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Bundling or unbundling? Integrated simulation model of optimal pricing strategies

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ABSTRACT

Bundling is the practice of selling goods together in a package. The extant research has recognised the role of three elements affecting the profitability of bundling strategies: (i) heterogeneity of consumer's reservation prices and their dependence structure; (ii) complementarity of the demand and (iii) economies of scale and scope in production. These major elements are well defined but have never been integrated into one model. We present an integrated simulation model and show how these three elements affect the profitability of different pricing strategies: pure components, pure bundling, and mixed bundling. This approach used recognises the complex relationships which cannot be directly inferred from a purely analytical approach. Multi-scenario analytical scheme flexibly adjusts to different real market conditions. We adopt copula functions in a simulation framework and propose a general form of cost function. We show that the effects of substitutability of the bundle components can be mitigated or even reversed by other supply and demand side factors, such as the correlation of demands or economies of scope. In consequence, studies which do not integrate all these elements can be misleading in the assessment of bundling performance.

1. Introduction

Bundling is a marketing technique of selling two or more products jointly at a discounted price. It is a widespread sales format on various markets, including airlines, banking, telecommunications, online media and digital content. In the telecommunications industry, dual-play, triple-play and quadruple-play bundles command for 70% of subscription revenues. According to the Eurobarometer survey, in 2017 exactly 59% of EU households purchased telecommunication services in packages (European Commission, 2018). Bundles of electronic services increasingly include online components such as music streaming or video-on-demand.

Adams and Yellen (1976) list the three canonical bundling options available to a seller with market power. The pure components (PC) refer to a sale of the unbundled products, the pure bundling (PB) is a choice to sell only a package, and the mixed bundling (MB) is an option to sell the component goods both in a package and individually. Since the publication of seminal works of Stigler (1963) and Adams and Yellen (1976), economists have extensively studied the factors under which bundling is more profitable than a separate sales. Several elements on the demand and supply sides rationalise bundling. The correlation structure of the component reservation prices is among the most studied elements that facilitate bundling (Chen and Riordan, 2013; Fang and Norman, 2006; McAfee et al., 1989; Schmalensee, 1984). Bundling works through a reduced variance of valuations. Therefore, it can generate profit gains for negatively dependent reservation prices. The magnitude of these gains is sensitive to various other factors. For example, they can be driven down to zero for the substantial marginal costs. The second rationale for bundling comes from the superadditivity of reservation prices, known as a complementarity of component demands (Stremersch and Tellis, 2002; Venkatesh and Kamakura, 2003). On the supply-side, the increasing unit costs, in general, reduce the profit gains from bundling. Mixed bundling is incrementally superior over pure bundling in this case due to the avoidance of an implicit subsidisation of low-end consumers. Another important, although less studied supply-side factor, which facilitates joint sales, is the subadditivity of the component costs (Baumol, 1986; Salinger, 1995). Our paper explores the cost aspect of bundling by introducing a synthetic measure of the economies of scale and scope. Our work contributes to the literature by testing how an interplay of the various factors listed above impacts profit gains from the two bundling strategies relative to the separate sales. This study integrates all the main determinants discussed in the literature for the first time and searches for robust relationships and stable results in the assessment of bundling. The paper has four parts.

The first part provides a literature review and a brief discussion of

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the main components influencing the profitability of bundling strategies.

The second part presents the three influential components and underlying theoretical frameworks in greater detail. The frameworks serve as a basis for the integrated simulation model for the analysis of profitability and welfare effects of bundling pricing. In particular, we: i) introduce copula functions in order to conveniently link the properties of distributions of product valuations with profits and the consumer surplus resulting from a particular pricing strategy; ii) relax the assumption about the additivity of valuations and thereby determine the optimal pricing strategies for a monopoly in the case of a substitutability and complementarity of goods; iii) derive the cost function of a multi-product company, which allows for the simultaneous modelling of the economies of scale and scope. Although all three steps complement each other, they were never combined in one coherent analytical model.

The third part presents the simulation framework, which is a core part of the proposed analytical model for the case of two goods. The numerical simulation makes it possible to study the joint impact of the three elements on monopoly profits and social welfare from the perspective of different bundling strategies (PB, MB, and PC). Our model encompases different joint distributions of reservation prices, the coefficients of complementarity and substitutability of goods, non-zero marginal costs and economies of scale and scope. As part of our study, we have created the package *bundling* for R software,[1] which implements our simulation framework and finds optimal prices for the three analysed sales strategies.

The fourth, empirical part shows the results of the selected simulations and highlights some relationships which cannot be directly inferred from the analytical studies. A deeper exploration of the insights from the proposed simulation framework requires a separate study.

