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Numerical investigation on mixed bundling and pricing of information products

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ABSTRACT

The bundling sale of information products has been a prevalent strategy in information industries. This paper attempts to study two issues that have not been adequately addressed in previous researches. First, we define the measure of customer heterogeneity by considering both the statistic characteristics of customer reservation price and the marginal cost of information products. Numerical computation indicates that the maximal profit of three bundling strategies (individual sale, pure bundling, and mixed bundling) drops monotonically with the increasing of heterogeneity among customers, and that mixed bundling is more profitable than schemes of either the pure bundling or individual sale when non-negligible heterogeneity exists among customers. Second, we present the mixed partial bundling scheme for real-world situations in which a large number of information products are offered and the preferences or valuations of customers considerably vary. We build a bilevel programming model to define the behaviors of the monopolist and customers, and develop a heuristic algorithm to construct optimal mixed partial bundling schemes. Numerical experiments verify that the mixed partial bundling engenders less substantial deadweight loss and extracts more surplus from heterogeneous customers, which illustrates that the mixed partial bundling strategy is a more flexible and efficient way to accommodate multiple segments of customers.

1. Introduction

Information products refer to anything that can be digitized and transmitted based on the information and communication technologies (ICT) (Shapiro and Varian, 1998), including various software and digitized contents on the Internet. Selling information products in bundles has been a prevalent strategy in the information industry. For instance, digital music and songs are always sold in discs or online as bundles. Enterprise resource planning (ERP) providers, such as the SAP, Oracle, and Kingdee, offer application-oriented bundles to firms of different sizes or industries. Microsoft Office Suites[1] 2010 was released in four bundles for retail, namely, the home and business, home and student, professional, and professional academic. This strategy has attracted the interest of researchers from the academia since the 1990s.

As a marketing strategy, product bundling involves offering several products to heterogeneous customers. These products can be offered for sale individually or as one combined product in a package deal. Three types of bundling schemes are usually assumed in previous researches: the individual sale, pure bundling, and mixed bundling. Individual sale refers to the scheme in which each product is priced individually. Pure bundling means that all products are offered in one package (called a full bundle) at a price and no product is provided individually; thus, a customer buys the bundle or nothing at all. In the mixed bundling scheme, all products are sold individually, and the full bundle is offered as well. A customer purchases the full bundle or different products, but usually not both.

A number of previous studies on product bundling are in conformity with the characteristics of information products. The seminal study by Stigler (1963) investigated the ticket pricing of movie packages. Later studies all assumed that customers only purchased one unit of each commodity individually or in the bundle (Adams and Yellen, 1976; Schmalensee, 1984; McAfee et al., 1989). For instance, customers buy modules or the all-in-one software according to specific requirements (Eppen et al., 1991). Analytical models were built for optimally pricing pure bundling (McAfee et al., 1989; Salinger, 1995), and economic features of the bundling and unbundling demand of heterogeneous customers were examined (Chuang and Sirbu, 1999; Bakos and Brynjolfsson, 1999; Bakos and Brynjolfsson, 2000). Since 2001, researches have focused mainly on the investigation about either the theoretical properties or empirical facets of bundling strategies, and various methods have been proposed to determine the optimal prices of

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[1] http://office.microsoft.com/en-us/suites/.

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bundles (Jain and Kannan 2002; Jedidi et al., 2003; Hitt and Chen, 2005; Geng et al., 2005; Crawford and Cullena, 2007; Wu et al., 2008; Ferrer et al., 2010).

Two issues have been inadequately addressed in previous studies. First, researches based on the analytical approach all propose that pure bundling can effectively reduce heterogeneity among customers, and that heterogeneous customer valuation determines a firm's choice of bundling strategies and optimal pricing. However, a measure to define the heterogeneity of customers for multiple products has not yet been developed. Several studies used the variance of the reservation price distribution (Jedidi et al., 2003; Ferrer et al., 2010; Sheikhzadeh and Elahi, 2013), whereas others adopted the ratio of the marginal cost over the maximal valuation under the uniform distribution assumption (Schmalensee, 1984; Venkatesh and Kamakura, 2003; McCardle et al., 2007). The number of positively valued products was also employed to measure the heterogeneity of customer valuation (Hitt and Chen, 2005; Wu et al., 2008) in the customized bundling. Nevertheless we have no idea about the optimal choice of bundling schemes and boundaries between bundling strategies with different degrees of heterogeneity under specific distribution of customer reservation price.

