Editorial

Preface to "The chilling effects of network externalities"

S. Stremersch [a,*], D.R. Lehmann [b], M.G. Dekimpe [c]

[a] Eramus University Rotterdam, The Netherlands; IESE, Spain
[b] Columbia University, USA
[c] Universiteit van Tilburg, The Netherlands; Catholic University-Leuven, Belgium

1. Introduction

Academic journals in marketing should publish more truly controversial papers, i.e., papers that challenge conventional wisdom. The paper co-authored by Goldenberg, Libai, and Muller (2009a) challenges that network effects drive market growth. The paper is among the first in the literature to try to separate the word-of-mouth process from network effects in the diffusion of new products. Moreover, it uses a novel methodology, cellular automata, introduced by the same authors in the marketing literature (also see, Goldenberg, Libai, & Muller, 2002).

The intersection of challenging conventional wisdom, being among the first to separate two important processes previously thought of as inseparable, and the usage of a novel methodology can be hard to accept for scholars who seek conclusive results and who are more comfortable with careful but modest extensions of existing paradigms. Still, scientific advance hinges at least as much on the publication of interesting and novel ideas, even if they lack conclusiveness, as on the publication of studies that fine-tune and perfect previously introduced ideas or that identify limitations or errors in previously reported findings. However, in most, if not all, academic journals the latter two types of articles far outnumber the former type.

The International Journal of Research in Marketing aims to be a journal at the forefront of academic knowledge on marketing research. Therefore, it hopes to also publish controversial papers, and on occasion supplement them with commentaries of other experts in the field of inquiry to offer readers the full scope of opinions on the areas of controversy. In that spirit, we are happy to publish the paper by Goldenberg et al. (2009a), and commentaries on it by Gatignon (2009), Tellis (2009) and Rust (2009), followed by a rejoinder of Goldenberg, Libai, and Muller (2009b).

2. Network externalities and new product growth

The study of the new product growth process is well-established in marketing research (for original contributions, see Bass, 1969; Golder & Tellis, 1997; Goldenberg et al., 2002). Network externalities—sometimes referred to as network effects—may play a profound role in new product growth.

There are plenty of case examples for which network externalities are claimed to have influenced the new product growth process, and thereby ultimately the success of the companies involved. For example, when launching the Compact Disc in 1983, Philips and Sony allied with music studios to provide a rich catalog of titles and thereby trigger a fast takeoff of their new technology, which occurred in 1985 just 2 years after its launch (Stremersch, Tellis, Franses, & Binken, 2007). Tellis (2009) cites the example of the word processor MS Word and how prior adoption among a small fraction of the population may have enhanced the utility of said software and thereby triggered future diffusion.

At the same time, notorious failures are often cited, such as quad sound and the CD-I which lacked platform support of complementors. Goldenberg et al. (2009a) also point out that standard battles—such as the VCR wars between VHS and Beta, or the DVD wars between HD-DVD and Blue-Ray—may constrain a new product's early growth (e.g., as captured by the parameter p in the Bass diffusion model). Given the widely varying results, academics have begun to investigate this phenomenon more thoroughly (for a recent literature review on indirect network effects[1] in new product growth and a detailed study of historical cases, see Stremersch et al., 2007).

3. Goldenberg, Libai, and Muller (2009a)

Goldenberg et al. (2009a) show that network externalities may have "chilling" effects on the new product growth process, especially early on, which can account for long incubation times (also see Kohli, Lehmann, & Pae, 1999). Though this slow process might be followed by an accelerated growth later on in the diffusion process, in terms of NPV it is not compensated by this faster growth. This finding complements those by Van den Bulte and Stremersch (2004), who showed that competing standards—one element underlying the theoretical reasoning of Goldenberg et al. (2009a)—inflate the q/p ratio, thus creating longer left tails of the diffusion curve but a steeper growth slope later on. Goldenberg et al. (2009a) show that this chilling effect is ubiquitous in the product categories they study.

---

[1] In markets with indirect network effects, the utility of the primary product, e.g., a CD player, and thus its sales, increases as more complements become available. In turn, this availability of complements depends on the installed base of the primary product (Stremersch et al., 2007). Direct network effects refer to the increase in a consumer's utility from a product when the number of other users of that product increases (Tellis, Yin, & Niraj, 2009).

* Corresponding author.
E-mail address: stremersch@ese.eur.nl (S. Stremersch).

The authors also show that the social contagion process can be isolated from network effects in new product growth. The identification comes from assuming that the contagion process operates on a local basis, while network effects are assumed to be global (system-wide). While one can certainly debate, as the authors concede, whether this is true in all cases, economists have also assumed in theoretical models that network effects depend on the total size of the installed base (e.g., by definition in the case of indirect network effects), while at least one way in which social contagion may occur is through local social contact.

The evidence that Goldenberg et al. (2009a) offer is grounded in an agent-based cellular automata model. Using this model, the authors simulate people's adoption behavior under different conditions to assess the aggregate diffusion pattern. They complement their simulation results with results from both aggregate-level analyses and cases.

4. Limitations and future research

Intelligent readers, as well as the leading experts who wrote the commentaries, can certainly identify several limitations of this paper. As is typical of a controversial, truly novel paper, Goldenberg et al. (2009a) probably raise more questions than they provide answers.

First, while Goldenberg et al. (2009a) assumptions on the global nature of network effects versus the local nature of social contagion may seem reasonable, imposing the existence of a threshold on the network externalities process—which the authors aim to validate through theoretical reasoning—clearly affects the outcome of the model, as well as loads the dice in favor of finding chilling effects (also see Gatignon, 2009; Rust, 2009). Also the assumption of social contagion having predominantly local effects seems more valid when contagion occurs through in-person word-of-mouth rather than through social status considerations (see Van den Bulte & Stremersch, 2004).

