Wired or wireless internet?

A situation in which standards don't matter

Gregory Gimpel
Center for Applied ICT
Copenhagen Business School
Frederiksberg, Denmark
gg.caict@cbs.dk

Abstract— **This paper finds that network externalities play a minimal role in the choice of internet access technology. Potential adopters of mobile laptop internet view broadband technology as a black box, the technological details of which do not matter. The study uses qualitative techniques to explore how the speed of technological obsolescence, market share dominance, and the black boxing of technology influence consumer intention to adopt WiMax and 3G wireless internet for their laptop computers. The results, implications for industry, and areas for further research are discussed.**

Keywords- Network externalities, wireless broadband, lock-in, black box

I. INTRODUCTION

In the USA, Europe, and parts of Asia, broadband internet penetration is high. A plethora of companies offer internet access through a wide variety of different technologies, such as dial-up, cable, DSL, fiber, satellite, 3G, and WiMax. Telecommunications companies have made heavy investments in high speed wireless data services such as 3G and WiMax. Anticipating the demand for advanced mobile services and wireless computing, telecoms bought expensive spectrum licenses and built new infrastructure, which resulted in the global debt of telecom companies reaching trillions of dollars [11]. With many markets experiencing flat voice service growth and competitive pressures shrinking the average revenue per user, telecoms must increase the income from wireless data services in order to maintain their profits [7]. Because of heavy sunk costs, providers hope that people will choose their technological offering rather than an alternative technology offered by a competitor. Although the wireless data market is growing, consumers have adopted the necessary hardware more slowly than expected, causing a dramatic shortfall from predicted return on investment.

This article explores the adoption of technology in a situation in which different technologies fill a similar consumer need. More specifically, it explores the determining factors for the adoption of wireless broadband over wire-based internet technology. Communication technology is a networked technology that is traditionally driven by demand-side economies of scale and increasing returns [3, 20, 43]. What can internet access technology tell us about the role network externalities play in the adoption of the wireless internet?

For research purposes, this study considers a home Wi-Fi router as fixed-line technology because users must decide which access technology to connect to the router when making an internet access technology adoption decision.

Following the example of Eynon [14], this article utilizes focus group methodology to explore user attitudes about the adoption of wireless broadband technology. The analysis employs the study of network economics pioneered by Artle and Averous [3] and Rohlfs [43] and developed by researchers such as Katz, Shapiro, Varian, and others [20, 21, 22, 45, 46, 50]. It builds upon the findings of Newell et al. [36] who write about the implications of black boxing technology. What role will network externalities play in the consumer choice whether to adopt wireless broadband technology?

The contribution of this study is three-fold. First, it illustrates how consumer attitudes about the rapid obsolescence of technology can affect the role of network externalities in a technological decision. Second, it demonstrates the role network externalities play in the adoption of competing proprietary technologies within an open network. Third, it adds to the study of network externalities by elaborating on the effect of black boxing on a category of technology within a networked system.

This article unfolds as follows: the next section reviews the existing IS literature that focuses on the influence network externalities have on internet access. The following section offers an introduction to network externalities, black boxing, and the role they play in technology adoption. The subsequent section details the research methodology used to conduct the focus groups and analyze the data. The ensuing section provides a presentation of data with an analysis. The article ends by discussing the implications for industry and suggestions for further research.

II. LITERATURE REVIEW

The study was motivated by a notable gap in Information Systems literature. Despite the increasing importance of the internet in people's daily lives and the telecom industry's increasing reliance on revenue from selling internet access (combined with necessary technology investments to stay competitive), studies about how network externalities impact consumers' choice of access technology is absent from mainstream IS literature. During the writing of this paper, a new survey of the literature was performed to see if any theoretical insights had appeared since the beginning of the study.

On 30 January 2010, a review of IS literature was conducted using the Social Science Citation Index. The following key words were used to identify potentially relevant articles and conference papers: "network externalities" and "network effects" were the key phrases used in the search. The query yielded 53 and 109 references respectively. Each results list was filtered to finding literature also containing either "internet," "wireless," or "mobile." The remaining number of citations totaled 60. After removing duplicate articles, 30 references remained. A survey of the abstracts revealed a wide variety of topics, but none specifically researched the choice of computer internet access technology, let alone addressed the question about the role that network externalities play in the adoption of wireless internet technology. It is this gap that this paper seeks to address.

