same time (which is consistent with $H_4$).

**Discussion**

The results of Study 2 show that for complementary goods, bundling can be substantially more profitable than separate auctions. On average, revenue from bundle auctions was 50.5% higher than the combined revenue from corresponding separate auctions. For 34 of the 48 bundles used in this study, offering the products in a single bundle auction produced higher revenue than doing so in separate component auctions. Note that this was the case even though the number of bidders who participated in a given bundle auction ($M = 10.3$) was considerably lower than the total number of bidders who participated in the two component auctions ($M = 16.8, p < .01$).

In addition to demonstrating the role of complementarity as a key driver of the relative profitability of bundle auctions ($H_3$), the findings provide support for two of the hypothesized interaction effects in our conceptual model. First, the positive effect of complementarity is greater when the bundle and the separate components are offered at different times ($H_4$). This suggests that the simultaneous availability of a bundle auction highlights the complementarity between the component products and thus results in more aggressive bidding in the separate auctions. Second, asymmetry in component valuations has a less negative impact

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\(^9\)To assess the relative profitability of bundle auctions across the different treatment conditions, we examine revenue from a bundle auction relative to that from the corresponding set of component auctions. To ensure comparability, we normalized the combined revenue from each pair of component auctions to 1.

\(^9\)Both these independent variables were coded as 0 = “no” or 1 = “yes,” indicating whether the bundle was offered in isolation (i.e., without the individual components being available at the same time) and whether the two separate component auctions were held simultaneously.

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**TABLE 3**

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<th>Independent Variables</th>
<th>Coefficient (SE)</th>
<th>t-Statistic</th>
<th>Hypothesis (Supported)</th>
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<tr>
<td>Intercept</td>
<td>$-925^{**}$ (.432)</td>
<td>4.72</td>
<td>$H_3$ (Yes)</td>
</tr>
<tr>
<td>Complementarity</td>
<td>$1.306^{**}$ (.367)</td>
<td>3.56</td>
<td>$H_3$ (Yes)</td>
</tr>
<tr>
<td>Bundle in isolation</td>
<td>.699 (519)</td>
<td>1.35</td>
<td></td>
</tr>
<tr>
<td>Components simultaneous</td>
<td>.191 (139)</td>
<td>1.37</td>
<td></td>
</tr>
<tr>
<td>Asymmetry</td>
<td>.025 (.075)</td>
<td>.33</td>
<td>$H_4$ (No)</td>
</tr>
<tr>
<td>Variation</td>
<td>-.055 (.061)</td>
<td>-.91</td>
<td>$H_2$ (No)</td>
</tr>
<tr>
<td>Complementarity × bundle in isolation</td>
<td>.991* (.463)</td>
<td>2.14</td>
<td>$H_4$ (Yes)</td>
</tr>
<tr>
<td>Asymmetry × components simultaneous</td>
<td>-.263* (.116)</td>
<td>2.26</td>
<td>$H_5$ (Yes)</td>
</tr>
</tbody>
</table>

\(^* p < .05, ^{**} p < .01\)
on the relative profitability of bundle auctions when the separate component auctions are held in sequence than when they are held simultaneously (H₃). This is consistent with the notion that auction participants bid more aggressively in sequential than in simultaneous component auctions for similar products because of the additional information they obtain from the outcomes of earlier auctions.

Studies 1 and 2 were based on auctions of sets of collectable stamps. Thus, the particular items sold were unique and not available elsewhere at the time we conducted the studies. In the interest of generalizability, Study 3 examines the relative profitability of bundle auctions across a broad range of product and service categories, which also enables us to vary the outside availability of the auctioned items.