Second, the core evidence the authors present lies in the cellular automata simulation. Like any simulation, the outcomes are only as realistic as the underlying individual process that is defined (assumed) ex ante by the researcher. Given the typical complexity of the behaviors underlying these models, simplifications may lead to erroneous outcomes (also see Gatignon, 2009).

This paper shows that more research is needed on both the substance—the role of network effects in the new product growth process—as well as on the methodology—agent-based simulation models. Fortunately, these suggest several fruitful research directions.

The separation of social contagion and network effects is certainly worthy of more attention. However, how this can be applied to a diffusion model on aggregate-level data is unclear. Goldenberg et al. (2009a,b) recognize that they exclude social status considerations in their approach. However, given that social status considerations may very well be a social contagion mechanism that is at least as important as word-of-mouth (Van den Bulte & Stremersch, 2004), future research should focus on disentangling network effects, word-of-mouth, and social status considerations in new product growth. Separating the underlying mechanisms is important as they all have very different implications for firms' optimal marketing policies.

Goldenberg et al. (2009a), in line with most economic and marketing research, model network effects through the quantity of prior adopters (global effect). A promising line of research, however, is moving beyond the characterization of network effects along the mere size of the network (e.g., see Binken & Stremersch, 2009; Tucker, 2008). Especially in new product growth, given local contagion influences, incorporating network effects in all their dimensions (e.g., size, quality, and content type) may generate more accurate insights that are more relevant for firms. For example, if one considers video game consoles, catalog size is a relatively minor concern to video console manufacturers like Sony, Microsoft, and Nintendo compared to content quality and type (Binken & Stremersch, 2009).

Tellis (2009) raises the issue of omitted variable bias in new product growth models (also previously raised by, for example, Van den Bulte and Lilien (2001)) such as the one presented in Goldenberg et al. (2009a). As the number of potential covariates in new product growth models easily inflates beyond estimation capabilities, e.g., because of multicollinearity, complex model structure, or poor or limited data, the field needs stronger methods to deal with the variable selection problem. In addition, time dynamics underlie the discussion between Goldenberg et al. (2009a,b) and Tellis (2009). Time-varying parameter diffusion models may not provide closure on this debate. Managers understand that optimality of decisions (e.g., lower price) is time-dependent but their mind works in periods (discrete time) rather than continuous time. Earlier papers have contrasted drivers of early growth versus late growth (e.g., see Tellis, Stremersch, & Yin, 2003; Stremersch & Tellis, 2004; Golder & Tellis, 2004). When one studies contagion mechanisms and network externalities, contrasting different growth stages in a contingency framework may lead to novel and valuable recommendations for managers in network markets.

Agent-based model simulations in marketing are in their infancy. Goldenberg, Libai and Muller (2001, 2002, 2004, 2009a, 2009b) need to be credited for their pioneering role in this area. On the other hand, every radical scholarly breakthrough should be followed by a process of improvement. An important improvement that would greatly benefit agent-based models and its application to network effects in new product growth specifically is validation of the theory underlying the simulation (Rust, 2009). As Tellis (2009) argues, earlier research (Tellis et al., 2009) shows that network effects may accelerate the rate at which a higher-quality product takes over from a lower-quality predecessor, thus challenging the theoretical rationale underlying the model by Goldenberg et al. (2009a). Prior theoretical literature has predominantly argued that network effects cause inefficiency—embedded in the ubiquitous use of the term network externalities, which is a term with negative valence (Liebowitz & Margolis, 1999), rather than network effects—while empirical analyses have shown such that inefficiencies rarely occur (e.g., Liebowitz & Margolis, 1999; Stremersch et al., 2007; Tellis et al., 2009). Thus, the time is right for a greater number of empirical analyses that test network effect theories.

5. Afterthought

Markets are increasingly influenced by network effects, partly because of interdependencies among technologies—often paraphrased by managers as "the ecology" around a technology. Such interdependencies are more prominent than ever because of technology itself (e.g., modularity) and because firms increasingly specialize in different parts of a technology platform (e.g., the evolution of IT from integrated hardware & software firms, to specialized software firms, to firms specialized in certain software application areas).

At the same time, social contagion becomes more apparent. The vast increase in social and professional networking services has made connections between people not only more visible, but people "network" more than ever through a diversity of media. In sum, the customer is increasingly "connected" (see Wuyts, Dekimpe, Gijbrechts, & Pieters, 2010).

Given its relevance, we hope you enjoy these papers and either adopt the concepts and/or methods of Goldenberg et al. (2009a) or develop a competing technology which you contrast with them on theoretical and empirical grounds and, in doing so, increase our understanding of new product diffusion in network markets.

References

Bass, F. M. (1969). A new product growth model for consumer durables. *Management Science, 15*, 215–227.

Binken, J. L. G., & Stremersch, S. (2009). The effect of superstar software on hardware sales in system markets.*Journal of Marketing, 73*, 88–104 March.

Gatignon, H. (2009). Commentary on Jacob Goldenberg, Barak Libai and Eitan Muller's "The chilling effects of network externalities". *International Journal of Research in Marketing, 27*(1), 16–17.

Goldenberg, J., Libai, B., & Muller, E. (2001). Talk of the network: A complex systems look at the underlying process of word of mouth. *Marketing Letters, 12*, 209–221.

Goldenberg, J., Libai, B., & Muller, E. (2002). Riding the saddle: How cross-market communication can create a major slump in sales.*Journal of Marketing, 66*, 1–16 April.

