Intern. J. of Research in Marketing 27 (2010) 4–15

Contents lists available at ScienceDirect

Intern. J. of Research in Marketing

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

The chilling effects of network externalities

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ARTICLE INFO

Article history:
First received in 18, December 2007 and was under review for 5 months

Area editor: Marnik G. Dekimpe

Keywords:
Agent-based models
Contagion
Net present value
Network externalities
New product growth
Threshold levels

ABSTRACT

Conventional wisdom suggests that network effects should drive faster market growth due to the bandwagon effect. However, as we show, network externalities may also create an initial slowdown effect on growth because potential customers wait for early adopters, who provide them with more utility, before they adopt. In this study, we explore the financial implications of network externalities by taking the entire network process into account. Using an agent-based as well as an aggregate-level model, and separating network effects from word of mouth, we find that network externalities have a substantial chilling effect on the net present value associated with new products. This effect may occur not only in a competitive framework, such as a competing standards scenario, but also in the absence of competition. Drawing on the collective action literature in order to relate network effects to individual consumer threshold levels, we find that the chilling effect is stronger with a small variability in the threshold distribution, and is especially affected by the process early on in the product life cycle. We also find a “hockey stick” growth pattern by empirically examining the growth of fax machines, CB radios, CD players, DVD players, and cellular services.

1. Introduction

How do network externalities affect the diffusion rate and the consequent economic value associated with a new product? Despite the sizeable academic literature on the dynamics of network goods markets, the answer to this question is not obvious. Network effects and network externalities exist when consumers derive utility from a product based on the number of other users; conventional wisdom suggests that such effects should drive faster market growth due to the bandwagon effect (Economides & Himmelberg, 1995; Rohlfs, 2001; Shapiro & Varian, 1999). Therefore, the rapid diffusion of fast-growing product categories has been attributed to network externalities (Doganoglu & Grzybowski, 2007).

However, initial network effects may also have a chilling effect on growth due to the “wait-and-see” position adopted by consumers who derive little utility from an innovation that has few other adopters (Farrell & Saloner, 1986). Therefore, the growth of network goods may follow a two-stage process, that is, slow initial diffusion followed by a very fast growth stage (Rogers, 2003). The question remains as to the overall network effects with respect to the time it takes for an innovation to develop. This growth rate is of considerable managerial importance due to the time value of money, as acceleration in growth can translate into a sizeable difference in the Net Present Value (NPV) of an innovation. However, little is known about the NPV impact of network externalities with respect to the growth rate and the factors that drive it. This lack of knowledge is noteworthy given the growing interest in optimal product strategies for network goods. Various market entry strategies or reactions to market entry of network goods have been suggested in recent years (Lee & O'Connor, 2003; Montaguti, Kuester, & Robertson, 2002; Sun, Xie, & Cao, 2004). Such strategies typically have an impact on or are affected by the rate of growth of the network good in question. A change in the economic value of network goods due to the growth rate should therefore be taken into account in any such analysis.

In this study, we analyze the fundamental effects of network externalities on new product growth rates and consequent profitability. To do so, we combine a classical diffusion model similar to the Bass model with a social threshold model consistent with the collective action literature in sociology (Chwe, 1999; Granovetter, 1978; Macy, 1991). We apply two modeling approaches toward this goal. First, we apply an agent-based model to simulate the growth of the market for a given network good. This bottom-up approach enables us to understand how individual-level network good decisions aggregate to market phenomena. We compare the profitability of similar growth processes with and without network externalities and examine how market characteristics affect the difference. Second, we present an aggregate diffusion modeling approach that enables an analysis using market-level data that is analogous to our first estimation. Consistent with diffusion research, all analyses as well as profitability measures are conducted at the industry level. A brand-level analysis of this diffusion process, even without network externalities, is beyond the scope of this paper (Libai, Muller, & Peres, 2009a,b).

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doi:10.1016/j.ijresmar.2009.06.006

Our work is consistent with recent calls for a better understanding of how network externalities affect the takeoff, growth, and decline of products (Hauser, Tellis, & Griffin, 2006). We find that network effects have an overall chilling effect on the profitability of new products. While the bandwagon effect can indeed lead to fast growth later on, the likely decrease in growth rate early on together with the effect of the discount rate create a general reduction in the NPV. This result is consistent across a wide range of parameter values. We also show that this phenomenon can be strongly affected by the mean and variance in threshold distribution. We find that the wider the variability in threshold distribution in the population is, the weaker is the effect of network externalities on growth. Overall, these results are critical for planning and profit calculation in network goods markets.

The rest of this article continues as follows. We first discuss the possible effect of network externalities on the growth rate and then show how a threshold model can be combined with a classic diffusion setting using an agent-based approach. We conduct an experiment comparing markets with and without network effect. Then we provide an aggregate-level analysis and empirically examine the growth of fax machines, CB radios, CD players, DVD players, and cellular services. We conclude with managerial implications.

2. Network externalities and growth rates

Due to their significance to numerous industries including technology, entertainment, and communications, the dynamics of network markets have received considerable attention in the past two decades. See Birke (2008), Farrell and Klemperer (2006) and Shy (2001) for reviews of economics and Stremersch, Tellis, Franses, and Binken (2007) for marketing literature. This dynamic setting contrasts with earlier work in economics that emphasized the state of equilibrium in network markets rather than the dynamic path toward that state (Economides, 1996; Esser & Leruth, 1998; Laffont, Rey, & Tirole, 1998; Rohlfs, 1974).