III. THEORY AND RESEARCH QUESTIONS

This section presents key concepts in network externalities. It begins by providing an overview to the roles of standards, compatibility, and lock-in within a networked system. Then it discusses the role durability plays in creating lock-in effects. It lays the theoretical grounding necessary to explore the degree of influence market share has on the viability of competing technologies. It continues with a review of the potential beneficiaries of network effects in the broadband market. Finally, it introduces common reasons that information and communication technology (ICT) is treated as a black box; and it paves the path for asking how black boxing may affect the decision to adopt wireless internet.

A. Network Externalities and Lock-In

Bell Labs introduced "external economies in consumption" to the discourse of communication technology in the 1970s when Artle and Averous [3] noted that the value of being part of a closed-standard telephone network increases with network size and Rohlfs [43] declared: "The utility that a subscriber derives from a communications service increases as others join the system." Subsequently, Katz and Shapiro [20] elucidate the consumption externalities that give rise to demand-side economies of scale, which will vary with consumer expectations. If consumers expect a seller to be dominant, then they will be willing to pay more for the firm's products, and it will, in fact, be dominant.

Because an individual's consumption benefit may depend on the future size of the relevant network, consumers will base their purchase decisions on the *expected* network size [20, 21, 22, 45, 46]. As more people *think* a technology will become the standard, they will adopt it [2, 20, 21, 22, 45, 46]. Lee, Lee, and Lee [26] argue that since potential adopters do not know the network size in advance, they make the decision to adopt or continue using a technology during each decision period, taking into consideration the number of previous adopters.

While both researchers and practitioners often frame technology standards through the winner-take-all diffusion lens, such a scenario is not necessarily the case. New entrants offering superior technology can overcome first mover advantage if the performance advantage is sufficient and the users are not inextricably locked-in. A dominant position in one generation of technology does not translate into dominance in the next generation [45, 46].

While much IT strategy is built around network externalities and increasing returns [39], some literature indicates that it may not be relevant for many types of ICT consumption decisions. For instance, Katz and Shapiro [20] make explicit that network externalities are present when a good is durable. David and Greenstein [10] write that the strength of lock-in is affected by technological obsolescence. Kim and Srinivasan [23] address ICT durability as follows: "Unlike traditional durables, technology products and their complementary products (e.g., personal computer [PC] and the application software) quickly become obsolete…" Accordingly, consumers experienced the rapid evolution of internet access technology as dial-up access speed doubled every 1.9 years, with each iteration requiring new hardware. The progression in the world-wide web era steadily climbed from 9600 b/s to 14.4 kb/s to 28.8 kb/s to 56 kb/s [13], followed by the switch to affordable broadband connections [18]. Likewise, mobile communications underwent the rapid wide-scale diffusion of pagers followed by 1G, 2G, 2.5G, and 3G mobile phones [17]. Similarly, Janssen and Mendys-Kamphort argue that technology goods depreciate quickly and therefore are not durable. Consequently consumers repeatedly purchase technology goods based on performance. Therefore, they adopt a technology in each period based on utility and are not wedded to their past purchases [19].

The influence anticipated product lifecycle exerts on lock-in leads to the following research question:

RQ1: What role does the expectation of rapid ICT obsolescence play in wireless broadband adoption decisions?

B. Competing Standards and Compatibility

In the case of competing standards, early adopters are affected by the choices of later adopters, who may or may not follow their lead. Once a critical mass is reached, however, the choice may become locked-in regardless of the advantages offered by alternatives. Often the higher the adoption rate of an individual technology, the more people learn about it. In turn, the product receives more improvement and becomes more attractive. Very often several technologies compete for shares of a market of potential adopters. Buyers' risk aversion causes a tendency to favor products with greater familiarity. As such, they discount the benefits of the new offering. Similarly, people merge new information with prior beliefs, causing them to underappreciate the benefits of the new technology and to favor the older, more established technology. A system with increasing returns can present many equilibrium points and networked economies do not necessarily imply monopoly outcomes [2]. As such, technologies can serve well-suited niches within an environment dominated by a rival technology [45, 46].

Liebowitz and Margolis [28] provide three categories of network externalities. Direct network externalities describe the physical effect that the number of purchasers have on the quality of the product. For example, as the number of homes with telephones increases, the value of adopting the telephone increases for subsequent users. Indirect network externalities describe the effects resulting from a large user base, such as complementary products or a large network of trained support personnel. Inframarginal externality is the marginal benefit received after the critical mass is reached. According to the authors, many technologies require a critical mass, but are not much helped by participation beyond that level. Similarly, Rohlfs [43] found that once critical mass is exceeded, the marginal value of each additional user declines. Lim et al. [29] and Swann [49] further the argument for diminishing inframarginal returns by writing that the benefit contributed by each individual shrinks as the total size of the network increases.

