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Innovation diffusion and new product growth models: A critical review and research directions

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ABSTRACT

Diffusion processes of new products and services have become increasingly complex and multifaceted in recent years. Consumers today are exposed to a wide range of influences that include word-of-mouth communications, network externalities, and social signals. Diffusion modeling, the research field in marketing that seeks to understand the spread of innovations throughout their life cycle, has adapted to describe and model these influences.

We discuss efforts to model these influences between and across markets and brands. In the context of a single market, we focus on social networks, network externalities, takeoffs and saddles, and technology generations. In the context of cross-markets and brands, we discuss cross-country influences, differences in growth across countries, and effects of competition on growth.

On the basis of our review, we suggest that the diffusion framework, if it is to remain a state-of-the-art paradigm for market evolution, must broaden in scope from focusing on interpersonal communications to encompass the following definition: *Innovation diffusion is the process of the market penetration of new products and services that is driven by social influences, which include all interdependencies among consumers that affect various market players with or without their explicit knowledge.*

Although diffusion modeling has been researched extensively for the past 40 years, we believe that this field of study has much more to offer in terms of describing and incorporating current market trends, which include the opening up of markets in emerging economies, web-based services, online social networks, and complex product–service structures.

1. Introduction

At the end of 2008, 4 billion people around the world were using mobile phones (ITU, 2008; The Economist, 2009). Launched in 1981 in Scandinavia, mobile phone service has become a part of everyday life for more than half of the world's population residing in 211 countries. Moreover, in several developed nations, the mobile phone has reached a penetration level that now exceeds 100%, with consumers adopting more than one handset, more than one phone number, and possibly more than one provider. The massive penetration of mobile telephony is not exceptional — many commonly used products and services, such as DVDs, personal computers, digital cameras, online banking, and the Internet, were unknown to consumers three decades ago. As firms invest continually in innovation, this influx of new products and services is expected to continue into the future.

The spread of an innovation in a market is termed "diffusion". Diffusion research seeks to understand the spread of innovations by modeling their entire life cycle from the perspective of communications and consumer interactions. Traditionally, the main thread of diffusion models has been based on the framework developed by Bass (1969). The Bass model considers the aggregate first-purchase growth of a category of a durable good introduced into a market with potential m. The social network into which it diffuses is assumed to be fully connected and homogenous. At each point in time, new adopters join the market as a result of two types of influences: external influences (p), such as advertising and other communications initiated by the firm, and internal market influences (q) that result from interactions among adopters and potential adopters in the social system. The Bass model states that the probability that an individual will adopt the innovation — given that the individual has not yet adopted it — is linear with respect to the number of previous adopters. The model parameters p, q, and m can be estimated from the actual

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adoption data. Parameter estimation issues are discussed in Jiang, Bass and Bass (2006); Boswijk and Franses (2005); Van den Bulte and Stremersch (2004); Venkatesan, Krishnan and Kumar (2004); Lilien et al., 2000; Sultan, Farley and Lehmann (1990); and Van den Bulte and Lilien (1997).

The proliferation of newly introduced information, entertainment, and communication products and services and the development of market trends such as globalization and increased competition have resulted in diffusion processes that go beyond the classical scenario of a single market monopoly of durable goods in a homogenous, fully connected social system. The diffusion modeling literature since 1990 has attempted to extend the Bass framework to reflect the increasing complexity of new product growth. Table 1 provides an overview of the main changes in research focus over the past two decades.

One of the fascinating shifts of focus described in Table 1 is an in-depth discussion of the various types of internal influences involved in the diffusion process. In the original article by Bass, as well as in many of the diffusion studies that followed it, the internal parameter q was interpreted as representing the influence of word of mouth between individuals. Recent contributions to the diffusion modeling literature have reexamined this interpretation to identify and discuss other types of social interactions. On the basis of these recent developments, we believe that the definition of diffusion theory should be revised. The traditional perception of diffusion as a theory of interpersonal communication (Mahajan, Muller & Bass, 1990; Mahajan, Muller & Wind, 2000) should be extended to encompass social interdependence of all kinds (Goldenberg et al., 2010; Van den Bulte & Lilien, 2001). We therefore define diffusion of innovation as follows:

> *Innovation diffusion is the process of the market penetration of new products and services, which is driven by social influences. Such influences include all of the interdependencies among consumers that affect various market players with or without their explicit knowledge.*

We discuss two types of additional social influences (besides word-of-mouth communications) that have garnered recent interest: network externalities and social signals.

