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Demand forecasting for multigenerational products combining discrete choice and dynamics of diffusion under technological trajectories

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Abstract

The discrete choice model generally captures consumers' valuation of the product's quality within the framework of a cross-sectional analysis, while the diffusion model captures the dynamics of demand within the framework of a time-series analysis. We propose an adjusted discrete choice model that incorporates the choice behavior of the consumer into the dynamics of product diffusion. In addition, a new estimation structure is proposed, within the framework of the time-series analysis, which enables the estimation of the discrete choice model on market-level data to be performed in such a way as to avoid the problem of price endogeneity and to obtain greater flexibility in forecasting demand. As an empirical application, the suggested model is applied to the case of the worldwide DRAM (dynamic random access memory) market. In forecasting future demand of DRAM generations, we integrate Moore's law and learning by doing to reflect the future technological trajectories of DRAM innovations, as well as consumers' consumption trends to reflect the dynamics of demand environments. As a result, the suggested model shows better performance in explaining the diffusion of new-generation product with limited number of data observations.

Keywords: Multigeneration product; Discrete choice; Diffusion; Moore's law; Learning by doing

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1. Introduction

One of the major features of recent market evolution is that the products, especially high-tech products, become differentiated into multiple generations with path dependency in the advancement of their technological performance. This phenomenon primarily stems from the discrete patterns of innovation in the product characteristics in a standardized and competitive technological environment. Moreover, not only do the products become differentiated with distinct and predictable features in their characteristics, but also the interval between these generations becomes shorter as the competition becomes more intensive. In contrast to these salient features in product development and technological environment, previous approaches to the study of the evolution of the market did not pay much attention to the concept of generation and their technological trajectories when characterizing product diffusion and substitution mechanisms.

In the development of the diffusion models, since the benchmark models were suggested by Mansfield [1], Bass[2], and Fisher and Pry [3], the models have subsequently been extended with a single product considered within the framework of a time series under the strict assumption that the diffusion of one product is independent of that of other successive ones. Recently, Norton and Bass [4] extended the Bass-type diffusion model to the case of multigeneration product market, capturing both the diffusion and substitution patterns simultaneously. Later, Mahajan and Muller [5] suggested a model that allows switching by only a fraction of the market. Both Norton and Bass [4] and Mahajan and Muller [5], however, pointed out that further improvement in their models would be needed to incorporate the differences in features among product generations, which affect potential adopters' decisions of when and whether to adopt the next-generation product with more reasonable specification of the diffusion and substitution processes.

Jun and Park [6] approached the diffusion mechanism with the concept of the discrete choice model, which primarily focused on describing decision-makers' choices over product characteristics and price, to capture the choice behavior of the consumer in product diffusion. However, their estimation structure was within the framework of the simultaneous equation model in parallel with those of Norton and Bass [4] and Mahajan and Muller [5]. These approaches of nonlinear systems using the simultaneous equation model have inherent shortcomings, such as increasing parameter instability and exacerbated misspecification problems with increasing complexity and nonlinearity, convergence and identification problems, sensitivity to the parameter starting values, etc.[1] These shortcomings limit the use of these models when it comes to forecasting demand for new products for which few historical observations are available. For this reason, data from the previous generation has to be used to be able to impute the diffusion parameters of the new generations when forecasting the diffusion of new generations.[2]

We, therefore, propose a model that cannot only overcome the problems encountered when using nonlinear systems with the simultaneous equation model, but also successfully forecast new-generation diffusion with limited historical data, by incorporating both the diffusion effect and the

[1] Mahajan et al. [7].

[2] Mahajan and Muller [5], Norton and Bass [4], Jun and Park [6], Speece and MacLachlan [8], etc. did not consider new-generation diffusion in forecasting demand.