Past literature has not yet reached a decisive conclusion on the effect of network externalities on the growth rate. Conventional wisdom suggests that network effects drive faster market growth due to increasing returns associated with such processes (Arthur, 1994). Economides and Himmelberg (1995), for example, suggested that introducing network externalities into a dynamic model of market growth "increases that speed at which market demand grows. Rohlfs (2001, p. 56) argued that "growth in demand generates bandwagon effects, which lead to further increase in demand; and so forth. As a result, demand may grow extremely rapidly." Shapiro and Varian (1999) first attributed network externalities to positive feedback and then suggested that "if a technology is on a roll…positive feedback translates into rapid growth: Success feeds on itself."

However, networks can also create the opposite effect of slowing growth in what is sometimes labeled "excess inertia" (Farrell & Saloner, 1986; Srinivasan, Lilien & Rangaswamy, 2004). Early in the product life cycle, most consumers see little utility in the product, as there are few adopters, and so they may take a "wait-and-see" approach until there are more adopters. Hence, diffusion early on may be very slow and occur among the few consumers that see enough utility in the product even without adoption on the part of other consumers. Overall, the process may be characterized by a combination of excess inertia and excess momentum, i.e., slow growth followed by a surge (Rogers, 2003; Van den Bulte & Stremersch, 2006).

This growth pattern can occur via various types of network externalities. In the case of *direct network effects*, such as fax, e-mail, or other communication products, the number of adopters drives utility directly because the higher the number of adopters is, the higher is the utility of the product. Regarding *indirect network effects*, such as hardware and software products, a possible increase in utility may occur through market mediation (e.g., the number of DVD rental outlets), which in turn is a function of the number of adopters. Consumers will wait for a hardware adoption until there is enough software. In the case of competing standards, early adopters take the risk of adopting the wrong standard, so many wait until the winning standard is clear, and more importantly, which standard or platform will no longer be supported.

The precise dynamics of the impact of network externalities on the growth rate can be determined by the source of the externalities under examination. Past literature has pointed to two types of effects in this regard, namely, *local* and *global*. Under *global externalities*, a consumer takes into account an entire social system when considering the impact of the number of adopters on utility, whereas under *local externalities*, a consumer considers adoption in relation to her close social network. Both approaches have been considered in the network goods literature (Farrell & Klemperer, 2006), and in many cases, both exist to some extent. However, explicitly modeling their joint effect is not trivial (Tomochi, Murata, & Kono, 2005). This *reference group effect* probably changes among various kinds of externalities. Regarding indirect externalities, the effect is expected to be more global, i.e., the vendor's decision to add more software typically depends not on local social network adoption but rather on the overall number of adopters or expected adopters. Therefore, user utility is affected by the total number of other adopters.

Competing standards growth will probably also invoke a global effect, since the "verdict" on what eventually becomes the *de facto* standard depends on the total number of users, not just those in the local social system. Some exceptions are worthwhile to note, as some standards have become *locally* dominant for long periods, such as Apple with artists and designers and Sony's Betamax videocassette format with broadcasters. In addition, the recent network effects literature has moved beyond considering the total number of users as the only characterization of network effects (Binken & Stremersch, 2009; Tucker, 2008).

The situation may be more ambiguous with direct network effects. One could argue that if an individual communicates mostly with her close social network, then the local utility from the number of adopters will drive adoption. Evidence for such effects has been largely based on geographic patterns of adoption, for example, in the case of personal computers (Goolsbee & Klenow, 2002). Yet, even under direct network externalities, users are often also quite interested in the overall utility that they may derive from communicating with others who are not necessarily in their close network. Indeed, communications researchers have argued that for interactive innovations such as fax, videoconferencing, and e-mail, growth and takeoff are driven by *perceptions* of global utility, which in turn are based on overall market ubiquity (Mahler & Rogers, 1999; Rogers, 2003). For some communication products, global utility is evident. For example, for Citizens Band (CB) radio much of the utility follows the ability to randomly communicate with other users on the road or at travel sites. The same goes for many user-generated media sites and file-sharing sites in which users enjoy the presence and contributions of others who are not necessarily part of their social system.

While the literature on the diffusion of innovations does not offer a straightforward approach to modeling the growth of a market for a network good (Chandrasekaran & Tellis, 2005; Peres, Mahajan, & Muller, 2008), there have been efforts to incorporate network effects into hazard growth models as part of the analysis of optimal pricing under competition (Xie & Sirbu, 1995).

A major challenge toward this end regards the multiple effects of previous adopters on the growth rate. Previous users are expected to accelerate growth due to interpersonal effects, including word of mouth and imitation, which is typically used to reduce both risk and search costs. Yet previous adopters also supply value through the increase in the utility of the network good. The literature on the modeling of the diffusion of innovations, specifically the Bass (1969) model and its extensions, generally do not separate the two, and a single parameter for internal influence is used to capture both the impacts of interpersonal communications and network externalities (Van den Bulte & Stremersch, 2004).