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# DRAMs, fiber and energy compared with three models of market penetration

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**Abstract**

When a new technology is introduced in the market, this technology generally follows an S-shaped curve, especially if measured on a relative (market share) basis. Marchetti and Nakicenovic and Norton and Bass have modeled the multivariant case of various technologies introduced at different times. A new, simple and flexible model has been proposed based on potential penetration. Potential penetration is penetration on the assumption that no other new technology will enter the market. In a stable competitive environment, potential penetration curves are typically positively sloped S-curves. The new model gives a good fit in markets with a limited number of competitors, which are capable of totally cannibalizing previous generations of technologies. It also fits well with markets with many competitors in a competitive equilibrium situation. Examples are the Dynamic Random Access Memory chips (DRAMs), fiber and energy market. The new model features fewer variables compared with existing models and can readily be adapted to technological processes with time varying parameters, which is particularly important in volatile competitive markets. 

*Keywords:* Technological diffusion; S-curve; Competition; Dynamic Random Access Memory chips; Synthetic fiber; Primary energy

## 1. Introduction

It is well known that when a new product, technology or raw material is introduced in the market, it will take some time to gain market share from existing products, technologies or

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raw materials. Generally, market penetration follows a typical pattern, at least in the beginning, called the (technology) S-curve. A vast array of diverse examples, which is by no means limiting, has been published [1,2] and a critical overview of these processes has been given by Grübler [3]. Many analytical models have been proposed to describe the S-curve of technology diffusion. Fisher and Pry [1] developed one of the first technology diffusion models called logistic model. The shape of this market penetration curve resembles the cumulative Gaussian distribution function. Fisher and Pry state that the substitution of an old technology by a new one will proceed to completion, which is not always true. Introduction of a parameter, the maximum attainable penetration, gives generally more realistic results [4]. Bass [5] has proposed another type of S-curve relevant to this paper. This model includes the time of introduction of a technology.

In this paper, we will deal with substitution processes with more than two competing technologies. Studies into a range of different technologies and markets have been published [6–16]. Marchetti and Nakicenovic have proposed a multivariate approach based on logistic S-curves for this case. The approach was first described by Marchetti [6]. A more comprehensive description of the model and assumptions has been given by Nakicenovic [17]. They subdivide the technological life cycle into three phases: growth, saturation and decline. In the first phase, there is implicit competition between the new and the other technologies. In the saturation phase, we have explicit competition between all technologies and in the last phase, no competition is considered. In generalized form, the model can mathematically be expressed as:

$$f_i = \begin{cases} \frac{1}{1+\exp(-\alpha_i t+\beta_i)} \text{ for } t < t_{b,i}; \alpha_i > 0 \\ 1 - \sum_{j=1}^{i-1} f_j - \sum_{j=i+1}^{k} f_j \text{ for } t_{b,i} \le t \le t_{e,i} \\ \frac{1}{1+\exp(\alpha_i^* t+\beta_i^*)} \text{ for } t > t_{e,i}; \alpha_i^* > 0. \end{cases} \quad (1)$$

$f_i$ represents the market share of the $i$th technology; $\alpha_i$, $\alpha_i^*$, $\beta_i$, $\beta_i^*$, $t_{b,i}$ and $t_{e,i}$ are constants; $k$ is the total number of technologies.

Norton and Bass [15,16] proposed another multivariate model. The model is based on sales volumes, which has the drawback that it combines the demand of the total market and the competition between the different technologies in that market. Both processes are likely to be driven by different factors. The model can easily be reformulated to market shares:

$$f_i = \frac{g_i(1-\xi_{i+1})}{\xi_1 + \sum_{j=2}^{k} m_j \xi_j} \quad (2)$$

with (Eq. (3))

$$g_i = \xi_i(m_i + g_{i-1}),\ g_0 = 0 \text{ and } \xi_{k+1} = 0. \quad (3)$$