European Journal of Operational Research 231 (2013) 617–630

Contents lists available at SciVerse ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Production, Manufacturing and Logistics

Bundling decisions in supply chains

A. Chakravarty [a,1], A. Mild [b,2], A. Taudes [b,*]

[a] College of Business Administration, Northeastern University, 214 Hayden Hall, Boston, MA 02115, USA
[b] Institute of Production Management, WU – Vienna University of Economics and Business, Nordbergstrasse 15, 1090 Wien, Austria

ARTICLE INFO

Article history:
Received 1 March 2012
Accepted 18 June 2013
Available online 2 July 2013

Keywords:
Supply chain management
Bundling
Price discrimination
Supply chain contract
Manufacturer retailer relationship

ABSTRACT

Firms often sell products in bundles to extract consumer surplus. While most bundling decisions studied in the literature are geared to integrated firms, we examine a decentralized supply chain where the suppliers retain decision rights. Using a generic distribution of customers' reservation price we establish equilibrium solutions for three different bundling scenarios in a supply chain, and generate interesting insights for distributions with specific forms. We find that (i) in supply chain bundling the retailer's margin equals the margin of each independent supplier, and it equals the combined margin when the suppliers are in a coalition, (ii) when the suppliers form a coalition to bundle their products the bundling gain in the supply chain is higher and retail price is lower than when the retailer bundles the products, (iii) the supply chain has more to gain from bundling relative to an integrated firm, (iv) the first-best supply chain bundling remains viable over a larger set of parameter values than those in the case of the integrated firm, (v) supplier led bundling is preferable to separate sales over a wider range of parameter values than if the retailer led the bundling, and (vi) if the reservation prices are uniformly distributed bundling can be profitable when the variable costs are low and valuations of the products are not significantly different from one another. For normally distributed reservation prices, we show that the bundling set is larger and the bundling gain is higher than that for a uniform distribution.

1. Introduction

1.1. Motivation

Price bundling is the sale of two or more separate products in a single package (Stremersch & Tellis, 2002). SAP and Microsoft, for instance, offer their products as software suites comprising several different programs. This is an instance of pure bundling by an integrated firm where only the bundle is sold. In the TV industry pure bundles of information goods are offered in a supply chain setting, where channels aggregate content from a number of third-party firms. An example of pure bundling involving a classical retailer and independent suppliers is that German electronics retailer Conrad sells certain low-end electric guitars and low-end amplifiers only bundled together. On 22.02.2010, for instance, Conrad offered 20 low-end guitars on the website www.conrad.de with a mean price of €132.38, and 15 low-end amplifiers with a mean price of €111.51. Also 7 bundles consisting of a guitar and an amplifier that were not sold separately were offered. In most cases one of the suppliers conferred his brand name to the bundle and the mean bundle price was €194.71, i.e. on average a discount of 20.17% was given. Examples of mixed bundling in a supply chain are McDonald, who sells both drinks and burgers individually as well as in bundles at discounted prices, and Amazon, who offers its customers the choice of buying single books or books bundled with others at discounted prices.

Various explanations for bundling have been proposed in literature. The use of bundling for price discrimination by an integrated monopolist has been studied in Adams and Yellen (1976), Bitran and Ferrer (2007), Eckalbar (2006), Fang and Norman (2006), Hanson and Martin (1990), Hubbard, Saha, and Lee (2007), McAffe, McMillan, and Whinston (1989), McCardle, Kumar, and Tanga (2007), Oldenrog and Skiera (2000), Salinger (1995), Schmalensee (1984) and Stremersch and Tellis (2002). The assumptions of this stream of research are summarized in Oldenrog and Skiera (2000) as follows:

1. The variable costs of the products are constant.
2. The variable costs of a bundle is determined by the sum of the costs of the products that comprise the bundle.
3. Consumers require only one unit of a product.
4. The reservation price for the bundle is determined by the sum of the reservation prices for the products comprising the bundle.

* Corresponding author. Tel.: +43 1 31336 5612; fax: +43 1 31336 5610.
E-mail addresses: akc@neu.edu (A. Chakravarty), andreas.mild@wu.ac.at (A. Mild), alfred.taudes@wu.ac.at (A. Taudes).
[1] Tel.: +1 617 373 3690.
[2] Tel.: +43 1 31336 5612; fax: +43 1 31336 5610.