Goldenberg, J., Libai, B., & Muller, E. (2004). Complex, yet simple: Cellular automata as an enabling technology in marketing strategy research. In Donald Lehmann, & Christine Moorman (Eds.), *Assessing marketing strategy performance* Cambridge, MA: Marketing Science Institute.

Goldenberg, J., Libai, B., & Muller, E. (2009). The chilling effects of network externalities. *International Journal of Research in Marketing, 27*(1), 4–15.

Goldenberg, J., Libai, B., & Muller, E. (2009). The chilling effects of network externalities: Perspectives and conclusions. *International Journal of Research in Marketing, 27*(1), 22–24.

Golder, P. N., & Tellis, G. J. (2004). Going, going, gone: Cascades, diffusion and turning points of the product life cycle. *Marketing Science, 23*(2), 180–191.

Golder, P. N., & Tellis, G. J. (1997). Will it ever fly? Modeling the takeoff of new consumer durables. *Marketing Science, 16*(3), 256–270.

Kohli, Rajeev, Lehmann, Donald R., & Pae, Jae H. (1999). The extent and impact of incubation time in new product diffusion.*The Journal of Product Innovation Management, 16*, 134–144 March.

Liebowitz, S. J., & Margolis, S. E. (1999). *Winners, losers, and Microsoft: Competition and antitrust in high technology*, 2nd ed Oakland, CA: The Independent Institute.

Rust, R. T. (2009). Network externalities: Not cool? A comment on "The chilling effects of network externalities". *International Journal of Research in Marketing, 27*(1), 18–19.

Stremersch, S., & Tellis, G. J. (2004). Understanding and managing international growth of new products. *International Journal of Research in Marketing, 21*(4), 421–438.

Stremersch, S., Tellis, G. J., Franses, P. H., & Binken, J. L. G. (2007). Indirect network effects in new product growth.*Journal of Marketing, 71*, 52–74 July.

Tellis, G. J. (2009). Network effects: Do they warm of chill a budding market? *International Journal of Research in Marketing, 27*(1), 20–21.

Tellis, G. J., Stremersch, S., & Yin, Y. (2003). The international takeoff of new products: The role of economics, culture and country innovativeness. *Marketing Science, 22*(2), 188–208.

Tellis, G. J., Yin, Y., & Niraj, R. (2009). Does quality win: Network effects versus quality in high tech markets. *Journal of Marketing Research, 46*(2), 135–149.

Tucker, C. (2008). Identifying formal and informal influence in technology adoption with network externalities. *Management Science, 54*(12), 2024–2039.

Van den Bulte, C., & Lilien, G. L. (2001). Medical innovation revisited: Social contagion versus marketing effort. *American Journal of Sociology, 106*(5), 1409–1435.

Van den Bulte, C., & Stremersch, S. (2004). Social contagion and income heterogeneity in new product diffusion: A meta-analytic test. *Marketing Science, 23*(4), 530–544.

Wuyts, S., Dekimpe, M., Gijsbrechts, E., & Pieters, R. (2010). *The connected customer: The changing nature of consumer and business markets.* NY: Routledge: Taylor & Francis Group.

Commentary on Jacob Goldenberg, Barak Libai and Eitan Muller's "The chilling effects of network externalities"

Hubert Gatignon

INSEAD, Boulevard de Constance, 77305 Fontainebleau, France

ARTICLE INFO

ABSTRACT

This commentary builds on the paper by Goldenberg, Libai, and Muller (2009) and on the areas of the contribution it makes to the field: the distinction between word-of-mouth and network externality effects, agent-based simulations and extensions of the Bass model for aggregate models including word-of-mouth and network externalities. It reflects on some of the issues raised by this paper and provides directions which the author thinks would be beneficial for future diffusion modeling efforts.

© 2009 Elsevier B.V. All rights reserved.

Even after several decades of research attempting to explain the speed and shape of growth of new products, our Marketing modeling efforts remain strongly based on the Bass model (Bass, 1969) with its multiplicity of extensions. Within this research stream, Goldenberg, Libai, and Muller (2009) address the important issue of distinguishing between two well known phenomena, the word-of-mouth effect on the one hand, and network externalities on the other hand. In this commentary, we will first discuss this particular issue. We will then make a few remarks concerning their modeling approaches which include agent-based simulations as well as their Bass model extension with a variable market potential.

1. Distinguishing word-of-mouth from network externality effects

Goldenberg et al. (2009) suggest a solution for separating the impact on product growth of interpersonal communications and of network externalities, as pointed out by Van den Bulte and Stremersch (2004). Network externalities concern the utility of the innovation; this utility is explained, in part, by the extent to which the innovation has already been adopted. Word-of-mouth does not directly affect the product's utility (although it may do so indirectly). The word-of-mouth process is complex; not all adopters have the same opportunity to equally influence a potential buyer (i.e., the global vs. local issues discussed in Goldenberg et al., 2009). Indeed, closeness of ties leads to greater communication, but, at the same time the strength of weak ties has been demonstrated (Burt, 1973; Granovetter, 1983). The distinction between word-of-mouth and network externalities in Goldenberg et al. (2009) is due to the

definition of a specific utility function derived from the existence of a threshold: the utility from the network only comes after the network has reached a certain size (Eq. (1) in Goldenberg et al., 2009). This behavioral process appears quite plausible and is certainly worth investigating.

The approach of developing an individual model and deriving its consequences on the diffusion pattern follows the tradition of economic diffusion models such as Stoneman (1981), Jensen (1982) or Feder and O'Mara (1982), as reviewed in Gatignon and Robertson (1986). Although Goldenberg et al. (2009) use a different adoption process, the distribution of the key factor – the threshold level – across the population presents similarities with the model of Feder and O'Mara (1982). Indeed, in Feder and O'Mara (1982), the prior utilities of the current technology are distributed across the population to explain different times of adoption. Instead, in Goldenberg et al. (2009), it is the utility of the innovation which varies depending on the threshold level which is itself distributed throughout the population.