**Study 3**

**Pretest of Stimuli**

We conducted an Internet-based survey of 48 consumers to guide the selection of stimuli for this study. They were paid $30 for their participation. Although the demographics of this sample closely matched those of the population of prospective bidders in the auctions conducted for Study 3, none of the survey respondents participated in any of these auctions. For each of a large number of candidate component items and bundles, we obtained the same set of measures as in the pretest for Studies 1 and 2. In addition, for each bundle, participants indicated how easy or difficult they thought it would be to buy one of the two components separately (i.e., without the other), using an 11-point scale with endpoints “very easy” (0) and “very difficult” (10), which is an indicator of (the lack of) outside availability.

**Experimental Design and Procedure**

The overall method was similar to that used in the first two studies. One difference is that we conducted Study 3 on a local Internet auction site available only to residents of one major North American city. At the time of the study, the auction site had more than 7400 registered users. As in Studies 1 and 2, ascending-bid auctions with predetermined ending times were used.

This study focused on selling formats in which the two separate component auctions were run simultaneously. The main manipulation was whether the bundle auction was held at the same time as the component auctions or at a different time (Cells 3 and 4 of Table 2). We varied selling format within a given bundle using the following treatments: (1) bundle and components offered at the same time, (2) bundle only, and (3) components only. We administered these treatments at different times and counterbalanced their six possible orders. Four identical replicates of each of 96 components were sold—twice separately and twice as part of a two-component bundle. Thus, the study involved 192 component auctions and 96 corresponding bundle auctions.

Half the bundles consisted of services, and the other half included tangible goods. In addition, the bundles were designed to vary in the degree of complementarity between the components, the degree of asymmetry in component valuations, and market value. For example, a bundle of complementary tickets for a concert (one type of service used in this study) might consist of two preassigned adjacent seats, whereas two general admission tickets for an event would constitute noncomplementary components. Moreover, some of the bundles contained components with high asymmetry in valuations (e.g., a ticket for a classical music concert and one for a hockey game), while others consisted of components with low asymmetry. (We provide examples of the different types of auctions used in this study in the Web Appendix, Figures A1–A3 [http://www.marketingpower.com/mjuly10].)

The auctions were conducted over a period of three days, with each auction running for 23 hours, starting at 9:00 P.M. and ending at 8:00 P.M. the following day. No items similar to any of the ones used for this study were available on the auction site at any point during this period. All auctions were conducted through an established seller account (with more than 300 feedbacks).

**Results**

All 288 auctions resulted in a sale (for summary statistics, see Table 4). On average, revenue from the bundle auctions ($58.44) was higher than the combined revenue from the corresponding component auctions ($52.40; t₅₉ = 2.38, p = .019). For complementary items, average revenue from the bundle auctions ($65.79) was substantially higher than that from separate component auctions ($43.92; t₅₁ = 6.291, p < .001). The opposite was true for substitute items, for which bundle auctions on average resulted in lower revenue ($50.11) than corresponding component auctions ($62.27; t₄₃ = 6.436, p < .001). This pattern of results is consistent with H₃.¹⁰

Again, we estimated a general linear model, with the log of the ratio of the revenue from the bundle auction to the combined revenue from the component auctions as the dependent variable (R² = .54). We summarize the results in Table 5. The positive effect of the degree of complementarity is again highly significant, providing further support for H₃. The main effects of the two aspects of heterogeneity, asymmetry and variation (which are virtually uncorrelated in these data; r = −.03), are not significant. In line with H₄, the interaction between component complementarity and a bundle in isolation is significant, indicating that the positive effect of complementarity on the revenue of a bundle auction relative to separate component auctions is greater when the bundle is offered in isolation rather than along with the separate auctions. This corroborates the results of Study 2. Outside product availability has a significant main effect, suggesting that bidding in the separate component auctions was less aggressive when items were more difficult to obtain elsewhere. However, the interaction between complementarity and availability (H₅) is not significant. Finally, we find a positive main effect for services (relative to tangi-

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¹⁰This classification is based on the mean of the measure of the degree of complementarity obtained in the pretest (i.e., the ratio of the valuation of the bundle to the sum of the valuations of the components), with values exceeding 1 indicating complementary items and values less than 1 indicating substitute items.
**TABLE 4**
Summary Statistics for Study 3