2. Literature review

Relatively few studies deliver analytical solutions to the bundling problem (Eckalbar, 2010; Sheikhzadeh and Elahi, 2013; Venkatesh and Kamakura, 2003). Tractable analytical frameworks are possible only for discrete distributions or the simplest continuous stylizations of component reservation prices and specific dependency patterns. For example, Eckalbar (2010) explores the optimality of bundling under the uniform distributions of reservation prices. He provides analytical solutions for mixed and pure bundling, but only for the three special cases: the full independence and the perfect positive or negative correlation of the valuations. The partial correlation usually requires at least a supportive use of simulation techniques, as in Sobolewski et al. (2017). The analytical approach brings some insights but is quite limited in the ability to capture general patterns of heterogeneity and dependence of valuations (Venkatesh & Mahajan, 2009). Most studies analyse bundling pricing in a monopoly setting as it is the simplest price-setting market structure.[2] Another stream of literature considers the emergence of bundling as an equilibrium outcome of the strategic interaction between oligopoly sellers (Chen, 1997; Economides, 1993; Matutes and Regibeau, 1992; Raghunathan and Sarkar, 2016). Choi (2008) examines the foreclosure effects of mergers driven by mixed bundling, while Nalebuff (2004) points to a market power leveraging and an entry deterrence effect of pure bundling. As this literature is not directly linked to the present work, we do not summarise these studies in greater detail.

The marketing literature, on the other hand, focuses on the design and implementation of procedures that make it possible to find the optimal structure of bundles and the corresponding prices. The first-best solution for larger problems can be computationally challenging because the number of the potential bundles increases exponentially in components. This concern has practical relevance in the case of information goods. Hence, several papers propose different second-best solutions and analyse their efficiency. In any case, the recovery of a full joint distribution of valuations is required to find the solution to the bundle pricing problem. The early papers worked with a finite collection of deterministic valuations. For example, Hanson and Martin (1990) implement the mixed integer linear programming to find the optimal bundling prices for a finite number of customer types. For a class of bundling problems with a single key component, such as a car or a house and add-on components, such as car options or housing features, a number of binding constraints increases linearly in the components. Hanson and Martin (1990) find a solution to a bundling problem with 21 components. They allow for a non-additivity of costs and apply a linear programming approach on the consumer data collected in a survey.

Chu et al. (2011) reduce the complexity of the multi-product bundling by adopting the bundle-size pricing, where bundles composed of a different number of items are priced differently. The bundle-size pricing is more profitable than the separate sales and closely approximates profits from the first-best mixed bundling solution. They work with a continuum of consumer types represented by the continuous distributions of reservation prices (normal, exponential, logit, normal, uniform). Chu et al. (2011) allow for a positive and negative correlation and positive marginal costs but assume a full additivity of costs and valuations. Hence only little is known about how their approach would work under the cost economies and the substitutability and complementarity of demand.

The multi-product bundling has been extensively studied in the context of information good markets, such as digital media platforms, online music stores, online games and online financial services. It has been recognised that the bundling of the information goods, featured by a (nearly) zero marginal cost, can be economically attractive but also complex due to their plurality. Some of the ways adopted to reduce the complexity of mixed bundling, in this case, have been investigated. Bakos and Brynjolfsson (2000) show that if valuations of all components are drawn from the same distribution, pure bundling constitutes an asymptotically efficient strategy. Numerous studies investigated the case of information goods and heterogeneous consumers when the above pure bundling solution is no longer optimal. Hitt and Chen (2005) propose customised bundling as a possible simplification to the full-size mixed bundling, whereby heterogeneous consumers select the products within the fixed-size bundle. Hui et al. (2012) add a new dimension – the preference heterogeneity. They consider consumers with different saturation points. They show that increasing the heterogeneity and a number of positively valued information products incentivises the use of mixed bundling pricing.

Departing from the information goods, the higher the unit cost, the less likely it is that the mixed bundling dominates pure components in profits (Schmalensee, 1984; Salinger, 1995). An increase in the cost may thus question the profitability of bundling and incentivise a move towards separate sales (Cao et al., 2015). A notable example of such a transition has been observed in the airline industry. The low-cost carriers introduced unbundling in reaction to a spectacular fuel price peak and an economic recession triggered by the financial crisis in 2008. The introduction of a separate checked-in bag fee led to only minor reductions in air fares. The total cost for bag-checkers increased, and carriers clearly benefited from unbundling. Despite the theoretical insights, the quick financial recovery of the low-cost carriers driven by the unbundling came as a surprise to industry practitioners (Brueckner et al., 2015).

Recently, the use of the copula functions (Triverdi and Zimmer, 2005; Nelsen, 2013) has become a noticeable practice in the theoretical and empirical research on bundling. This framework offers a convenient

[1] The package is available on the project website: github.com/tomvar/bundling/.

[2] Only a firm with the monopolistic power has the ability to set pricing strategy.