The particular pattern emphasized in Goldenberg et al. (2009)'s title concerns the "chilling" or slowing down effect of network externalities. However, the network externalities modeled in their paper are characterized by a very specific pattern which requires a threshold of existing adopters to exhibit an effect on the utilities of those who have not yet adopted (0 probability of purchase if less than threshold, according to Eq. (1) in Goldenberg et al. (2009)). The model certainly distinguishes between a global effect of the size of the base of adopters and the effect of such a base that is subject to a threshold. However, is it the case that the first type can be clearly identified as being a word-of-mouth effect while the latter is a type of network effect? Furthermore, the existence of the "chilling" effect is determined by the presence of a non-zero probability of zero utility or no purchase in the case of the presence of a threshold. In other words, Eq. (1) constrains the adoption probabilities in the case of a threshold,

which is not the case otherwise as only the top equation applies in this case with probability 1.

The role and formation of the network structure are clearly identified in the article as critical issues. The modeling approaches that Katona and Sarvary (2008) or Zubcsek, Chowdhury, and Katona (2008) propose could serve as a basis for developing further the impact of such structures beyond the four parameters varied in the simulation experiments, i.e., external influence, internal influence, mean and standard deviation of the threshold distribution.

2. Agent-based simulations

Although, as mentioned above, there is a tradition dating from the 1980's of modeling individual (or firm) adoption behavior, the complexity of the model was typically limited by the ability to track the aggregate-level diffusion. Agent-based modeling allows the development of more complex behavior which can be simulated to assess the aggregate diffusion pattern. As indicated by Goldenberg et al. (2009), this has been a tradition in many other fields like sociology or epidemiology. A number of questions can be raised, however. For example, to what extent does the chosen individual level process correspond to a reasonable process? Even if the interest is more analytical as a method to better understand the implications of the individual model's assumption, to what extent are the implications at the aggregate diffusion pattern level not directly the result of the assumptions? If this effect is indirect, what insight is gained about the process that goes beyond the assumption itself?

Goldenberg et al. (2009) point out that the results concerning the distribution of the threshold (effect 2) are not straightforward to understand. They explain that greater variance causes two effects described on pages 16–17. This complexity is also perhaps due to the lack of independence between the mean of the threshold and its variance: the range of the standard deviation is defined as a function of the mean h. It may be possible that the varying range, depending on the mean h, influences the results. This is further obscured by the use of a single variable (σ/h) in the regression estimated to analyze the results.

In summary, agent-based simulations have interesting potential, as illustrated in Goldenberg et al. (2009). They allow us to derive diffusion patterns from complex interdependent individual behaviors of innovation adoption. Future research may need to go beyond the simple structure assumed in typical current research. The experimental designs to analyze the various factors involved need to be carefully examined in order to draw unequivocal insights into the mechanisms that explain these effects.

3. Extended Bass Model to reflect word-of-mouth and network externalities

Goldenberg et al. (2009) model the network externalities threshold as affecting the market potential at time t in the Bass model. Word-of-

mouth is reflected by the regular coefficient of internal influence q. While these mathematical representations enable us to distinguish between the two types of effects, it is not clear that they correspond to the constructs of network externalities and word-of-mouth. Indeed, if one were to assume a process without internal influence (no word-of-mouth effect), i.e., where $q = 0$ in Eq. (2), the network externalities would still be reflected by the varying market potential according to Eq. (3). However, in such a case, the utility which varies according to the level of network externalities could arguably more appropriately affect the propensity to purchase, i.e., the factor p would be increased by the purchase propensity due to the network externalities which would apply to the remaining unsatisfied market $(N - x(t))$. Following Bass (1969), it is the likelihood of purchase at time T given that no purchase has yet been made, i.e., $f(T)/[1 - F(T)]$, which represents these network externalities.

In conclusion, Goldenberg et al. (2009) contribute to the literature on diffusion of innovations in that they address key questions which have not received a complete answer to date. They propose a modeling approach which can be useful to develop further our understanding of the patterns of diffusion by providing explanations at the individual level of aggregate phenomena. The communication process of word-of-mouth communication involving social interactions is of a different nature than the evaluation of an innovation which may depend on the utility being derived from the number of users of a product. Distinguishing between these two notions and modeling better these critical processes are fruitful endeavors. This should open the road to the modeling of complex behavioral patterns, with important strategic implications at the aggregate level.

References

Bass, Frank M. (1969). A new product growth model for consumer durables. *Management Science*, *15*(5), 215–227.

Burt, Ronald S. (1973). The differential impact of social integration on participation in the diffusion of innovations. *Social Science Research*, *2*(2), 125–144.

Feder, Gershon, & O'Mara, Gerald T. (1982). On information and innovation diffusion: A bayesian approach. *American Journal of Agricultural Economics*, *64*(1), 145.

Gatignon, Hubert, & Robertson, Thomas S. (1986). Integration of consumer diffusion theory and diffusion models: New research directions. In V. Mahajan, & Yoram Wind (Eds.), *Innovation diffusion models of new product acceptance* (pp. 37–60). Cambridge, MA: Ballinger Publishing Company.

Goldenberg, Jacob, Barak Libai, and Eitan Muller (2009), "The Chilling Effects of Network Externalities," *International Journal of Research in Marketing*, forthcoming.

Granovetter, Mark S. (1983). The strength of weak ties: A network theory revisited. *Sociological Theory*, *1*, 201–233.

Jensen, Richard (1982). Adoption and diffusion of an innovation of uncertain profitability. *Journal of Economic Theory*, *27*(1), 182.

