



Reference quality-based competitive market structure for innovation driven markets



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ABSTRACT

Innovation-driven durable goods markets see substantial changes in quality and available choice sets and subsequent changes of the reference quality in the market over time. Considering the multi-attribute characteristics of these goods, it is important for businesses to identify attribute-specific competitive landscapes and develop competitive innovation strategies at the product attribute level. Therefore, this paper proposes a reference-dependent choice model for product quality at the product attribute level that can capture the asymmetric effect of innovation shocks on product demand, i.e., the *innovation elasticity of demand*, as well as the competitive market structure in product innovation. Moreover, we confirm that there is a certain quality span for a product attribute where the values of products depreciate most significantly due to innovation shocks, which we refer to as the *innovation shadow zone*. We demonstrate the effectiveness of the proposed approach in developing attribute-specific product innovation strategies using U.S. mobile telephone market data.

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1. Introduction

Product innovation is important and rapid in high-tech durable goods markets, such as those for mobile telephones, laptop and desktop computers, and digital cameras, in which companies constantly introduce new, better-quality products and remove older versions. For example, in the electronic chip market, 'Hwang's Law,¹' which states that the memory density of electronic chips doubles every year, replaced 'Moore's Law,²' which states that it doubles roughly every two years, in 2002.

Due to the nature of rapid innovations in high-tech markets, consumer choice sets in these markets change rapidly, and consumers constantly update their expectations of the standard quality of product attributes. For example, in the desktop computer market, standard CPUs are rapidly replaced by newer versions, e.g., Core Solo by Core Duo; Core 2 Duo; and Core i3, i5, and i7 on an almost annual basis, while the standard capacity of hard disk drives has also improved from 128 G (gigabytes) to 256 G, 500 G, 1 T (terabyte), and currently large SSDs (Solid State Drives)³ over

the past few years. Additionally, the speed of innovation differs across product attributes, generating heterogeneous consumer preferences for products and creating strategic opportunities for companies.

Therefore, due to the multi-attribute characteristics of these innovation-based durable products, it is important for businesses to identify attribute-specific competitive landscapes and develop competitive innovation strategies at the product attribute level. This effort is also advisable from the perspective of multi-attribute portfolio management because of the distinct impacts of product innovations across different product attributes. Moreover, previous literature suggests that consumers' choices are mainly influenced by only some key product attributes (Bettman & Park, 1980; Nowlis, Dhar, & Simonson, 2010; Shi, Wedel, & Pieters, 2013).

Therefore, in this study, we suggest a new approach to analyzing competitive market structure at the product attribute level using the concept of reference quality. The reference effects of product attributes have been found to have a significant impact on consumer choice (Kalwani, Yim, Rinne, & Yoshi, 1990; Kalyanaram & Little, 1989; Kalyanaram & Winer, 1995; Lattin & Bucklin, 1989; Mazumdar & Papatla, 2000; Rust, Inman, Jia, & Zahorik, 1999; Rust & Oliver, 2000; Tversky & Kahneman, 1991; Winer, 1986). This finding has an important strategic implication for product innovation at the product attribute level, such as asymmetric gain and loss in consumer product values from quality improvement. Since Tversky and Kahneman (1991) introduced the importance of a reference point on consumer utility in their prospect theory framework, many succeeding studies have documented reference effects for both product attributes and price (Hardie, Johnson, & Fader, 1993; Kalwani et al., 1990; Kalyanaram & Little, 1989; Kalyanaram & Winer, 1995;

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¹ Samsung has doubled the memory density of its products every year since 2002. The company dubbed this phenomenon "Hwang's Law" that year after Hwang Chang-gyu, the former head of Samsung Electronics' semiconductor business (Richter, 2014).

² Moore's Law was based on a 1965 observation by Intel co-founder Gordon Moore, who claimed that the computing power of chips doubles every 18 months.

³ SSD uses electronic interfaces compatible with traditional blockinput/output (I/O) hard disk drives, thus permitting simple replacement in common applications. SSD differs from traditional electromechanical magnetic disks, such as hard disk drives (HDDs) or floppy disks, which contain spinning disks and movable read/write heads. Compared with electromechanical disks, SSDs are typically more resistant to physical shock, run silently, and have less access time.

Lattin & Bucklin, 1989; Rust & Oliver, 2000; Rust et al., 1999; Winer, 1986). For example, Simonson and Tversky (1992) demonstrated that the reference-dependent evaluation of an attribute applies not only to price but also to all other product attributes, while Rust et al. (1999) and Rust and Oliver (2000) analytically validated the importance of reference quality to consumer choice. Experimental studies have also demonstrated (e.g., compromise effect) the contextual-reference concept in consumers' quality perception (Kivetz, Netzer, & Srinivasan, 2004; Simonson, 1989; Simonson & Tversky, 1992).

However, an attribute-specific analysis of competitive markets has not yet been fully explored due to the limitations of previous approaches in discrete choice models for differentiated product demand, such as BLP (Berry, Levinsohn, & Pakes, 1995) type choice models and competitive market structure analysis. Standard BLP models do not reflect product attribute-level innovation shocks because each product's characteristics are fixed. In other words, these models cannot capture the relative changes in consumers' valuation of product quality that is driven by rapidly changing standards, especially in high-tech durable goods markets. Therefore, the estimated own- and cross-elasticity of quality for an attribute do not reflect attribute-specific innovation shocks in the corresponding market, and as a result, the preceding studies were only able to provide limited strategic implications specific to a product attribute.

