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Industrial Marketing Management 33 (2004) 689–699

INDUSTRIAL
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Across the threshold: Role of performance and compatibility in innovative new products' market penetration

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Received 29 October 2003; received in revised form 6 February 2004; accepted 25 March 2004
Available online 2 July 2004

Abstract

Both academicians and practitioners agree that there exists a critical threshold to cross for an innovative new product to be able to achieve ultimate market penetration. In this article, the authors characterize the threshold as depending upon innovation characteristics: performance and compatibility, in particular. Based on the insights from evolutionary games, several numerical simulations are conducted to investigate how the critical threshold changes as each parameter representing the innovation characteristics undergoes a change. The analysis results confirm that relative advantage and compatibility are of critical influence in impacting the threshold and thus the successful market entry. Moreover, the effect size was different depending on the size of the firm's proprietary customer base. Based on the findings, discussion on new product design strategies for companies having different market positions (i.e., new start-up firms, established firms, and incumbent market leaders) is provided.
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Keywords: New product introduction; Innovation diffusion; Relative advantage; Compatibility; Network externality

1. Introduction

While many innovations successfully enter the market, take off, and make full diffusion, others diffuse only partially and then perish. As an attempt to explain the successful versus failed market penetration, the so-called "threshold model" has garnered much attention in both academic and business realms (Barabasi, 2002; Geroski, 2000; Goldenberg, Libai, Solomon, Jan, & Stauffer, 2000; Golder & Tellis, 1997; Haldar & Rao, 1998; Rogers, 1995). In his seminal book, Rogers (1995, p. 313) asserted that

> A crucial concept in understanding the social nature of the diffusion process is the *critical mass*, a point in the process when diffusion becomes self-sustaining.

A network scientist Barabasi (2002, p. 131) also mentioned that

> Recognizing that passing a *critical threshold* is the prerequisite for the spread of fads and viruses was probably the most important conceptual advance in understanding spreading and diffusion.

In this article, we try to contribute to the understanding of how the design characteristics of an innovative product impact its penetration success in the market, by characterizing the threshold as depending upon the innovation characteristics.

Many adoption models designate the innovation characteristics (i.e., relative advantage, compatibility, complexity, triability, and observability) as a key factor affecting the pattern of market penetration (Guiltinan, 1999; Holak & Lehmann, 1990; Rogers, 1995; Souder & Song, 1997; Tornatzky & Klein, 1982; Waarts, van Everdingent, & van Hillegersberg, 2002). After Holak and Lehmann (1990) provided empirical evidence that relative advantage and compatibility "directly" affect consumers' purchase intention, the two factors have received favoritism in recent published articles in the area of product innovation. Studies by Guiltinan (1999), Plouffe, Vandenbosch, and Hulland (2001), and Waarts et al. (2002) are some of the examples that put special emphasis on the two innovation attributes.

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0019-8501/$ – see front matter © 2004 Elsevier Inc. All rights reserved.
doi:10.1016/j.indmarman.2004.03.001

The two innovation characteristics are also peculiar in that they are defined in relation to existing products, while others (complexity, trialability, and observability) indicate the innate characteristics of an innovation. Further, popularity of the two "relative" measures suggests that it would be more intuitive to see a new product's market penetration process as the process of building its own base of users in the face of an established network of an incumbent product (Shapiro & Varian, 1999). The present study resorts to an evolutionary game approach in portraying the competition between the old and new products.

The purpose of this article is to investigate how an innovative product's competitive characteristics such as relative advantage and compatibility affect the likelihood of its successful market penetration.[2] By "successful" market penetration, we mean the innovation making a full market penetration beyond the threshold up to its potential. To do that, we first derive a formula of the threshold for successful market penetration in terms of innovation characteristics. We then examine via numerical analyses how the design characteristics affect the probability distribution of the threshold and, subsequently, the probability of successful market penetration. We conclude with a discussion on the implications about new product design strategies for firms under various market positions.

2. Background

2.1. New product success and innovation diffusion

In marketing, very much attention has been paid to the topic of new product success and the drivers of it (e.g., Cooper, 1979; Cooper & Kleinschmidt, 2002). Recently, Henard and Szymanski (2001) summarized, via meta-analysis, the predictors of new product success into four categories: product characteristics, firm strategy characteristics, firm process characteristics, and marketplace characteristics. As discussed in the previous section, many scholars examined the effect of the innovation characteristics on new product success. Others have investigated into the roles of strategic orientation (e.g., Matsuno, Mentzer, & Ozsomer, 2002; Narver & Slater, 1990), order of entry (e.g., Lieberman & Montgomery, 1998), NPD process management (e.g., Schmidt & Calantone, 2002), cross-functional integration (e.g., Sethi, Smith, & Park, 2001), knowledge (e.g., Brockman & Morgan, 2003), and so forth.

Another big topic of new product research is new product growth or the "diffusion." The new product diffusion model was first introduced to marketing by Bass (1969), and we have seen great amount of research in this area (see Mahajan, Muller, & Bass, 1990 for a review). The diffusion research has expanded to the issues of multigeneration diffusion (e.g., Norton & Bass, 1987), cross-product (e.g., Talukdar, Sudhir, & Ainslie, 2002), and cross-country diffusion (e.g., Kumar & Krishnan, 2002). In fact, our model specification may relate to that of Bass (see Footnote 4). However, our model tries to describe the effect of innovation characteristics, whereas Bass's model parameterizes the market behavior of innovation and imitation. Further, our model is more flexible in the sense that the diffusion process may yield failed as well as successful market penetration. Bass's model somehow presupposes that the innovation will spread up to its potential sooner or later.

2.2. Network externality and compatibility

High-tech products, especially IT products such as computer and communication software and hardware, typically exhibit "network externalities." The network externality refers to the phenomenon that the value of a product rises as its network gets larger. Inasmuch as network effect drives somewhat unique market response patterns, there is a need for researchers to investigate certain launch strategies for products exhibiting network effects (e.g., Lee & O'Connor, 2003).

Rogers (1995) defines "compatibility" rather broadly as the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. Compatibility has been extensively researched in the context of network externalities (e.g., Farrell & Saloner, 1985, 1986; Katz & Shapiro, 1985, 1986). In particular, Farrell and Saloner (1985) examined the influence of the installed base of old technology in markets where compatibility is important. Katz and Shapiro (1985) even regarded compatibility and network externalities in the same light by analyzing a model in which consumers value a product more highly when it is "compatible" with other consumers' products.

Many recent papers agree that the network effect is oftentimes critical in new products' (especially in software products') market success, and that compatibility or interoperability (in terms of file compatibility and transferability) influences the extent of network externality (Haruvy & Prasad, 2001; Xie & Sirbu, 1995). Pae and Hyun's (2002) work is one of the empirical studies that established the relationship between compatibility and network externality. Following the convention of network effects research, the term 'compatibility' is used in this paper somehow narrowly in the context of cooperation among consumers.

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[2] Although there are other variables that affect market penetration of new products (e.g., price and launch strategy), we do not take them into consideration in this article to tease out the exact trade-off between performance and compatibility.

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