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Bidders/Bids in Bundle Auction</th>
<th>Combined Number of Bidders/Bids in Component Auctions</th>
<th>Revenue from Bundle Auction</th>
<th>Combined Revenue from Component Auctions</th>
<th>Degree of Complementarity&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Retail Price</th>
<th>Number of Auctions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tangible Goods</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitutes</td>
<td>5.6/11.5</td>
<td>10.3/18.3</td>
<td>$62.32</td>
<td>$72.22</td>
<td>.96</td>
<td>80.63</td>
<td>78</td>
</tr>
<tr>
<td>Computer</td>
<td>5.0/11.5</td>
<td>10.7/16.3</td>
<td>$50.11</td>
<td>$66.55</td>
<td>.90</td>
<td>69.31</td>
<td>18</td>
</tr>
<tr>
<td>Electronics</td>
<td>5.7/12.5</td>
<td>11.8/24.0</td>
<td>$123.00</td>
<td>$127.12</td>
<td>.98</td>
<td>147.95</td>
<td>18</td>
</tr>
<tr>
<td>Health/beauty</td>
<td>5.6/10.3</td>
<td>10.1/17.1</td>
<td>$32.77</td>
<td>$34.96</td>
<td>.96</td>
<td>33.58</td>
<td>24</td>
</tr>
<tr>
<td>Others</td>
<td>6.0/12.3</td>
<td>8.5/16.2</td>
<td>$53.25</td>
<td>$72.68</td>
<td>.90</td>
<td>87.37</td>
<td>18</td>
</tr>
<tr>
<td><strong>Substitutes</strong></td>
<td>5.0/9.2</td>
<td>9.3/16.6</td>
<td>$51.94</td>
<td>$41.79**</td>
<td>1.47</td>
<td>75.31</td>
<td>66</td>
</tr>
<tr>
<td>Electronics</td>
<td>5.6/10.9</td>
<td>8.5/16.2</td>
<td>$72.68</td>
<td>$53.25**</td>
<td>1.37</td>
<td>92.75</td>
<td>24</td>
</tr>
<tr>
<td>Jewelry</td>
<td>5.0/8.9</td>
<td>9.7/14.4</td>
<td>$46.32</td>
<td>$28.10**</td>
<td>1.73</td>
<td>83.65</td>
<td>30</td>
</tr>
<tr>
<td>Others</td>
<td>4.0/6.5</td>
<td>6.8/10.5</td>
<td>$11.38</td>
<td>$10.56</td>
<td>1.05</td>
<td>19.59</td>
<td>12</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitutes</td>
<td>5.4/9.6</td>
<td>9.3/15.6</td>
<td>$40.52</td>
<td>$51.88**</td>
<td>.98</td>
<td>72.71</td>
<td>54</td>
</tr>
<tr>
<td>Dinner</td>
<td>5.6/9.4</td>
<td>8.6/16.0</td>
<td>$42.54</td>
<td>$48.64</td>
<td>.99</td>
<td>60.00</td>
<td>24</td>
</tr>
<tr>
<td>Sporting events</td>
<td>4.3/8.3</td>
<td>9.3/15.0</td>
<td>$33.88</td>
<td>$42.50</td>
<td>1.00</td>
<td>102.98</td>
<td>12</td>
</tr>
<tr>
<td>Other tickets</td>
<td>6.0/10.7</td>
<td>10.3/15.5</td>
<td>$42.27</td>
<td>$62.46**</td>
<td>.96</td>
<td>69.49</td>
<td>18</td>
</tr>
<tr>
<td><strong>Complements</strong></td>
<td>5.7/10.0</td>
<td>7.2/13.4</td>
<td>$71.10</td>
<td>$43.10**</td>
<td>1.28</td>
<td>95.20</td>
<td>30</td>
</tr>
<tr>
<td>Fine dining</td>
<td>9.0/15.8</td>
<td>11.5/23.5</td>
<td>$163.50</td>
<td>$117.75**</td>
<td>1.14</td>
<td>150.00</td>
<td>12</td>
</tr>
<tr>
<td>Sporting events</td>
<td>5.3/9.1</td>
<td>5.4/11.0</td>
<td>$31.76</td>
<td>$60.96**</td>
<td>1.29</td>
<td>96.67</td>
<td>36</td>
</tr>
<tr>
<td>Other tickets</td>
<td>5.1/9.1</td>
<td>7.6/12.5</td>
<td>$53.39</td>
<td>$31.49**</td>
<td>1.30</td>
<td>78.29</td>
<td>42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8.9/15.9</td>
<td>5.5/10.1</td>
<td>$58.60</td>
<td>$52.33**</td>
<td>1.19</td>
<td>82.48</td>
<td>288</td>
</tr>
</tbody>
</table>

