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# A technology replacement model with variable market potential — An empirical study of CRT and LCD TV

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ABSTRACT

The rapidly changing economic environment and increasingly fierce competition indicate that companies must innovate in both their products and marketing strategies if they are to continue to flourish. Specifically, the ability to accurately predict the demand for products is crucial when firms decide to allocate their resources, especially in the fast moving high technology industries, where there is very high investment in R&D and production facilities. This study establishes a forecast model for technology replacement based on the diffusion model with population growth used for the variable market potential. The proposed model is then applied to investigate the CRT and LCD TV market.

The results suggest that the new model is more accurate than the constant market potential model in fitting and forecasting performance. Consumers who purchase a TV for the first time are likely more attracted to LCD TV rather than CRT TV. As for those individuals who already own a CRT TV, the attraction is not strong enough to encourage them to replace their current CRT TV with a new LCD TV. Moreover, it is noted that the falling price of LCD TV is an essential factor in encouraging purchases.



## 1. Introduction

Product diffusion model can be utilized to understand the attitude and behavior of consumers at different stages of a product's life cycle, and thus enable enterprises to set appropriate policies with regard to manufacturing, marketing and finance.

The studies on product diffusion model began in the early 1960s, when Fourt and Woodlock [1] and Haines [2] undertook research that focused on product innovation, innovation diffusion and adoption. Later, Robertson [3] and Bass [4] carried out assessments of new products in terms of quantitative models. The Bass Diffusion Model has been applied to investigate diffusion patterns and demand forecasting [4], although it has some limitations. Specifically, it provides a prediction of the first-purchase of a new product, without considering repurchases and other essential factors in marketing. Consequently, many researchers have worked to expand, incorporate, modify and introduce new methods into the Bass Model in order to better reflect the complexity of the market.

As to change in market potential, extensions of the Bass model that address this assumption have attempted to relax it by specifying the market potential as a function of relevant exogenous and endogenous variables controllable as well as uncontrollable [5]. Mahajan and Peterson [6] indicated the total population in a social system in an influential factor on market potential, while Sharif and Ramanathan [7] represented the market potential as a function of population growth. Kalish [8] set market potential as the function of price and number of adopters and Jain and Rao [9] reckoned the price of the product had an effect on the whole market potential. In addition, Jones and Ritz [10] claimed that an increase in the number of retailers would affect the whole market. Lilien et al. [11] investigated the diffusion of medications situation with a repeat-purchase model. Simon and Sebastian [12] proposed competition among the products and marketing mix variables. Norton and Bass [13] developed a multi-generation substitute diffusion model and applied it to obtain the substitution and diffusion for high-technology products

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for each successive generation. Islam and Meade [14] analyzed the mobile phone systems in eleven countries to test the hypothesis of coefficient constancy assumed in the empirical work of Norton and Bass, and the results showed that with the introduction of products of different generations, only parameter $q$ would change. Mahajan and Muller [15] explored the adoption and substitution patterns of four successive generations on IBM mainframe computers, and demonstrated that the timing of the introduction of a new technology was a key element in new product strategy. Finally, Speece and MacLachlan [16] presented a multi-generation diffusion model with pricing factors and employed it to investigate milk container technology.

With regard to multi-generation diffusion models, Norton and Bass [13], Speece and MacLachlan [16], Mahajan and Muller [15] all expanded the basic form of the Bass Model. Jun and Park's [17] study revealed that the demand for products originated from consumers' choice behavior, and they would purchase products with the maximal utility, a finding which has been used to shed light on new products' sales patterns and for developing multi-generation models that capture both the diffusion and substitution processes. Chen and Watanabe [18] employed Jun and Park's [17] model to investigate the information and communication technology products in Japan. In addition, Jun et al. [19] adopted Jun and Park's [17] model and developed a choice-based competitive diffusion model to forecast the substitutive and competitive environment of South Korean telecommunication services.

To date, the "choice-based diffusion model" and related research [17–19] assume that the market potential of a product remains unchanged over its entire life. This study addresses this limitation by specifying the market potential as a function of population growth, and thus attempts to construct a more precise model. By extending this model, the phenomenon of replacement with regard to CRT and LCD TVs and the related consumer behavior will be examined.

The purpose of this study is in respect of the academic concern to propose a precise model which can precisely forecast the technology replacement of CRT TV and LCD TV in view of the variable market potential that can mirror the capricious nature. In respect of practical consideration, this study aims to not only probe into the crucial factors in replacement but also forecast the variations of TV market potential demand in each period of time. Therefore, the proposed model of this study is anticipated to serve as a reference for both decision-making and strategy-scheming.

This paper is organized as follows: Section 2 presents the methodology, including models of constant and variable market potential. Section 3 contains an overview of the LCD TV industry and provides the results of empirical analysis and a clear description of the variable market potential. The conclusion is made in the final section, along with some practical suggestions.

## 2. Technology replacement model

### 2.1. Choice probability

Sales patterns of the new products and the replacement are in close relation with the choices made by consumers. By studying the consumers' behavior of choice-making, the sales patterns of new products can be inferred and the sales forecast can be developed.

Firstly, considering the problem in making choices faced by potential first-purchase consumers tend to choose a specific product that can maximize utility under available resources. In the case of replacement, a potential first-purchase consumer must decide in each time period whether to make a purchase and if so, which kind of product to purchase.

It can be defined that the utility of the $i$-th potential first purchaser would require by buying the $k$-th generation product at time $t$ as

$$U_{ti}^{(0,k)} = V_t^{(0,k)} + \varepsilon_t^{(0,k)},\ k\ =\ 0,\ 1,\ 2. \tag{1}$$

$k = 0, 1, 2$ indicates non-purchase, purchase old product and purchase new product, respectively.

In the superscript, the first term represents the status of the individual just before making a choice, and the second represents the choice made at time $t$ and the chosen product can be either old or new. Therefore, (0,1) and (0,2) indicate that the non-purchase consumer purchases an old or new product at time $t$, respectively.

In Eq. (1), $V$ and $\varepsilon$ serve as the deterministic term and the error of the utility, respectively. $V$ is independent of the individual consumer and is dependent only on the attributes of each factor (e.g. price, advertising, design, etc.). The error term, $\varepsilon$, is stochastic and captures both random taste variation across the population and model specification error.

Secondly, considering the user who owns the old product at time $t$, the decision is whether or not to replace it with the new one. Therefore, the $i$-th consumer who owns the old product makes a decision whether to replace it at time $t$, and the utility resulting from this decision can be depicted as:

$$U_{ti}^{(1,k)} = V_t^{(1,k)} + \varepsilon_{ti}^{(1,k)},\ k\ =\ 1,\ 2. \tag{2}$$

The superscript (1,1) denotes the consumer keeps using the old product, while (1,2) indicates the consumer replaces it with a new one.

According to Jun and Park [17], the deterministic terms of the utility are specified as follows:

$$V_t^{(0,0)} = c^{(0,0)}. \tag{3}$$

$$V_t^{(j,k)} = t^{(j,k)}(t - \tau_k + 1)) + p^{(j,k)}X_t^{(k)},\ j =\ 0,\ 1,\ k = 1,\ 2. \tag{4}$$