Katona, Zsolt, & Sarvary, Miklos (2008). Network formation and the structure of the commercial World Wide Web. *Marketing Science*, *27*(5), 764–778.

Stoneman, P. (1981). Intra-firm diffusion, Bayesian learning and profitability. *Economic Journal*, *91*(362), 375–388.

Van den Bulte, Christophe, & Stremersch, Stefan (2004). Social contagion and income heterogeneity in new product diffusion: A meta-analytic test. *Marketing Science*, *23*(4), 530–544.

Zubcsek, PeterPal, Chowdhury, Imran, & Katona, Zsolt (2008). *"Information communities: The network structure of communication"*, 09.

Network externalities—Not cool?
A comment on "The chilling effects of network externalities"

Roland T. Rust*

Robert H. Smith School of Business, University of Maryland, College Park, MD 20742, USA

In "The Chilling Effects of Network Externalities" (Goldenberg, Libai, & Muller, 2010), the authors seek to disentangle the effects of word-of-mouth vs. network externalities in driving product diffusion. This is a very appealing article in many respects. The topic is well-chosen, in that understanding the influence of network externalities in the diffusion process is important. In addition the authors employ an appropriate methodology, agent-based modeling, in the form of cellular automata. Agent-based models, although still not widely used in the marketing literature, make it possible to explore how complex aggregate-level phenomena can emerge from a large number of individual actors (agents) following fairly simple decision rules.

At the same time, the construction of the model leads one to question the substantive conclusions of the article. Let me first explain why the construction of their model makes the substantive implications a foregone conclusion. Then I will demonstrate an alternative model formulation that would result in opposite conclusions, still using an agent-based approach. Finally I will propose an approach that could be used to select the best model and validate the agent-based model, to provide the basis for more authoritative substantive results.

1. The current model

In the network externalities case, each consumer (agent) who has not yet adopted has the following decision rule:

Current Adoption Rule (Network Externalities): *Adopt if 1) word-of-mouth is received, AND 2) the network externality threshold level is exceeded.*

It is not clear from the paper, but communication with the authors confirms that the following is the decision rule in the no network externalities case:

Current Adoption Rule (No Network Externalities): *Adopt if 1) word-of-mouth is received.*

It is quite obvious from examining the above two rules that for any individual consumer (agent) and any non-zero threshold level, adoption will be faster in the no network externality case, because only one condition must be met, rather than two. In other words, the "chilling effects" of network externalities are "baked into" the model by construction. The substantive result is tautological.

* Tel.: +1 301 405 4300.
E-mail address: rrust@rhsmith.umd.edu.

2. An alternative model

Let me now show how an alternative model construction can result in opposite conclusions. Following the conventional wisdom about network effects (Doganoglu & Grzybowski, 2007; Shapiro & Varian, 1999), let me formulate a model in which the consumer chooses to adopt whenever the utility of adoption exceeds a utility threshold. Let the utility of adoption have two parts—a word-of-mouth part and a network externalities part. That is:

$$\text{Utility} = \text{Utility from word-of-mouth} \qquad (1)$$
$$+ \text{Utility from network externalities}$$

Then the adoption rules are:

Alternative Adoption Rule (Network Externalities): *Adopt if Utility from word-of-mouth + Utility from network externalities ≥ Utility threshold.*
Alternative Adoption Rule (No Network Externalities): *Adopt if Utility from word-of-mouth ≥ Utility threshold.*

It is easy to see that under this model formulation adoption will always be faster under the network externalities case. Again the result is "baked into" the model construction, and the substantive result is tautological.

3. Which is right?

The demonstration above is not an indictment of agent-based modeling. Note that it is not the agent-based modeling approach that is producing the substantive ambiguity, but rather the modeling assumptions that underlie the agent-based model. Also theory alone cannot resolve the issue. As the authors note, there is theory to support their proposed model, and also theory to support my alternative model (which represents the current conventional wisdom).

In any simulation-based approach, such as agent-based modeling, validating the model's inputs is an essential part of the process (Rand & Rust, 2009). In this particular case, the model construction itself needs to be validated. Because individual consumers are simulated, the appropriate validation is at the individual consumer level. The appropriate validation test would then be to observe individual consumers with respect to their received word-of-mouth, network externalities, and decision whether to adopt. Then the two competing models could be fit to the individual-level data to see which model

provided the better fit. It may also be possible that some consumers use one model and other consumers use the other. The validation could be performed in the field (for high external validity, but perhaps less internal validity) or in the laboratory (for high internal validity, but perhaps less external validity).

4. Conclusion

The authors have performed an important service by exploring an important problem using appropriate methodology. The effects of network externalities on diffusion can be explored effectively using this approach. At the same time, the substantive results from their current study appear to be an artifact of the chosen adoption decision rule. Alternative models, using the same agent-based approach, could produce diametrically opposite results. Validation of the individual decision modeling framework, using observation of actual consumers, would be necessary to fully validate the model and provide confidence in the substantive results.

References

Doganoglu, Toker, & Grzybowski, Lukasz (2007). Estimating network effects in mobile telephony in Germany. *Information Economics and Policy*, *19*(1), 65–79.

Goldenberg, Jacob, Barak, Libai, & Eitan, Muller (2010). The Chilling Effects of Network Externalities: Perspectives and conclusions. *Intern. Journal of Research in Marketing*, *27*(1), 22–24.

Rand, William and Roland T. Rust (2009). Agent-Based Modeling in Marketing. unpublished working paper.

Shapiro, Carl, & Varian, Hal (1999). Information rules Cambridge, MA: HBS Press.

Network effects: Do they warm or chill a budding product?