These own- and cross-elasticity of product attributes have been extensively investigated in the literature on competitive market structure analyses due to their usefulness in assessing the impact of companies' and competitors' marketing actions on market shares (Lattin & Bucklin, 1989). Previous studies have even suggested a perceptual map that explains how customers perceive existing brands and the corresponding substitutability/complementarity among brands using a few dimensions that underlie many attributes (DeSarbo & Rao, 1986; Elrod, 1991; DeSarbo, Manrai, & Manrai, 1993; Elrod et al., 2002). However, with this approach, the dimensions of the resulting map are unlabeled, and managerial judgment and subsequent analyses of consumer perceptions are needed to interpret the map (Elrod et al., 2002). Similarly, the competitive market map using competitive clout and vulnerability suggested by Cooper (1988) and Kamakura and Russell (1989) is restrictive in that it focuses only on the elasticity of price or other non-fixed variables, such as advertising (Kamakura & Russell, 1989). Therefore, the existing models in competitive market structure analysis do not provide any information beyond the market structure specific to price competition.

Therefore, in this study, we propose a reference-dependent choice model for product quality that can capture the asymmetric effect of innovation shocks on product demand and competitive market structure at the product attribute level. Because the reference changes for each time period depending on the competitive market environments, the reference-adjusted product quality variables are not dependent on a fixed term and change relative to the varying market references that reflect attribute-specific innovation shocks in this estimation. Therefore, a distinctive feature of the proposed model is that the product attributes become strategic variables that researchers can examine from the perspective of product innovation. In other words, the model estimates the asymmetric elasticity of gain and loss for the reference quality separately, which generates different innovation insights for businesses depending on their strategic positions over the product quality span of an attribute relative to the reference point. It also provides important strategic implications regarding the management of product attribute portfolios, i.e., how to manage the innovation levels and the combinations of different product attributes from the perspective of new product development. It is also noted that in regard to the empirical model setup, this study uses a static model of competition in each time period. However, competitive outcomes change across time periods because the reference quality level changes, i.e. consumers' level of desired product quality constantly changes, due to a continuous introduction of new products that are generally higher in quality than the current conventional level.

The remainder of this paper is organized as follows. In the next section, we discuss the relevant literature. We then present the theoretical concept behind our model. Next, we specify our reference quality-dependent demand model, which takes into account the key theoretical concepts. The subsequent sections relate to our empirical results, and we conclude with limitations and suggestions for future studies.

2. Literature review

2.1. Market structure analysis

The analysis of competitive market structure is an important area of marketing research due to its significance in explaining the nature and extent of competition among companies and their products (Elrod et al., 2002), including the identification of competitors, market segmentations, product positioning, and pricing (Elrod et al., 2002; Cooper, 1988; Kamakura & Russell, 1989).⁴ From the demand-side perspective, market structure analyses explain the extent to which the products under consideration are substitutes for or complements to competing products in the market. Therefore, these analyses aid in understanding competition and are useful for companies in designing new products or altering existing ones. Additionally, because they are based on a multi-attribute utility model, market structure analyses provide useful information regarding customer perceptions and evaluations of existing products in terms of product attributes (Elrod et al., 2002).

However, neither external nor internal market structure analyses⁵ provide information about market structure and competition at the product attribute level (Bronnenberg, Mahajan, & Vanhonacker, 2000; Elrod, 1988, 1997; Elrod et al., 2002, Elrod & Keane, 1995; Erdem & Keane, 1996; Shocker, Bayus, & Kim, 2001; Wittenschlaeger & Fiedler, 1997). Although both approaches use information on the attributes of existing products to construct the perceptual map at the brand level, the dimensions are abstracted and assumed without labels, and the specific attribute information cannot be considered when building attribute-specific product design strategies, i.e., product innovation strategies (Chintagunta, Dube, & Singh, 2002; DeSarbo & Rao, 1986; DeSarbo et al., 1993; Elrod, 1991; Lenk, 2001).

Competitive market structures can be examined using price elasticities, as in the case presented by Kamakura and Russell (1989). They proposed a model that can identify the underlying determinants of brand-switching probabilities and aggregate responses to price changes. Using the cross-price elasticity from the multi-attribute choice model, these authors obtained a representation of a market structure that simultaneously revealed the brand preferences of key consumer segments and enabled the prediction of the magnitude of aggregate own- and cross-price elasticities. In their analysis, cross-price elasticity was divided into two different methods of competitive clout and vulnerability depending on how a company's own price change will affect the market share of the competing brands and vice versa (Kamakura & Russell, 1989).

Following Kamakura and Russell (1989), other scholars including Cooper and Inoue (1996), Heerde, Mela, and Manchanda (2004), and Rutz and Sonnier (2011), have used the concept to analyze various marketing issues while considering the competitive market structure. However, these approaches do not provide a complete picture of the

⁴ From the supply-side perspective, the economic literature contains an extensive and comprehensive discussion of industrial organization, while the demand-side market structure is predominantly covered by the marketing literature (Elrod et al., 2002).

⁵ External analyses presume that the attributes that drive choice and the values of the brands with regard to these attributes are known to the researcher and use data about consumer perceptions of existing brands. A good example is conjoint analysis. In the case of internal analyses, conjoint analysis assumes that a few dimensions are enough to explain substitutability/complementarity among brands. However, the number of dimensions and the locations of the brands on these dimensions are determined solely from preference/choice data. However, the dimensions of the resulting map are unlabeled (Elrod et al., 2002).

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