In a system built on networked technology, there can be multiple equilibria [43]. Clements [9] writes that in the presence of high compatibility, there is not much difference in value derived from network size. Multiple networks can coexist when no additional marginal benefits of network size are achieved at network sizes that are small relative to the market. Therefore, it is possible to have a set of satisfactory networks, not necessarily only one monopolistic network [28]. Tipping to a single standard is not inevitable [48]. In fact, "one standard monopolies are anything but common" [51].

While network effects may be present on the internet, the openness of the internet and its standard protocols make it difficult for single companies to control a network effect. Accordingly, even if a company controls a network effect, the effect provides diminishing returns once it reaches a critical mass of customers [39].

The role of conforming standards within the internet leads to the following proposition regarding ISP technology:

RQ2: What can user attitudes tell us about the likelihood of coexisting technologies versus a "winner-take-all" scenario?

C. Beneficiaries of Network Effects

In the network of competing technology and firms, the technology may not be the principal beneficiary of network effects. Battles over standards can be mitigated. For example, adapters that enable one technology to be used with the other can defuse a standards war and can substitute for interface standards [1, 6, 45, 46]. For example, the mobile phone market uses incompatible phone technology, but ultimately all users have compatibility because they can connect with users on other systems [45, 46]. This supports the argument that despite different access technologies, network effects are invisible to the end users of wireless technology [48]. Openness and compatibility are critical when no one firm is strong enough to dictate technological standards [46].

A fundamental factor contributing to the growth and success of the internet is the openness of the TCP/IP protocols that underlie the network [38]. These nonproprietary protocols are available to everyone. As such, "Anyone who uses the standard to transmit data from her computer is 'on' the internet; anyone who does not use the standard is not" [27].

The compatibility among broadband access technology and the internet backbone results in the following proposition about the impact of network externalities:

RQ3: Because all ISP technologies are all compatible with the internet, do network externalities influence the adoption decision? If so, who receives the benefits?

D. Black Boxing and Technology Commoditization

The use of the term "black box," and the underlying concept of a device that turns inputs into outputs without users understanding how it happens, coincides with the advent of wireless technology. In the late 1890s, Guglielmo Marconi transformed electromagnetic theories into a viable wireless communication device. The device was encased in a small box that became known as the "black box." Marconi gave effective demonstrations of the revolutionary technology, but while people could use the technology, no one knew how it worked until he filed the patent [16].

Callon and Latour [8] provide the following definition: "A black box contains that which no longer needs to be considered, those things whose contents have become a matter of indifference." McBride [31] explains that once a technology is black boxed it is treated as part of everyday life and taken for granted because only the inputs and outputs matter to the users.

Scarbrough [44] writes that black boxing is a long-established strategy among IT service providers. The perception of technological complexity inhibits adoption of new technologies [30]. Accordingly, complex integrating technologies are often marketed as relatively simple solutions. The technical complexity and specifics of how it works are concealed deliberately so that the product can be pushed to the consumers without heavy technical explanations. Black boxing of the technology is necessary because otherwise the technology would have characteristics such as high complexity, etc., that inhibit acceptance. While this approach facilitates technology acceptance, such black boxing commoditizes the underlying technology and knowledge [36]. This link between black boxing and commodification is supported by Bergman [5] who asserts that young ICT users do not care how the technology works. She supports the claim using interview statements like: "As long as I can text and upload pictures and download music and surf the Web and talk to my friends and make videos and play video games, who cares what app or widget makes it all go."

The stress on input and output rather than technological specifications results in the following research question:

RQ4: Has internet technology been black boxed? If so, how does this affect the adoption decision?

IV. METHODOLOGY

This section describes the research methodology used in this study. It begins by detailing the selection of the research instrument and details the study design, recruitment of participants, data collection methods, and data analysis technique.

A. Instrument and Venue Selection

The study was conducted in Denmark, because of its high internet penetration [12] and because telecom contracts are limited to 6 months, rather than the longer periods allowed in some markets. This helps isolate the effects of technology lock-in versus contract-based service provider lock-in.