0377-2217/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.ejor.2013.06.026

We demonstrate the intuition behind pure bundling using the reservation prices shown in Table 1. We start out by assuming zero variable costs. In Example 1 the optimal prices for selling the items separately are clearly 90 for product 1 and 80 for product 2. It follows that the firm can sell each product to customers A and B, making a profit of $90 * 2 + 80 * 2 = 340$. If the price for a pure bundle comprising both products is set at 180, both consumers buy the bundle and the firm can increase her profit by $20–180 * 2 = 360$. To understand this phenomenon let us investigate the consumer surplus defined as the difference between the reservation price of the consumer and the price set by firm. In the separate sales case consumer A has a positive surplus of 100–90 = 10 for product 1 and consumer B of 100–80 = 20 for product 2, so that total consumer surplus is 30. If the firm bundles, only consumer B has a surplus of 190–180 = 10, i.e. profit has increased because the 10 units of difference to the average willingness to pay of 90 have been transferred from product 1 to 2 for consumer A. As can be seen, the variations in reservation prices by products and consumers are moderated significantly when the products are sold as bundles, creating a greater opportunity for extracting the consumer surplus. As shown in Example 2 of Table 1, this effect is stronger if the reservation prices are perfectly negatively correlated with a high variance and have a high mean valuation. Here, the optimal profit when selling separately is $60 * 4 = 240$, while the optimal bundle profit is $160 * 2 = 320$ and all consumer surplus is extracted. On the other hand, bundling is not beneficial in cases of positive correlation as the variance in reservation prices is not reduced. In Example 3, for instance, the optimal profit is $80 * 2 + 60 * 2 = 280$ for both separate sales and bundling. Also, the bundling gain is reduced if the mean valuations of the products differ as the product with the smaller value limits the amount of willingness to pay that can be transferred between the products. In Example 4 in the separate sales it is optimal to sell Product 1 to consumer A only, resulting in a profit of $100 + 20 * 2 = 140$. The bundling profit, on the other hand, is $40 * 2 = 80$ only, as willingness to pay can only be transferred for consumer B. Bundling also looses its appeal for products with significant variable costs. Assuming variable costs of 85 in Example 1 results in a profit of $360 - 85 * 4 = 20$ for the bundle. In the case of separate sales it is optimal to set the price per unit to 100 and to sell product 1 to consumer A and to sell product 2 to consumer B only, which results in a profit of $15 * 2 = 30$. Thus, in the case of significant variable costs it is better to focus on the consumers with high valuations only, i.e. in our case it is better to sell two units for a margin of 100–85 = 15 instead of selling four units at a margin of 90–85 = 5.

1.2. Findings

Do these findings hold in a supply chain setting, too? In this paper we investigate the profitability of bundling if the maximization of the profit function of an integrated firm is replaced by the equilibrium of a game between a retailer and several suppliers. In particular we investigate situations where either all parties coordinate (first-best supply chain bundling), the suppliers coordinate (supplier led bundling) or the each party acts autonomously (retailer led bundling). While some of our findings are as expected, others are somewhat counter-intuitive. Our first finding that the retailer's margin equals the supplier's margin establishes that the equilibrium is Pareto optimal. The second finding that a supplier led bundling obtains higher gains in the supply chain than that of a retailer led bundling stems from the fact that in the later case profit must be divided equally between $n+1$ parties (with n suppliers) whereas in the former case profit is divided equally between 2 parties, the retailer and the coalition of suppliers. The third finding that the supply chain has more to gain from bundling relative to an integrated firm may not appear intuitive but it follows from the fact that in the separate sales scenario the supply chain profit is smaller than that of the integrated firm (because of double marginalization), and in the first-best bundling scenario both profits are identical. Therefore the net change in profit in the supply chain exceeds the corresponding value in the integrated firm. The fourth finding that the first-best supply chain bundling remains viable over a larger set of parameter values follows from the third finding above in that the parameter values that cause the net change in profit to be negative in the integrated firm scenario may continue to generate a positive net change in the first-best supply chain scenario. The fifth finding that supplier led bundling is preferable to separate sales over a wider range of parameter values than if the retailer led the bundling follows from our second finding for reasons similar to that explained in the fourth finding. The sixth finding that bundling can be profitable when the variable costs are low and valuations of the products are not significantly different from one another is specific to the case when reservation prices are uniformly distributed. In this case the profit made with the bundle is higher for supplier led bundling than for the integrated firm if the valuations are about the same, but bundling remains viable over a smaller set of parameter values. For normally distributed reservation prices the bundling gain is always higher than that for the integrated firm and bundling is profitable for a larger set of parameters.

Table 1
Example reservation price distributions.

Products	Example 1 Consumers		Example 2 Consumers		Example 3 Consumers		Example 4 Consumers	
	A	B	A	B	A	B	A	B
1	100	90	100	60	100	80	100	10
2	80	100	60	100	80	60	20	30
Sum	180	190	160	160	180	140	120	40

1.3. Literature survey

Oldenrog and Skiera (2000) start their investigation of the benefits of bundling strategies with the observation that the reservation price distribution for the bundle is obtained as the convolution of the reservation price distributions of the components (Assumption 4 above). The variance of this distribution is clearly dependent on the correlation between the reservation prices of the products comprising the bundle and, therefore, it may or may not exceed the variances of individual products. If, in addition, the correlation between the reservation prices of the items and the respective variable costs are low, a monopolist can extract more consumer surplus by offering the bundle instead of selling the items separately (see, e.g., Oldenrog & Skiera (2000)). Therefore bundling is especially attractive for information goods of which large numbers can be bundled conveniently (see Bakos & Brynjolfsson (1999)). In the case of independent symmetric log-concave reservation price distributions Fang and Norman (2006) derive conditions for the profitability of pure bundling.

Various methods have been used to arrive at these findings: McCardle et al. (2007) and Eckalbar (2010), for instance, employ uniformly distributed reservations prices to study bundling decisions involving two items. While interesting analytical results can be obtained using uniform distributions, modeling the impact of correlation and tackling bundles consisting of more than two products can still be cumbersome. For this reason researchers such as Oldenrog and Skiera (2000) and Schmalensee (1984) employ simulation techniques with a normal distribution. The results obtained in Bakos and Brynjolfsson (1999) rely on Chebyshev bounds,