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A factor-analytic generalized nested logit model for determining market position of airlines

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A B S T R A C T

This study presents a factor-analytic specification incorporated into the generalized nested logit model to gain insights into passenger service perceptions through positioning analysis of closely competing airlines. The model can illustrate market positions of competing airlines, while simultaneously capturing substitution patterns among airlines. The data used comes from a stated preference survey containing travelers' airline preferences for international trips from Taiwan to Japan. Two latent dimensions comprised of service attributes that were not considered in the stated choice design are identified, namely "amenities and ground service" and "reputation and credibility." The choice map identifies two highly competing groups based on similarities on latent attributes and shared error components. The factor-analytic generalized logit model statistically outperforms the factor-analytic multinomial logit and offers important behavioral and managerial suggestions for airlines and policy-makers.

1. Introduction

As one of three pillars of marketing strategy (i.e., segmentation, targeting and positioning) positioning helps firms to establish competitive advantage (Kotler and Keller, 2011). Positioning analysis also aids better understanding of consumers' perceptions of competing products or brands. Consequently, better market strategies can be tailored to fulfill customers' needs and beat rivals. The airline industry is highly competitive due to intense rivalry among large number of domestic and international airlines. Thus, market positioning has in recent years received more attention among researchers to understand relative firm advantages (e.g., Gursoy et al., 2005; Wen et al., 2008; Wen and Yeh, 2010; Wen and Chen, 2011).

Positioning analysis often relies on perceptual mapping techniques to graphically illustrate the competitive positions of products or services (Hooley et al., 2008). In general, perceptual mapping uses two distinct types of approaches: multivariate statistics and factor-analytic choice mapping. Multivariate statistics, such as correspondence analysis and multidimensional scaling, require customers' perceptions on products and attributes to produce perceptual maps (Myers, 1996). However, the drawbacks of a multivariate perceptual mapping analysis are: (1) that the differences in product market shares are not clarified because dependent variables (e.g., brand choice) are not specified in the model (Elrod, 1991); and (2) the approach belongs to an exploratory data technique that lacks the ability to test specific hypotheses (Hoffman and Franke, 1986). The alternative mapping approach for competitive positioning is factor-analytic choice map modeling, originally developed by Elrod (1988) for analyzing brand positions and consumer preferences using choice data. Derived from the principle of

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random utility maximization the approach has advantages over multivariate mapping analysis. It can identify important determinants affecting consumers' brand choices and predict changes in market shares of brands. Although the factor-analytic choice map models have been developed and widely applied in the marketing field, the application of such models in exploring travel mode choice or carrier selection has been very limited (e.g., Yang and Sung, 2010).

The multinomial logit (MNL) model is the most commonly used formulation for the factor-analytic choice map model (e.g., Chintagunta, 1994; Erdem, 1996; Erdem and Winer, 1999; Chintagunta, 1999; González-Benito et al., 2009). However, the assumption of independently and identically distributed error terms results in independence from irrelevant alternatives (IIA). Such model may produce biased results if the assumption is violated or the IIA property does not hold. To address this restriction of the MNL, Sinha (2000) developed the factor-analytic nested logit (NL) model to accommodate a flexible covariance (or correlation) structure among alternatives. However, the factor-analytic NL model still suffers from the shortcomings of the NL model that imposes constraints of equal correlation among alternatives in a common nest.

The objective of this research is twofold. First, to present a new factor-analytic choice map model formulated on the basis of flexible discrete choice models. Recently developed discrete choice models, are mostly derived from the generalized extreme value (GEV) model (McFadden, 1978) avoiding the IIA property by using a more general structure for the covariance among alternatives. An innovative discrete choice model is the generalized nested logit (GNL) which includes many other GEV models as special cases (Wen and Koppelman, 2001). The proposed new factor-analytic choice map model based on the GNL formulation is referred to as the factor-analytic GNL model that can illustrate positions of closely competing alternatives just as the standard factor-analytic MNL model can, while simultaneously capturing flexible covariance structure among alternatives. The development of the factor-analytic GNL model has contributed greatly to the literature. Second, to explore, by using the factor-analytic GNL model, how air travelers position international airlines. To achieve this we construct choice maps that illustrate relative positions of competing airlines. Although positioning of airlines has received considerable attention, most studies use multivariate perceptual mapping approaches, such as correspondence analysis, and fail to provide insights into the effects of service changes on airline shares. Then again, a large number of studies have explored airline or itinerary choices. Over time, the modeling has moved from simple MNL (e.g., Alamdari and Black, 1992; Proussaloglou and Koppelman, 1995) to various advanced GEV models that allow flexible substitution patterns among alternatives within various choice dimensions: airline, flight departure time and level-of-service (Coldren and Koppelman, 2005a, 2005b). In addition, using the stated choice surveys to collect data provides valuable information about the valuation of service attributes (e.g., Adler et al., 2005; Rose et al., 2005; Whitaker et al., 2005; Lijesen, 2006; Warburg et al., 2006; Hess, 2007; Espino et al., 2008; Balcombe et al., 2009). Most of these studies used the mixed logit model (Revelt and Train, 1998) to highlight the need for considering heterogeneous preferences among air travelers.

An alternative approach to consider individual heterogeneity is the latent class choice model with market segmentation to identify multiple sets of utility function parameters and segment sizes (e.g., Teichert et al., 2008; Wen and Lai, 2010). While airline choice modeling using market segmentation approaches has received much attention, no study explores competitive positioning with the factor-analytic choice mapping approach in the context of airline choice. This study contributes to the literature by advancing the factor-analytic choice mapping approach and by enhancing our understanding of how travelers select airlines.

2. Model structure

The factor-analytic choice model simultaneously identifies decision makers' preferences for alternatives and illustrates competitive positions of choice alternatives on a map. The utility of alternative i for decision maker n is defined as

$$U_{in} = c_{in} + \beta' X_{in} + \varepsilon_{in} \tag{1}$$

where c_{in} contains the average effects of all variables that are not included in the model, which is defined for alternative i and varies across decision maker n; in contrast, the standard logit choice model specifies a constant for alternative i, which is invariant across decision makers. X_{in} is a vector of explanatory variables, and β is a vector of unknown parameters associated with X_{in}. ε_{in} is the unobserved error component that accounts for the variables influencing utility but are not included in the systematic component.

The factor-analytic approach characterizes the positioning of closely competing alternatives with the similarity on the average effects of all excluded variables captured by the alternative-specific constants. Individuals differ in their preferences for alternatives leading to a number of latent dimensions, and each dimension can be captured by a vector of importance weights. Thus, the constant term c_{in} can be decomposed into two or more latent dimensions as follows

$$c_{in} = l_i w_n \tag{2}$$

where l_i is an $(1 \times M)$ matrix of the positions of airlines on the M-dimensional map; w_n is a $(M \times 1)$ vector with M-variate normal distribution; $\bar{w}$ is an expected value of dimension M, which may be positive or negative.

This model requires a set of restrictions to avoid identification problems (Elrod, 1988). The first restriction is to ensure translational invariance, so adding a constant value to the utilities of all elemental alternatives does not alter the choice probabilities of the alternatives. The constants of one alternative are fixed at zeros, so this alternative is placed at the origin of the map. Additional restrictions are imposed to account for rotational invariance that requires fixing $M - 1$ coordinates of