The goal is to gain insight, theoretical generalizability [4] and conceptual transferability [25]. It asks the research question: "what impact do network externalities have on the decision to adopt wireless broadband?" The explorative and attitudinal-based nature of the research question and propositions makes the focus group interview the logical choice of research formats. It provides rich data because "group discussions provide direct evidence about similarities and differences in the participants' opinions and experiences as opposed to reaching such conclusions from post hoc analysis of separate statements from each interviewee" [34]. Finally, the data gained from a particular study provide theoretical insights which possess a sufficient degree of generality or universality to allow their projection to other contexts or situations which are comparable to that of the original study [47].

While the small, non-random sample precludes developing a probabilistic model from the data, the format is well suited to provide theoretical generalizability [4] and conceptual transferability [25].

B. Study Design

This study consists of three focus groups in order to be able to analyze data across groups to find patterns and themes [25] and to reduce the effect of individual group dynamics on the overall dataset [34]. Dividing the fifteen participants into three separate groups achieves the data saturation recommended by [25, 34] that occurs when the range of ideas have been experienced and additional groups are not providing new, useful information. The interview questions were created prior to the focus groups [25]. The interview guide contains open-ended discussion questions that progressively narrow the topic of discussion specifically to gather data relevant to investigating the propositions. For example, general questions include: "What is important to you when selecting broadband service?" and "If you were to get broadband today, what would you buy? What are the reasons?" A more focused question is "how does popularity of technology / provider factor into decision?" Directed questions include: "Image this scenario: Today a broadband USB connector costs 300 Kroner [approx. €40]. If you knew a technology was coming out in 2 years that would be twice as good and the new connector would cost 300 Kroner, what would you do? A) Buy the adapter today, B) Wait 2 years and buy the new adapter, or C) Buy the adapter today and buy the new one in 2 years. Assume the monthly fees would be the same."

C. Participant Recruitment

The study selected young adult participants for several reasons. One goal was to achieve a balance of diversity and homogeneity and thereby facilitate interaction among participants [4, 24, 25, 34]. It also aimed to reduce extraneous variables; and prior studies show that age affects individual technology adoption [32, 35, 52]. The selected group has lived their entire lives since the introduction of mainstream personal computing and related technologies [41]. They make heavy use of ICT; particularly internet use, and they have incorporated it into their daily lives. They consider technology to be part of the landscape [37] and they consider computers as commonplace, not as technology

[15, 33]. Networked for most their lives [41], they are generally unaware of the pre-internet era [42]. Equally important, they are consumers whose entrance as decision makers into the marketplace closely coincides with the wide-scale launch of mobile internet services for laptop computers.

D. Data Collection

Each focus group lasted approximately 1.5 hours. Brief field notes were written during the focus group sessions. Shortly after the meetings ended, field notes were typed recording salient points and researcher impressions of the discussions. The conversations were recorded in order to maintain accuracy during the analysis phase of the project. In keeping with the effort to make participants feel comfortable about sharing their opinions, the research plan followed established privacy guidelines [25].

E. Analytical Tools

The analysis used both the field notes and transcripts. The data were analyzed at the group level and on a comprehensive (study-wide) level. ATLAS.ti was used to code the data. At times many statements contained similar information; and other statements were short statements that required the context of the surrounding conversation to convey a point. The quotations included in the next section of this paper serve as demonstrative exemplars.

V. FINDINGS AND ANALYSIS

The focus group participants indicate that the choices of internet technology are interchangeable, as long as they meet certain price and performance requirements, in line with the claim that the new generation of ICT users do not care how the technology works [5]. The general indistinguishability among some technologies combined with the lack of knowledge that some technologies exist, demonstrates that ISP technology has been commoditized in the mind of the consumer, as exemplified by the following statement:

> "You're used to the internet. It's kind of a commodity. You have some basic requirements and you don't really care about the way those requirements are met. It's probably because it's become sufficiently cheap and sufficiently fast that you don't have to do the big technical evaluations. You look at these basic requirements and whatever way you get it, that's fine."

The study data provide empirical support for the argument that once the black box has become part of everyday life, only the inputs and outputs matter [31]. It also evinces the claims that ICT users do not concern themselves with how the technology accomplishes a task [5, 8].

The participants described how internet providers focused their marking efforts on price and speed rather than technical details of the delivery technology. Additionally, the participants have not noticed corporate messages differentiating specific mobile technology from the fixed range of "wireless internet" (which to them refers to the WiFi routers to which they are accustomed). This provides consumer-level data that helps corroborate the assertions that companies black box their offerings in order to make them easier to understand so they can more easily push them unto potential customers [36, 44].

