Technovation 34 (2014) 162–176

Contents lists available at ScienceDirect

Technovation

journal homepage: www.elsevier.com/locate/technovation

# Diffusion of multi-generational high-technology products

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ARTICLE INFO

Available online 30 December 2013

*Keywords:*
Diffusion models
Multi-generational
High-technology products
Forecasting

ABSTRACT

Previous multi-generational product diffusion (MGPD) models were developed based on the diffusion patterns at that time, but may not be adopted in today's cases. By incorporating the effect of customers' forward-looking behaviour, this paper offers a parsimonious and original model that captures the dynamics of MGPD in current high-technology markets. We empirically examine the feasibility of using previous MGPD models and our suggested model to explain the market growth of new products from high-technology industries. The results show that the new model exhibits better curve fitting and forecasting performance than the prior MGPD models in the cases of this study. For marketing researchers, our model and its results suggest customers' forward looking behaviour is perhaps one of the key sales affecting factors that are missing in previous MGPD models in explaining nowadays' cases. For marketing practitioners, this study offers a valuable tool for marketing strategies in high-tech industries.



## 1. Introduction

One important field of the study of diffusion phenomena is to understand and predict the purchase demand of new products utilising diffusion models. At an aggregated level, the purchase behaviour of first-purchase demand usually follows a bell shape curve that will finally decay due to the saturation of market potential (Bass, 1969; Griliches, 1957; Meade and Islam, 1998), that is, the sales curve reaches a peak and decline is expected thereafter. Following the pioneering work of Bass (1969), a number of diffusion models have been proposed to understand the trend of the first-purchase demand. Some introduce new variables such as marketing-mix variables; some apply the model to more complicated contexts such as internet and global diffusion; and a few others use the model to understand specific phenomena such as the saddle effect (Baldridge and Burnham, 1975; Bass, 2004; Geroski, 2000; Mahajan et al., 1990; Mahajan et al., 2000; Meade and Islam, 2006; Peres et al., 2010).

However, successful products in the market are normally substituted by newer generations with advanced attributes that can create new markets, update existing users, and thus repeatedly boost market demand. Examples are abundant, such as TVs (Tsai, 2013b), cellular phones (Anderson et al., 2008), and video game consoles (Cenamor et al., 2013),. The diffusion process of those multi-generational products has its unique attributes, thus cannot be explained by the first-purchase demand models. Therefore, one of the key demanding issues for both academics and practitioners is to understand, model, and predict the sales behaviour of multi-generational products (Bass, 2004; Mahajan et al., 2000; Meade and Islam, 2006; Peres et al., 2010).

Two of the more frequently cited cases in previous MGPD modelling studies are the cases of IBM mainframe machine and PC DRAM shipments. The diffusion curves in the two examples are generally a set of consequent and overlapped bell shape curves, in which one generation starts to decline after its successor is released (see Fig. 1). However, in recent years, the product growth pattern may have changed due to changes in the competitive environment and advances in firm level marketing strategy. Consider Apple's PC product (iMac) and smartphone product (iPhone), they are some of the most proliferated products in today's market and they both span multiple successive generations. Fig. 1 shows that sales of the two products both have an increasing trend. However, the sales curves are no longer overlapped between generations, as the company normally only maintains one generation of its PC product in the market and has different marketing strategies for its smartphone product through time (initially the company only maintained one generation in the market; however, since the release of the product's third generation they allow multiple generations in the market). Furthermore, the pattern of sales trends for the two products changes after each new generation is released to market, for instance, the second generations of both products

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http://dx.doi.org/10.1016/j.technovation.2013.11.008