Network externalities exist when the utility of a product to a consumer increases as more consumers adopt the new product (Rohlfs, 2001). Network externalities are considered to be direct if utility is directly affected by the number of other users of the same product, as in the case of telecommunication products and services such as fax, phone, and e-mail. Network externalities can also be indirect if the utility increases with the number of users of another, complementary product. Thus, for example, the utility to a consumer of adopting a DVD player increases with the increased penetration of DVD titles (Stremersch & Binken, 2009; Stremersch, Tellis, Franses & Binken, 2007). Interpersonal communication is not necessarily needed for network externalities to work. Potential adopters can find out about the penetration level of a new product from the media or simply by observing retail offerings. For example, during the transition from videotape to DVD, a consumer had merely to walk into a Blockbuster movie rental store and observe the amount of aisle space devoted to VHS vs. DVD to understand that DVDs were about to become the new standard. We elaborate on network externalities in Section 2.2.

Table 1
Shifts in focus of research interests.

Previous focus	Complemented with current focus
Word of mouth as driver	Consumer interdependencies as drivers
Monotonically increasing penetration curve	Turning points and irregularities in the penetration curve
Temporal	Spatial
Industry-level analysis	Brand-level analysis
Aggregate or segment-based models	Individual-level models
Fully connected networks	Partially connected and small-world networks
Products	Services
Forecasting	Managerial diagnostics

Social signals relate to the social information that individuals infer from adoption of an innovation by others. Through their purchases, individuals may signal either social differences or group identity (Bourdieu, 1984). These signals are transmitted to other individuals, who follow the consumption behavior of people in their aspiration groups (Simmel, 1957; Van den Bulte & Joshi, 2007; Van den Bulte & Wuyts, 2007). Social signals operate vertically and horizontally. A vertical social signal indicates the status of the adopter. Recent research indicates that the competition for status is an important growth driver, sometimes more important than interpersonal ties, and that the speed of diffusion increases in societies that are more sensitive to status differences (Van den Bulte & Stremersch, 2004). Social signals are also transmitted horizontally to indicate group identity. Adoption of an innovation by people in a given group signals to members of that group to adopt and to members of other groups who want to differentiate to avoid adoption (Berger & Heath, 2007; 2008). While social signals can be transmitted via word of mouth and/or advertising, neither is a necessity. These signals are observed by potential adopters who *infer* from them the social consequences of adoption.

We note that a distinction should be made between social signals and other types of signals, such as functional signals. Functional signals contain information regarding the market perception of the functional attributes of a product, such as its quality or the amount of risk involved in adopting it, whereas social signals contain information regarding the social consequences of adopting the product, including the social risk of adopting the innovation. An important question is whether inclusion of social inference and network externalities as internal influences contradicts the Bass framework. Traditional applications of the Bass framework have interpreted internal influence in terms of word-of-mouth and personal communications (Mahajan et al., 1990). However, this interpretation is not dictated by the model itself, which does not specify the drivers of social contagion. Thus, the consumer interactions of network externalities and social inference certainly fit the framework, as do other possible growth drivers, as long as they imply that the probability of purchase increases with the number of previous adopters.

In spite of growing evidence of the importance of personal communication in product adoption, an alternative research branch has emerged. This branch argues that the major driver of growth of new products is consumer heterogeneity rather than consumer interaction. The heterogeneity approach claims that the social system is heterogeneous in innovativeness, price sensitivity and needs, leading to heterogeneity in propensity to adopt. Thus, innovators are the least patient in adopting, whereas laggards are the most patient. In such models, patience is often inversely related to product affordability, consumer willingness to pay, or reservation price (Bemmaor, 1994; Golder & Tellis, 1998; Russell, 1980; Song & Chintagunta, 2003). The dynamics of market volume are determined by the shape of the distribution of "patience" in the face of falling prices. If incomes are log-normally distributed in the population, then growth is S-shaped (Golder & Tellis, 1997). This line of research implies that the current approach of diffusion-based research has overemphasized the influence of word-of-mouth communication (Van den Bulte & Lilien, 2001, and Van den Bulte & Stremersch, 2004). Fig. 1 illustrates the range of possible drivers of new product diffusion, arranged according to the level of direct interpersonal communication they involve.

Our objective in this paper is to review the interaction-based diffusion literature published in the past decade and analyze how it has broadened its scope to describe the richness of consumers' internal influences so as to bring these influences in a unified way into the diffusion framework. We do not aim in this paper to cover the entire diffusion literature; for that, we refer the reader to recently published diffusion overviews (Mahajan et al.