<sup>a</sup>Difference between revenue from bundle auctions and combined revenue from separate component auctions is significant at significant at p < .1.

<sup>**</sup>Difference between revenue from bundle auctions and combined revenue from separate component auctions is significant at p < .05.

<sup>+</sup>Measured in the pretest.
TABLE 5  
Study 3: Determinants of Revenue from Bundle Auctions Versus Separate Component Auctions

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Coefficient (SE)</th>
<th>t-Statistic</th>
<th>Hypothesis (Supported)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.338 (.218)</td>
<td>1.55</td>
<td>H3 (Yes)</td>
</tr>
<tr>
<td>Complementarity</td>
<td>1.694*** (.483)</td>
<td>3.51</td>
<td>H3 (Yes)</td>
</tr>
<tr>
<td>Asymmetry</td>
<td>.021 (.066)</td>
<td>.32</td>
<td>H1 (No)</td>
</tr>
<tr>
<td>Variation</td>
<td>-.012 (.079)</td>
<td>-.15</td>
<td>H2 (No)</td>
</tr>
<tr>
<td>Product availability</td>
<td>.248** (.083)</td>
<td>2.99</td>
<td></td>
</tr>
<tr>
<td>Service</td>
<td>.190* (.116)</td>
<td>1.65</td>
<td></td>
</tr>
<tr>
<td>Bundle in isolation</td>
<td>.087 (.110)</td>
<td>.79</td>
<td></td>
</tr>
<tr>
<td>Complementarity \times bundle in isolation</td>
<td>.740** (.404)</td>
<td>1.83</td>
<td>H4 (Yes)</td>
</tr>
<tr>
<td>Complementarity \times product availability</td>
<td>.073 (.276)</td>
<td>.26</td>
<td>H6 (No)</td>
</tr>
<tr>
<td>Complementarity \times service</td>
<td>1.446** (.552)</td>
<td>2.62</td>
<td></td>
</tr>
</tbody>
</table>

*p < .1.  
**p < .05.  
***p < .01.

The increasing prevalence of auctions as a selling format demands a better understanding of the comparative profitability of different strategies for auctioning sets of goods or services. Although bundling strategies are commonly used in both fixed- and variable-price settings, little empirical evidence exists regarding their profitability. This article introduces and empirically tests a conceptual model of the determinants of the revenue of a bundle auction relative to separate component auctions (see Figure 1). The conceptual model consists of three key components: (1) heterogeneity in bidders’ valuations, (2) complementarity between component products, and (3) different multi-item selling strategies. Table 6 provides an overview of the key results of the three studies that were designed to test this model empirically.

First, heterogeneity in bidders’ valuations is an important factor in theoretical models of bundling. We decompose this heterogeneity into two aspects—asymmetry and variation. The empirical evidence regarding the impact of heterogeneity on the relative profitability of bundling in auctions is nuanced. In Study 1, both asymmetry and variation had a substantial influence, as we hypothesized. In contrast, neither aspect of heterogeneity had a significant main effect in Studies 2 and 3, which included bundles of complementary items. A reason we observed an effect of heterogeneity in connection with substitute items (consistent with prior theoretical work) but not for complementary items might be that the influence of heterogeneity was overshadowed by that of product complementarity in Studies 2 and 3.

