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Optimal versioning and pricing of information products with considering or not common valuation of customers

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ABSTRACT

Since information products are often offered to market in multiple versions to make vertical differentiation, the optimal versioning strategy has become a hot topic in the research community. This paper focuses on the numerical investigation of the properties of optimal versioning under linear utility functions by considering or not the common valuation (or reservation price) of all customers. The bilevel programming model is built for the optimal versioning task of an information product with the monopolist as the leader and all customers as followers, and it is able to formulate the optimal versioning strategy by considering both quality levels and prices of an information product. The utility functions are defined by considering or not the basic willingness to pay shared by all customers with some-degree of homogeneity, and then the optimality of the two-version scheme is evaluated. It is found that the two-version scheme consisting of both the highest-quality version and the lower-quality version is superior to the one-version scheme with only the highest-quality version when there is nonzero common valuation of customers. But the introduction of the interim-quality version will cannibalize market shares of both the highest-quality version and the lowest-quality version in the three-version scheme according to numerical computation results based on the bilevel programming model. The three-version scheme cannot bring more profit to the monopolist than the two-version scheme, or there does not exist an optimal three-version scheme for the versioning strategy with linear utility functions.

1. Introduction

The versioning strategy has become a common practice for the vertical differentiation of information products in information industries. It has also been a hot spot in the community of academic research since the 1970s (Mussa & Rosen, 1978). What we define by the information products means anything that can be digitized and transmitted based on the information and communication technologies (ICTs). Shapiro and Varian (1998) presented all the more clear-cut silhouette of the versioning strategy for information products by profound qualitative analyses. Multiple versions of an information product have become the tried-and-true strategy in design and marketing as verified by many successful industrial instantiations. However, the analytical models and derivations contributed controversy findings about the versioning strategy under specific assumptions and conditions.

For instances, the versioning was proved to be suboptimal when the customer valuation for an information product (or called the customer utility) was defined as a linearly multiplicative function of the product quality and customer preference (Bhargava & Choudhary, 2001, 2008; Chen & Seshadri, 2007; Fathian, Sadjadi, & Sajadia, 2009; Jing, 2007). It was usually assumed that all potential customers were uniformly distributed with the marginal willingness to pay. The versioning strategy became optimal for a monopolist only under restrictive conditions, such as the highest-quality version of an information product had the best benefit-to-cost ratio (Bhargava & Choudhary, 2001), or the relative valuation decreased with the customer preference (Bhargava & Choudhary, 2008), or the presence of positive network effects was considered (Jing, 2007). These researches all assumed that the marginal cost was positively proportional to the quality level of an information product, which did not conform to the fact that a firm usually developed an information product of the highest quality and then degraded it to various versions of lower quality, thus there did not exist significant difference among marginal costs of all versions (Shapiro & Varian, 1998).

These results confuse firms when the versioning strategy is attempted to practice. Since all propositions and corollaries hinge on the customer utility function which originated from the proposal of Mussa and Rosen (1978), an investigation about impact of the customer's utility function, especially in the case that there exists positive common valuation for all potential customers of some homogeneity, on the optimality of versioning strategy is surely interesting. Besides, if the versioning strategy is optimal

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for a monopolist with specific utility function, what is the best scheme for the versioning strategy, such as what is the maximal number of versions, and how to set quality levels and price them for obtaining maximal revenue. There is surely a need to make analytical or numerical investigation on these issues.

The rest of this paper is organized as follows. In Section 2, we review some previous researches that used the linear utility function to evaluate the optimality of versioning strategy in various situations. Section 3 introduces the bilevel programming model for optimal versioning with multiple quality levels. The properties of optimal versioning with the linear utility functions that include or not the common valuation of all customers are investigated in Section 4. In Section 5, three-version scheme under the linear utility function with nonzero common valuation are examined numerically based on the bilevel programming model. Section 6 concludes this study and points out future research directions.

2. Review of related work

Shapiro and Varian (1998) pointed out that information products had different production economics to physical products. They investigated qualitatively on versioning rationale, and pointed out that the number of versions and prices were decided by both the characteristics of an information product and the value that customers placed on them. The versioning strategy of information products brought benefit to firms by serving segmented customers with better managed product lines.

Bhargava and Choudhary (2001) focused on the impact of marginal costs on the optimality of versioning under the linear utility function, and concluded that multiple versions were suboptimal if the highest quality version had the best cost-quality ratio. The supper-linear increase of the marginal cost with regard to the quality levels would make the versioning optimal.

Lee, Yu, and Kim (2006) considered the optimal versioning of information goods or services. Free goods or services were offered by a monopolistic e-business company to create a market network, and premium goods or services were developed to gain profit in the same market. The optimal strategies (optimal qualities and prices) were derived by maximizing total profit gain.