Gerard J. Tellis

USC, Marshall School of Business, University of Maryland, Los Angeles, 90089-0443, CA, USA

Goldenberg, Libai, and Muller (2010) argue that network effects may slow the takeoff and growth in sales of a new product as adopters wait for sufficient others (threshold) to adopt. They call this the chilling effects of network externalities. They carry out a cellular automata experiment to examine how changes in certain parameter values affect profits due to this effect. They also adapt the Bass model to compute the chilling effect in five markets.

Goldenberg et al. (2010) have produced a fine piece of research on the role of network effects in new product growth. Their adaptation of the Bass model is clever and their results appealing. However, their works seem to echo a persistent theme in the economics literature, that network effects have negative effects that can lead to inefficient and perverse markets (e.g., Church & Gandal, 1993; Farrell & Saloner, 1986; Katz & Shapiro, 1986, 1992). With due respect to their rigorous analysis, our research seems to suggest just the opposite — that network effects enhance the efficiency of markets (Tellis, Yin, & Niraj, 2009a,b). To show this effect, I will point to two issues, omitted variables and an enhanced perspective of network effects.

1. Omitted variables

Our past research suggests that, besides network effects, price and quality play a critical role in new product growth, in addition to many other cultural and economic factors (Golder & Tellis, 1997; Tellis, Stremersch, & Yin, 2003). Prices come down steadily and steeply while quality goes up (Golder & Tellis, 2004). Based on extensive case and empirical research, I have come to the conclusion that price (and quality) might be the most important factor in the takeoff and growth of new product sales (see Golder and Tellis (1997) for evidence). For example, when mobile phones first emerged about 30 years ago, they sold for over $3500 ($7500 today), had limited talk time, poor reception, weighed a ton, and were relatively monstrous. No wonder they had limited sales and a forecast by McKenzie of a worldwide market of 900,000 units! Today mobile phones offer a world of benefits at a fraction of that price. No wonder they are hot times even in the remote villages of China and India. Goldenberg, Libai and Muller do not consider price and quality either in their simulation or their empirical analysis. As such, they may positively bias the estimated chilling effects of network effects (Tellis, 1988). I suspect their estimate of 86% for cellular phones is upwardly biased.

2. Enhanced perspective of network effects

The two common perspectives of network effects are direct and indirect. A direct network effect is the increase in utility of a product as the number of users increases (e.g., fax machines). An indirect network effect is the increase in utility of a product as the number of associated accessories to that product (e.g., operating system with software programs that run on it) (Stremersch, Tellis, Franses, and Binken, 2007). In a recent article in the *Journal of Marketing Research*, we have pointed to an enhanced perspective of the first of these effects. The increase in utility occurs as users of the product in one's immediate network increases (Tellis et al., 2009a). For example, in a small network of co-authors who use WordPerfect, a switch by some informed authors to Word may prompt all the rest to do so. When the quality of a new product is superior to alternatives in the market, a small fraction of informed adopters can lead to quick adoption of this new product due to such network effects. The early adopters in the network enhance the utility of the new product to others, signal its quality, and provide counsel to the non-adopters. In such cases, network effects enhance rather than hinder the adoption of the superior new product. Indeed, we show that in a sample of 19 markets, the presence of such network effects causes new entrants with superior quality to surpass the market share of entrenched market leaders in just a few years after the entry (Tellis et al., 2009a). In this respect, network effects may be said to warm and not chill a budding market.

This new perspective of network effects is of growing importance in the modern era characterized by Web 2.0. News and information on prices and quality travel rapidly through small inter-connected networks causing widespread adoption of views, products, and services. The rapid growth of eBay, MySpace, and YouTube may be attributed to this effect. So may the fall of CBS anchor Dan Rather over his story that George Bush got special treatment during the Vietnam War. Recently, the success of unknown outsider Barack Obama over well known insider Hillary Clinton in the Iowa primary may be attributed to the clever launch of his campaign through networks of followers (Deighton, 2008).

3. Conclusion

Network effects are a rich and complex phenomenon that marketing researchers are just beginning to incorporate in their models. Goldenberg et al. (2010) have done the field a great service by showing how this phenomenon may be responsible for key

E-mail address: tellis@usc.edu.

characteristics of the takeoff and diffusion of new products. I caution that this role can be properly appreciated only if one also considers price and quality, which are two other key drivers of new product takeoff and growth.

References

Church, Jeffrey, & Gandal, Neil (1993). Complementary network externalities and technological adoption. *International Journal of Industrial Organization, 11*, 239–260.

Deighton, John (2008). "Obama versus Clinton: The YouTube Primary", Case N9-509-032 Cambridge, MA: Harvard Business School.

Farrell, Joseph, & Saloner, Garth (1986, December). Installed base and compatibility: Innovation, product pronouncements and predation. *American Economic Review, 76*(5), 940–955.

Goldenberg, Jacob, Libai, Barak, & Muller, Eitan (2010). The chilling effects of network externalities. *International Journal of Research in Marketing, 27*(1), 4–15.

Golder, Peter N., & Tellis, Gerard J. (1997). Will it ever fly? Modeling the takeoff of new consumer durables. *Marketing Science, 16*(3), 256–270.

Golder, Peter N., & Tellis, Gerard J. (2004). Going, going, gone: Cascades, diffusion, and turning points of the product life cycle. *Marketing Science, 23*(2), 180–191.

Katz, Michael L., & Shapiro, Carl (1986). Technology adoption in the presence of network effects. *Journal of Political Economy, 94*(4), 822–841.

Katz, Michael L., & Shapiro, Carl (1992, March). Product introduction with network externalities. *Journal of Industrial Economics, XL*(1), 55–83.

Stremersch, Stefan, Tellis, Gerard J., Franses, Philip Hans, & Binken, Jeroen L. G. (2007). Indirect network effects in new product growth. *Journal of Marketing, 71*(3), 52–74.