However, we found support for the novel predicted interaction effect between asymmetry and whether the components are offered simultaneously in the one experiment that allowed a test of this hypothesis (Study 2). As we hypothesized, asymmetry in component valuations has a less negative impact on the relative profitability of bundle auctions when the separate component auctions are held in sequence than when they are held at the same time.

Second, we found that complementarity between component products had an important impact on the relative profitability of bundle auctions versus separate component auctions across all three studies. In the absence of complementarity, the allocative inefficiency of bundle auctions...
results in higher revenue from separate auctions than from a single auction for the bundle.

Moreover, we find substantially lower bundle revenue for substitute goods, with the bundle in some cases actually selling for less than one of its components. In Studies 1 and 3, we observed this for 45.8% and 31.8% of bundles consisting of substitutes, respectively. It is also worth noting that 42.9% of such instances in Study 3 occurred when the bundle auction and the corresponding component auctions were held simultaneously as adjacent listings.

However, we also show that in the case of complementarity between components, a bundle auction can lead to substantially higher revenue than a set of component auctions. Revenue from bundle auctions for complementary items exceeded that from corresponding separate component auctions by an average of 50.5% and 49.8% in Studies 2 and 3, respectively. Moreover, the empirical evidence reveals that even a small degree of complementarity between components is sufficient to render bundle auctions substantially more profitable. This finding is in contrast to Subramanian and Venkatesh’s (2009) analytical results for sealed-bid auctions, which suggest that separate auctions outperform bundle auctions for low levels of complementarity. This discrepancy in conclusions might be due to ascending auctions (e.g., those used in the studies we presented herein) amplifying the exposure risk associated with separate component auctions. Examining the potential moderating role of auction format (e.g., sealed-bid versus ascending) with respect to the findings of this article would be a worthwhile area for further research.

Third, different multi-item selling strategies also have an important influence on the relative profitability of bundle auctions. We compared the results of the three multi-item selling strategies commonly used in a fixed-price setting—a pure components strategy, a pure bundling strategy, and a mixed bundling strategy. The results provide novel insights into bundling in auctions relative to bundling in fixed-price settings (see Stremersch and Tellis 2002). For complementary items, we find that a pure bundling strategy, in which the bundle auction is held in isolation (without the components being available separately), tends to maximize revenue. In the absence of complementarity, the results indicate

<table>
<thead>
<tr>
<th>Products</th>
<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of products</td>
<td>Stamps</td>
<td>Stamps</td>
<td>Tangible and services</td>
</tr>
<tr>
<td>Substitute</td>
<td>Substitutes</td>
<td>Complements</td>
<td>Both</td>
</tr>
<tr>
<td>Number of auctions</td>
<td>168 (56 bundles)</td>
<td>144 (48 bundles)</td>
<td>288 (96 bundles)</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>Supported: $H_1$, $H_2$, $H_3$, Not supported: $H_3$, $H_4$, $H_5$, $H_6$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comparison of Bundle Auctions Versus Separate Component Auctions**

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Supported</th>
<th>Not supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>$11.34 versus $14.50</td>
<td>$24.87 versus $16.52</td>
</tr>
<tr>
<td>Number of Bidders</td>
<td>6.6 versus 11.2</td>
<td>10.3 versus 16.8</td>
</tr>
<tr>
<td>Valuations (Survey)</td>
<td>Mean (range)</td>
<td>5.4 versus 9.6</td>
</tr>
<tr>
<td>Substitutes</td>
<td>.77 (.39–1.24)</td>
<td>1.19 (.83–1.78)</td>
</tr>
<tr>
<td>Complements</td>
<td></td>
<td>1.37 (.95–2.65)</td>
</tr>
<tr>
<td>Main Findings: Auction Revenue</td>
<td>Substitutes</td>
<td>.80 (.20–3.05)</td>
</tr>
<tr>
<td>Complements</td>
<td></td>
<td>.83 (24–1.07)</td>
</tr>
</tbody>
</table>

Significantly lower revenue from bundle auctions for substitute goods; both aspects of heterogeneity influence revenue.