Jing (2007) considered the optimal versioning when there were network externalities in the market of an information product and customers' utility was defined as a linear function of the product quality. It was proved that the presence of network externalities made multiple versions the optimal strategy for price discrimination, and the optimal versioning scheme consisted of two versions: the highest-quality level and the lowest-quality level.

Bhargava and Choudhary (2008) derived a set of decision rules for determining the optimality of versioning. Their conclusion pivoted on the assumption that customers preferred higher quality and higher types of customers had higher marginal valuations, which meant that the customer utility function increased supper linearly with the customer type. The impact of the variable cost on the optimality of versioning was also examined. They discussed the versioning optimality of linear valuations with regard to the existence of the homogeneous benefit for all customers, but there was no detailed analysis.

Wattal, Telang, and Mukhopadhyay (2009) investigated two-dimensional information product differentiation by considering both product differentiation and customer segmentation in the duopoly via a game-theoretic model. The linear utility function was used in the model, but the non-zero reservation price shared by all customers was also assumed to make sure that the entire market was covered in equilibrium. Their work was the first to define the common valuation for all customers on vertical product differentiation. Their study showed that the non-zero reservation price supported the modeling of the versioning strategy in the duopoly.

Dogan, Ji, Mookerjee, and Radhakrishnan (2010) studied the temporal versioning in two periods by considering the initial release version and the upgrade version, where the utility function of customers was also represented as proportional to consumer's type and the product's quality level. It was shown that features allocation in the initial version and the upgrade version were impacted by demand variability and market uncertainty.

The linear utility function was commonly used in these previous researches on the versioning or vertical differentiation of information products. But there has been not comparative study on the utility functions with zero or non-zero common valuation of all customers regarding their impact on the optimal versioning. This is the main issue that this paper attempts to address via numerical computation.

3. Model of optimal versioning

As discussed in the Section 1, we focus on the monopoly market[1] of an information product. The monopolist offers one version or multiple versions of an information product to all potential customers in the market.

Suppose that the available highest quality of an information product is determined exogenously via various market investigation channels, and a monopolist has developed the highest-quality product, denoted as q_H ($q_H > 0$). Since the fixed cost is sunk in the design and development of the highest-quality version of an information product, the investment for developing a lower-quality version with fewer features is usually very small, which also does not constitute a hard demand for the firm's budget. Technically, there exist not challenging tasks to develop the lower-quality versions.

Thus, it is very common that a firm offers a group of compatible information products of different quality levels as multiple versions: $Q = \{q_1, q_2, \ldots, q_K\}$, where $q_L = q_1 > 0$ denotes the lowest quality level that meets the basic or the least requirement of customers; $q_H = q_K$, $q_1 < q_2 < \cdots < q_K$, and $\{q_L, q_H\}$ denote the versions of the lowest-quality level and the highest-quality level; K is the maximum number of quality levels that a monopolist offers about an information product. For information products that can be digitally stored and transmitted on the Internet or in the large-capacity compact disks, marginal costs of different versions are assumed to remain constant and are often treated as identical (or as zero in literatures). For the sake of generality, we represent the marginal costs of different versions as $MC = \{c_1, c_2, \ldots, c_K\}$. The monopolist charges a price p_i for the version of quality level q_i, and the price decision set is denoted as $P = \{p_1, p_2, \ldots, p_K\}$. These characterize the firm-side features of the optimal versioning problem.

[1] In the real world, there are many situations that the market of an information product is close to monopoly. For instance, the Windows takes 92.23% of the desktop OS market in 2011 (http://marketshare.hitslink.com/operating-system-market-share.aspx?qprid=8&qpcustomd=0), the Google-Global takes 83.38% of the desktop search engine market in 2011 (http://marketshare.hitslink.com/search-engine-market-share.aspx?qprid=4&qpcustomd=0). Worldwide PC users use the Microsoft Office to produce digital documents and sheets, where the Microsoft Office takes nearly 95% market share in 2006 (http://www.businessweek.com/magazine/content/06_27/b3991412.htm). In the developing OA market of China, the Microsoft Office holds a 73% share and the Chinese office software takes about 27% share during 2008–2009 (http://software.it168.com/zt/office2010/index.html). Besides, there are often monopolists in the segment markets of some application software. For instance, the SAP takes about 85% share in the ERP market of the petroleum and natural gas industry of China (http://www1.sap.com/china/about/company/index.epx). The Founder Chinese E-publishing System invented by the Founder Electronics of China has been installed for the typesetting and printing of books and newspapers by 95% users in the global Chinese publishing market (http://baike.baidu.com/view/173695.htm).