Tellis, Gerard J. (1988, November). The price sensitivity of competitive demand: A meta-analysis of sales response models. *Journal of Marketing Research, 15*(3), 331–341.

Tellis, Gerard J., Stremersch, Stefan, & Yin, Eden (2003, Spring). The international takeoff of new products: Economics, culture and country innovativeness. *Marketing Science, 22*(2), 161–187.

Tellis, Gerard J., Yin, Yiding, & Niraj, Rakesh (2009a, April). Does quality win: Network effects versus quality in high tech markets. *Journal of Marketing Research, XLVI*(2), 135–149.

Tellis, Gerard J., Yin, Yiding, & Niraj, Rakesh (2009b). Why and how quality wins over network effects and what it means. *Journal of Marketing Research, XLVI*(2), 160–162.

The chilling effects of network externalities: Perspectives and conclusions ☆

Jacob Goldenberg [a], Barak Libai [b], Eitan Muller [b,c,*]

[a] School of Business Administration, Hebrew University, Jerusalem, 91905, Israel
[b] Leon Recanati Graduate School of Business Administration, Tel Aviv University, Tel Aviv, 69978, Israel
[c] Leonard Stern School of Business, New York University, New York, NY 10012, United States

1. Network externalities: a constraint, or added value to the consumer?

Both Rust (2010) and Gatignon (2010) question the extent to which the chilling effect is a universal phenomenon, arguing to the effect that it might be an artifact of the way the integration of network externalities and word of mouth is modeled in our paper. Rust suggests an alternative utility–additive model in which network effects create additional value to the customer and thus speed – rather than chill – the process.

To examine this point, one should go back to the definition of a network good. Conventional use of the term suggests that network effects (or externalities) exist when the utility an individual obtains from the product increases with the number of others using it. What is absent from this popular economic definition is the issue of absolute utility, with and without network effects (see for example Jackson, 2008).

The approach we take views the need for other users as a *constraint*, where with an increase in additional users, the constraint gradually dissipates. In a sense we could imagine a theoretical utility one could obtain if the network effects would not have existed at all, and that with each additional user, the product's realized utility moves closer to that upper bound. The distribution of thresholds is a function of the distribution of this upper-bound utility in the population.

We believe that our view is appropriate for nearly all the network products analyzed in the literature. Consider as an example a direct network effect product: a new type of fast-streaming cellular video that requires others to have the same technology to be able to engage in video chat with them. This is clearly a network good, as the number of others that have the technology increases a given user's ability to use it, and thus its utility. However, from the customers' point of view, this network effect is a constraint. S/he would clearly rather from start be able to engage in video chats with *all* other cellular users, and not wait until enough others adopt the specific technology. Similarly, when considering adopting an indirect network good such as the DVD, customers would rather there had been numerous DVD titles in stores to begin with, so that the number of titles did not have to depend on others' adoption. Therefore the wait for others chills the adoption process – not enhances it – which is also true for other "hardware/software" indirect network goods (e.g., see examples in Stremersch, Tellis, Franses & Binken, 2007).

The alternative to which Rust points models network externalities not as a constraint but rather as a source of additional utility over a non-network effect option. It implies that the greater the need for others, the greater the utility. While this implication does not seem feasible for most products, one may imagine certain status-based products for which it will be true, i.e., the more others are needed, the more status-based utility is attached to this brand (probably up to a limit). As indicated in our paper, our approach does not explore the case of status-based utility; yet modeling such growth along the lines suggested here is a promising topic for future research. One should also note that as we discuss in the appendix of our paper, the group of initial buyers with a threshold of zero – which is crucial to the takeoff of the innovation – is ill-identified in the additive model. This ill-identification renders it less appealing as a model for network externalities.

2. The chilling effect under competition

Tellis (2010) considers the chilling effect from another angle: the replacement of a network good by a new network good. He gives an example taken from Tellis, Yin, and Niraj (2009) where Microsoft, introducing the superior Word technology, was able to replace WordPerfect. The basic idea is that in a case where a superior product challenges an existing one in a network goods market, a small fraction of informed adopters can lead to rapid adoption of the new product by enhancing its utility to others. In such cases, Tellis argues, network effects enhance rather than hinder the adoption of the (superior) new product.

Tellis' explanation of how the local effect of a small expert group helps to overcome the existing lock-in of network effect is not only

intriguing, it is an important contribution to the lively debate in economics and marketing on the ability of a new entrant to overcome the network effect of existing players. However, we believe that it does not contradict the chilling effect, nor does it lead to the conclusion that "… network effects may be said to warm and not chill a budding market". While our paper does not explicitly model competitive effects, Tellis' remarks do shed some light on how the chilling effect fits such scenarios.

The first issue to consider in such a competitive case is the question of whose network effect is the focus of analysis. Building on the Microsoft Word example, consider two competing network effects: a) WordPerfect's and b) Microsoft Word's.

Regarding the former, clearly the WordPerfect network externalities created a chilling effect on MS Word that is very similar to the one we described in the paper. Initially few people were willing to switch, because the number of others using MS Word did not surpass their individual thresholds. However, as others began moving over to MS Word, more people passed the threshold, and at some point in time, a strong takeoff was expected. While not modeled explicitly, we expect the overall effect on Microsoft Word's profits to be a chilling one compared to a case wherein WordPerfect *would not have network effects installed*. Of course, the higher the quality of Word, the lower we can expect WordPerfect users' thresholds to be, and the weaker the chill. Thus, the chilling effect analysis helps us to explore how much money Microsoft would have saved if it would have made Word compatible with WordPerfect, or to what extent it should have invested in partial compatibility.