Significantly higher revenue from bundle auctions for complements; mixed bundling reduces difference in revenue between bundle and component auctions.

Bundle revenue is greater for complementary services; mixed bundling reduces revenue from bundle auction for complements (relative to pure bundling) and increases revenue from component auctions for noncomplements; outside availability does not moderate the effect of complementarity.

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*Valuations (survey) or revenue (auctions) for bundle relative to sum of separate components.*
that separate component auctions tend to result in the highest revenue. These findings are in contrast to fixed-price settings, in which a mixed bundling strategy outperforms all other multi-item selling strategies, as long as there is some heterogeneity in consumer valuations (Stremersch and Tellis 2002).

**Competition Among Bidders and Exposure Risk in Component Auctions**

The empirical evidence demonstrates that separate auctions of complementary components result in less aggressive bidding due to the risk of winning only one of the items and not obtaining the complementarity (i.e., the exposure risk). In particular, further analyses show that the comparatively high revenue from bundle auctions of complementary items is due to the exposure risk associated with separate component auctions and not to increased demand in bundle auctions. For the data from each of the three studies, we conducted mediation analyses for the effect of the number of bidders on relative bundle revenue. However, the number of bidders did not influence revenue in any of these cases.

Krishna and Rosenthal’s (1996) theoretical analyses indicate that increased competition among bidders enhances the exposure risk in separate component auctions for complementary items, which should lead to less aggressive bidding. However, in contrast to these theoretical predictions, we found no evidence of such adaptation of bidding strategies in the studies. Notably, in Study 3, in all but two cases, the same bidder won both the component auctions for highly complementary items. Because of the exposure risk, these bidders were able to obtain both items at significant savings. However, we observe some instances in which bidders appeared to get into bidding wars in separate component auctions, resulting in higher combined revenue than that from the corresponding bundle auctions. Additional research is needed to examine the conditions under which either of these effects (i.e., that of exposure risk versus that of a bidding war or bidding "frenzy") might dominate the other.

**Managerial Implications**

The findings of this research have important implications for retailers and manufacturers that are increasingly using online auctions as an alternative channel of distribution. For these sellers, determining the profit-maximizing strategy for offering multiple items is of great importance. Should a set of goods be bundled or offered separately? If they are sold separately, should they be offered simultaneously or sequentially? The results of the studies show that substantial differences in profitability can result, depending on the type of product and the selling format.

What is the optimum multiproduct selling strategy? While the combined revenue from separate component auctions tends to be higher than revenue from a corresponding bundle auction in the absence of complementarity, even a modest degree of complementary between items can cause a bundle auction to result in substantially higher revenue. The relative profitability of bundle auctions is particularly high for services, according to the results of Study 3. Moreover, pure bundling tends to dominate mixed bundling and pure components strategies for complementary items, while a pure components strategy tends to be more profitable than the two other multi-item selling strategies in the absence of complementarity.

With respect to the timing of separate component auctions, the findings of Study 2 show that the profit-maximizing strategy for selling complementary items is to offer the components simultaneously rather than sequentially. The intuition behind this result is that bidders are less likely to be aware of all (both) component auctions when the latter are held at different times (rather than simultaneously), and thus bids in the separate auctions are less likely to reflect the complementarity between the items. However, this effect is mitigated when there is asymmetry in bidders’ valuations of the components (see H3).