Second, pure bundling or mixed bundling becomes profitable when a high homogeneity of customers' valuation on information products exists. However, the heterogeneity of customer valuation is often nontrivial in reality when a large number of products are offered (Bakos and Brynjolfsson, 2000), and the pure bundling and mixed bundling schemes will thus become inefficient. Some researchers have proposed the customized bundling strategy to accommodate the heterogeneous demand (Hitt and Chen, 2005; Wu et al., 2008) under the assumption that the price of a bundle was a function of only the bundle size, independent of the bundle contents. This assumption makes the bundling problem tractable, but it also sets a limit to its general applicability. Chuang and Sirbu (1999) asserted that the three bundling schemes were inappropriate for the bundling and unbundling of journal articles and recommended multiple bundling styles to treat readers of varying interests. Wu et al. (2008) suggested the concept of full mixed bundling, in which a firm offers bundles consisting of any subset of products except for the individual sale and the full bundle, but they did not conduct further research. This concept is able to meet the demand of multiple segments of customers when a large number of goods are offered, but it poses a complicated task that cannot be handled via either analytical methods or conventional optimization methods. We propose to build a bilevel programming model to define the behaviors of the monopolist and customers, and attempt to construct mixed partial bundling schemes to address the mixed bundling problems on heterogeneous customers.

The rest of the paper is structured as follows. Section 2 reviews relevant work on bundling information products. Section 3 defines basic concepts, pricing methods and assumptions for individual information product and bundles. In Section 4, customer choices among individual products or bundles are analyzed, and customers' purchase behaviors are described. The optimal choice of bundling strategies is illustrated under specific parameter settings in Section 5. In Section 6, we propose a bilevel programming model for the mixed partial bundling strategy, and then experiments are conducted. Section 7 summarizes the key points of the paper and presents future research directions.

2. Review of related work

Stigler (1963) revealed the practicability of pure bundling to obtain more surplus from customers who shared equal valuation for all products in the bundle. Adams and Yellen (1976) illustrated through instances that the bundling of two products would become more profitable by grouping customers with different reservation prices. Schmalensee (1984) further pointed out that pure bundling led to a reduction in the diversity of customer reservation price, which would help obtain more consumer surplus. McAfee et al. (1989) investigated conditions that made bundling an optimal strategy based on the Adams and Yellen model (Adams and Yellen, 1976). Jedidi et al. (2003) used the variation coefficient of customer reservation price distribution to capture continuous heterogeneity, and conducted an analytical study on bundle price.

The optimal choice of bundling strategies and the boundary between different strategies have not been investigated in terms of both product marginal cost and the distribution of customer reservation price. One reason is the difficulty in obtaining close-form solutions under a general distribution of customer reservation price; and another is that there has not been a measure defining the heterogeneity of customer valuation on products. Meanwhile, most studies only considered the pricing of two products and a few customers through illustrative or analytical investigation under the assumption of the uniform distribution for customer reservation price (Salinger, 1995; Venkatesh and Kamakura, 2003; McCardle et al., 2007). None has presented a method to compute the optimal bundle price when many products are offered and a large number of customers have heterogeneous valuations.

Chuang and Sirbu (1999) studied the bundling and unbundling demand for many information products, such as journal articles. They examined the economic features of customers and producers of journal articles, and identified that the three bundling schemes were inappropriate. Thus, they proposed the N-good bundling model with multi-dimensional consumer preferences and recommended multiple styles of bundling (articles, site-licenses, and various mixed subscriptions), which is a special instance of the mixed partial bundling that we define in this paper.

Bakos and Brynjolfsson (1999, 2000) examined the bundling strategy of a large number of information goods (small-value information goods, such as news, songs, and small software). However, this bundling scheme is not fit for information goods with sophisticated functions, high prices, and non-negligible marginal costs in a market of heterogeneous customers.

Crawford and Cullena (2007) used numerical computation to analyze the impact of bundling on product choice and pricing of a monopolist as well as consumer welfare in cable television service. Given the limitation of theoretical bundling models, numerical simulation helped calibrate the price decision of bundling service and assess its impact on customers' benefit and behaviors.

Hanson and Martin (1990) were probably the first to use a programming method to determine bundle contents and optimal prices of product line breadth to meet the segmented customer demands. However, the number of constraints and variables in the model grows exponentially with the component number for product line breadth.

Hitt and Chen (2005) studied customized bundling, in which a customer paid a fixed price p for a quantity M of information products selected from a larger pool of N information products. Wu et al. (2008) addressed customized bundling for distributing J information goods to I customer segments by building a nonlinear mixed-integer programming model. Ferrer et al. (2010) considered the pricing problem of bundles composed of a service and an associated product, and a dynamic programming approach was used to find the optimal pricing policy to maximize the profit. The programming model becomes inefficient in more complex situations with a large number of information products and customers. It was argued that the number of positively valued goods was more important than customers' valuation function in determining the optimal pricing scheme.