A second source of chill stemmed from MS Word's own network effects. Tellis suggests that by imposing its own network externalities, MS Word could have helped mitigate the chill created by the WordPerfect network effect. The dynamics described are interesting and deserve a close analysis. We believe a better understanding demands individual-level modeling, e.g., an agent-based model that will take up where the aggregate-level work of Tellis et al. (2009) left off. Regarding the overall financial effect of the second entrant's network externalities, the final justification for additional network effects is unclear. While MS Word's network externalities could have helped at some point to begin a bandwagon, initially they would have also slowed down the transition of some users who appreciated the quality of MS Word, yet hesitated because of the new network effects. If MS Word could have achieved at least partial compatibility (as it did in practice), it is possible that a network effect-free product would have helped to accelerate the speed of diffusion. Of course, eventually Microsoft benefited from Word's own lock-in, which may be an independent reason for an imposed network effect. An agent-based analysis will help to untangle some of the complexity of the situation.

3. On agent-based modeling

Gatignon raises a number of interesting issues regarding the use of agent-based models, particularly the validity of the individual-level assumptions. One should note that the implicit assumption of the Bass model and most of its extensions is that the social system is homogenous and fully connected. Yet the extensive research on social networks conducted recently reveals that social networks are neither homogenous nor fully connected (see for example Van den Bulte & Wuyts, 2007). In order to deal with the complexity of heterogonous individuals in a partially connected network, the models have to be constructed at the individual rather than the aggregate level. Thus the basic assumptions made in agent-based models in marketing are in response to the rather severe constraints of aggregate-level analysis.

We believe that individual-level models are the key to the future directions of diffusion modeling: combining individual-level perspec-

tive into diffusion theory can be an effective tool in solving many of the questions still left open in marketing of new products. Specifically, these models can contribute to incorporating heterogeneity into the diffusion framework, and separating the effects of word-of-mouth, signals, and network externalities.

One way of adding a reality check to the models is to use actual network structures on the communication patterns of individuals, and then use an agent-based framework to model the growth of the innovation. Thus if the agent-based models construct a "would-be world", an agent-based model that builds on an existing structure of an actual social network represents "would-be growth" of an innovation in that network (see for example Libai, Muller, & Peres, 2009b).

4. Price, quality and other variables

Both Tellis and Gatignon reflect on the need to consider additional variables in the analysis. Tellis focuses on the variables of price and quality and their expected impact on the chilling effect. However, after decades of research into the diffusion of innovation, the roles of social interactions such as word of mouth, network effects, and imitations have been well established as major drivers of growth (see Peres, Muller, & Mahajan, 2009 for a recent review). Hence, while price and quality certainly play a role in the growth of new products, accepting them as the sole drivers of the dynamics of growth would not be supported by the majority of research to date. Take the example of markets for cellular phones mentioned by Tellis, where social interaction dynamics have been used and documented in numerous research studies to explain growth. In a recent example, Libai, Muller, and Peres (2009a) show how consumer communications dynamics help to explain the growth of cellular brands in Western Europe. Interestingly, across-countries price played but a minor role in the dynamics.

The question remains whether the omission of price and quality biases the chilling effect we report. As Tellis rightly points out, in most markets the dynamics are such that price goes down and quality goes up with time. Nevertheless, the implication is that it is harder to "sell" the new product early on. In such situations, it becomes less common for consumers to overcome their thresholds and adopt, *and so the chilling effect will be stronger*. Indeed, in the paper we find that externalities have a stronger effect on profitability early in the product life cycle than they do in later periods. The chilling effect can therefore aid in motivating price reductions early on.

We agree that the more specific effect of dynamics in price/ quality on the chilling effect, as well as the relationship to other network structure variables Gatignon suggests, are worthwhile subjects of study. Future research can take advantage of the flexibility of agent-based models to further examine the interaction of additional variables, as well as to explore additional novel ways to separate network externalities, word of mouth, and other social effects. We hope that our work has been but the beginning of such journey.

References

Gatignon, Hubert (2010). Commentary on Jacob Goldenberg, Barak Libai, and Eitan Muller's "The chilling effects of network externalities". *International Journal of Research in Marketing, 27*(1), 16–17.

Jackson, Matthew O. (2008). *Social and Economic Networks* (pp. 162–163). Princeton, NJ: Princeton University Press.

Libai, Barak, Muller, Eitan, & Peres, Renana (2009). The roles of within-brand and cross-brand communications in competitive growth. *Journal of Marketing, 73*(1), 19–34.

Libai, Barak, Muller, Eitan, & Peres, Renana (2009). The social value of word-of-mouth programs: acceleration vs. acquisition. *Working paper.*

Peres, Renana, Muller, Eitan, & Mahajan, Vijay (2009). Innovation diffusion and new product growth: critical review and research directions. *Working paper.*

Rust, Roland (2010). Network externalities—not cool? A comment on 'The chilling effects of network externalities. *International Journal of Research in Marketing, 27*(1), 18–19.

Stremersch, Stefan, Tellis, Gerard J., Franses, Philip Hans, & Binken, Jeroen L. G. (2007). Indirect network effects in new product growth. *Journal of Marketing, 71*(3), 52–74.

Tellis, Gerard J. (2010). Network effects: do they warm or chill a budding product? *International Journal of Research in Marketing, 27*(1), 20–21.

Tellis, Gerard J., Yin, Eden, & Niraj, Rakesh (2009). Does quality win? Network effects versus quality in high-tech markets. *Journal of Marketing Research, 46*(2), 135–149.

Van den Bulte, Christophe, & Wuyts, Stefan (2007). Social networks and marketing, MSI Relevant Knowledge Series Cambridge, MA: Marketing Science Institute.