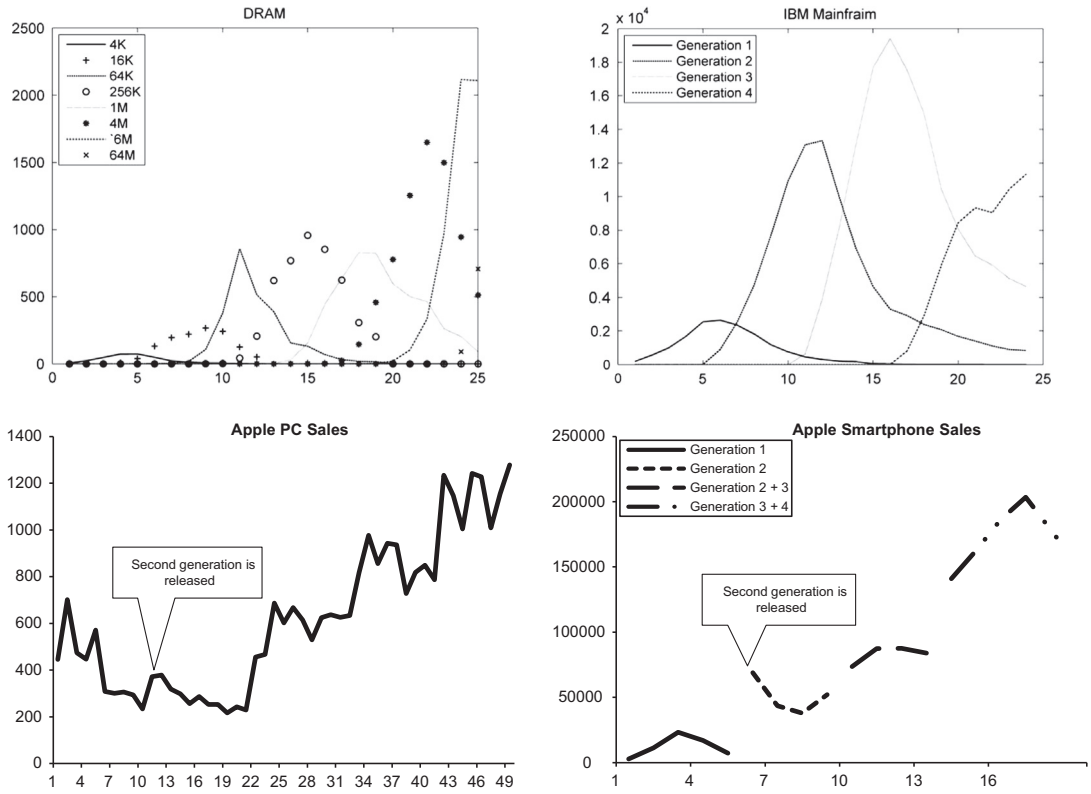


**Fig. 1.** MGPD processes.

have an immediate decline after they are released, which does not exhibit the classical bell shape curve (see Fig. 1).

The above two cases show that prior MGPD models are potentially inapplicable for explaining the diffusion of modern day high-technology products. Reflecting the importance of this issue, we proposed the current study with the objective of understanding and modelling the MGPD processes in the context of current markets. This topic is important, because marketing practitioners increasingly demand tools that help to explain and accurately predict the product sales trends, and because marketing researchers are constantly exploring and updating their understanding of the MGPD phenomena. We aim to provide a parsimonious and original model that captures the dynamics of MGPD in the current high-technology markets, and thus benefits both academics and practitioners who are keen to understand the phenomena.

The remainder of the paper is structured as follows. The next section reviews existing approaches for understanding and modelling MGPD. We then propose a new approach of modelling MGPD that includes a modified cross generation effect combined with the effect of customers' forward looking behaviour. We give empirical validation and discussion of the proposed model using sales data of eight high-technology products with diffusion patterns from different industries. Finally, conclusions are provided.

## 2. Related literature

### 2.1. Existing MGPD models

The phenomena of MGPD are mostly explained and modelled through homogeneous models. The basic concept behind these models is that, the customer base of each product generation changes due to the introduction of newer generations. Although early attempts in this field may have started from Fisher and Pry (1971), the pioneering work is usually credited to Norton and Bass (1987) (the NB model). The key concept embedded in the NB model is that, the later generation plunders the customer base of its earlier generation when they exist in the market simultaneously. As the NB model does not differentiates the leapfrogging and switching adoptions, Jiang and Jain (2012) recently develop a generalised NB model to fill this gap. Another important contribution in this field is a Bass-type model proposed by Mahajan and Muller (1996) (the MM model). Similar with the NB model, the primary focus of the MM model is the dynamic potential customers of each generation. Differently, the MM model suggests a customer after purchasing one generation of the product will immediately become a potential customer of the following generations through upgrading or leapfrogging. In others words, each generation plunders potential customers from its earlier generation in the NB model; each generation absorb product users from its previous generations as its potential customers in the MM model. Later works such as Speece and Maclachlan (1995), Islam and Meade (1997), Danaher et al. (2001), Kim et al. (2000), Chanda and Bardhan (2008), Stremersch et al. (2010), and Tsai, in press are more or less inspired by the NB model and the MM model.

Another popular approach of explaining the MGPD process is through choice models. In a simple case, Lattin and Rober (2000) and Kim and Srinivasan (2003) propose their models, in which customers decide to buy a newer version of the product if the expected utility of the new generation is greater than the utility of their current one. In a more complicated setting where multi generations of a product exist in the market at the same time, customers evaluate the utility obtained by adopting each generation and the non-purchase utility, and then choose the option that results in the highest utility. Following this understanding, Jun and Park (1999) and Jun et al. (2002) integrate the diffusion effects and choice effects to explain customers' purchase behaviour regarding successive generations of a durable technology (we name it the JP model in this study). This stream of modelling concept is recently