The results also have important implications for the selection of specific types of products for bundle auctions. We observed significantly greater differences in the relative profitability of bundle auctions for services than for tangible goods. On the one hand, the time-critical nature of services (e.g., tickets for concerts or sporting events) seems to increase the exposure risk associated with separate component auctions for complementary items, resulting in less aggressive bidding in these auctions and greater profitability of bundle auctions. On the other hand, for services that are substitutes, bundling results in substantially lower revenues than separate auctions, which may be due to greater differences in tastes—such as in the case of a bundle consisting of tickets for an orchestra performance and tickets for a National Hockey League game.

Finally, sellers are better off selling component products as a bundle when these items are more difficult to obtain elsewhere. Prior work on bundling in fixed-price settings has considered flexible product supply, while auction theory has assumed a supply of one unit. Because exposure risk plays a more significant role in the latter case, we expected bidders’ perceived exposure risk to be lower if the complementary items could be easily purchased elsewhere, resulting in more aggressive bidding in the separate component auctions. Surprisingly, however, the magnitude of the effect of complementarity was not influenced by the outside availability of the component products, suggesting that bidders tend to focus on the availability in the auction market and, therefore, that sellers have somewhat of a captive market.

**Limitations and Further Research**

This article examined the relative profitability of different multi-item auction strategies through controlled field experiments. Although this paradigm has many highly desirable properties (including that the empirical evidence is based on actual purchases), it has the limitation that we observed only the outcome (i.e., revenue) of each auction. In particular, this approach did not enable us to examine the willingness to pay of all bidders for both the bundles and the separate component items.

To shed some light on this, we conducted an additional (Internet-based) study in which each of 93 stamp collectors participated in 12 actual second-price sealed-bid auctions for sets of stamps. We independently manipulated the multi-
item selling strategy (as in Study 3) and the number of bidders per auction (2 versus 10) using a within-subject design. All bundles entailed complementary components. The key finding of this study is that sealed bids in bundle auctions (M = $51.94) were higher than their combined bids in corresponding separate component auctions (M = $44.98, p < .05). This replicates the findings of the field studies in a more tightly controlled setting in that it shows higher bundle revenue at the level of the individual bidder, which rules out bidder entry (e.g., the self-selection of bidders into bundle auctions) as an alternative explanation. Critically, this finding provides more direct evidence of how exposure risk leads to less aggressive bidding in separate component auctions for complements (compared with bundle auctions).

Contrary to theoretical models (Krishna and Rosenthal 1996) but consistent with evidence from the field studies, this was not moderated by the number of bidders. This suggests that exposure risk due to increased competition did not result in lower bids. (Detailed results of this study are available on request.)

Additional research is needed to develop a richer understanding of how the various aspects of bundle composition—such as the number of component items to include in a bundle, as well as the complexity, uniqueness, and similarity of the component products (Agarwal and Chatterjee 2003)—affect the relative profitability of bundling in auctions. Another important area for future work is consumers’ construction of their valuations of bundled goods, particularly against the background of recent findings suggesting that valuations of products can be influenced by the items with which they are bundled (Popkowski Leszczycz, Pracejus, and Shen 2008). Finally, further research is needed to explore factors that might underlie consumers’ perceptions of complementarity and fit between products both in general and in the specific context of bundle auctions.

A counterintuitive empirical result in the studies reported in this article is that in some instances, one of the components sold for more than a bundle that included this component (along with another item). In Study 3, we observed several such cases even when the bundle auction and the separate component auctions were held simultaneously. Further research should examine this phenomenon more closely.

Research should also investigate the trade-off between reduced revenue due to the allocative inefficiency of bundle auctions and increased revenue due to the transactional efficiencies of bundling. Moreover, although we examined component auctions that were held either strictly simultaneously or at different times, an important extension of this work would be to consider auctions that partly overlap in time (see Zeithammer 2006). The conceptual model introduced and tested in this article is an important step toward a more complete understanding of the complex interplay between the forces that determine the profitability of different strategies for selling multiple products in auctions.

REFERENCES