While participants may weigh future developments and the resulting lock-in for some products, they expect mobile and internet ICT to change quickly and do not concern themselves with whether their selected standard will be supported in the future, or whether it will be supplanted by superior options. One participant aptly articulates:

> "It's not that you're nervous that something better will come along – you *know* that there will be something better. So it's a matter of: do you want this now? Because obviously if you don't need it now, you wait. But if want it now, you buy it. We're used to technological change, and it wouldn't affect me very much."

Another participant illustrates how the fact that internet access technology changes in discrete, incompatible ways by explaining the futility of waiting for future innovation:

> "I don't know if it would factor into my decision since if we kept to that mindset, then we would all be using 56.6K modems still because we might all be anxious that ADSL would be an obsolete technology in two years. So basically, I think I would upgrade anyhow for what I felt would fulfill my needs to right here, right now. And then if the technology would become obsolete in half a year, 2 years, 5 years, or so, I'd simply just change to another provider."

This is consistent with the literature [19, 23]. Participants do not consider lock-in effects when making their purchasing decisions. While this finding goes against the commonly understood principle that users heavily weigh lock-in concerns into adoption decisions, it agrees with the assertion that obsolescence tempers lock-in effects[10], and it also conforms to the work of Katz and Shapiro [20], who state that the future size of a network is relevant for *durable* goods. In this case, participants do not perceive internet artifacts as durable.

Focus group participants pay little heed to the market share held by competing ISP technologies. While this finding may go against "winner-take-all" interpretations of network effects, it harkens back to Shapiro and Varian's [45] argument about mobile telephones. Although the technologies are different and may not connect to each individual network, they all connect to the same larger network. In the case of this study, all technologies connect to the internet, which interconnects them all. According to the participants, the different technologies all serve as intermediaries, weakening the need for a single standard. Thus participants indicate that they do not care whether everyone uses the same technology for access:

> "I don't think that we have that many technologies to choose from, really. Most providers only provide through [wired connections], so the technology factor plays no part at all in my decision."

Their attitudes lend credibility to literature that argues single standard is not necessary within an network [1, 6, 9, 27, 28, 38, 39, 43, 45, 46, 48, 51]. In accordance with Arthur's [2] argument, participants underappreciate and discount the benefits of mobility. Several participants do not envision using their laptops outside of the contexts currently available to them via their WiFi connections (which subscribe to wire-based access technology). One participant explains:

> "I think just now I don't have a need for wireless connection because everywhere I need to be online, I can get online. Here I can get online. At home I can get online. So I'm not really thinking about buying a little thing to plug in or anything like that."

ISP technology requires a critical mass in order for technology holders to be able to pay for the heavy infrastructure investment to avoid going out of business. When a technology reaches its minimum critical mass, consumers benefit because the technology affords them an additional choice, which increases overall competition. Beyond that necessary baseline, however, additional users might add value to a corporation, but add little value to the overall network because the alternative technologies are interchangeable. Participant indifference to specific internet access technology, combined with their mixed purchasing behavior, support the arguments that the benefits of market share are realized at sizes that are small relative to the overall network and that the environment can be favorable to the coexistence of different technologies [9, 28, 43, 48, 51]. It also supports the assertion that the nature of the internet makes it a strong candidate for the existence of multiple competing firms [39].

While participants do not consider the network effects of internet access technology to be material, the focus group data demonstrate the presence of network effects on broadband service providers. As companies gain market share, more people hear about them; therefore, the firms can experience positive feedback. As a provider grows in market share it will become more well-known. The participants describe how positive feedback can increase the use of a company's service while negative feedback can cause a downward spiral. The assessment of whether a firm – not a technology – will be dominant (and will survive) plays into the decision process, as does the reputation of the company. Participants explain:

> "And one other thing I thought of when I chose my operator was that it's a big company. There's a lot of new companies coming up providing new services, but I thought it was a lot safer to choose one of the larger companies that had been doing to for a longer time than one of the newer ones."

> "Reputation has a lot to say, I think. I would never pick a company like [company A], [company B] or [company C]. I'd never pick [company D] because there's been so much fuss around these providers in the past with problems for billing and faulty hardware that's never been replaced, which just gives the companies a bad reputation. You don't want to be in the same situation as their previous customers."

The data suggests that providers experience some of the basic principles of network externalities [2, 20, 43, 45]. They also support the theoretical explanation that buyers' risk aversion causes people to favor products with greater familiarity [2].

VI. Discussion and Conclusion

There are many stakeholders in the internet value chain. The three closest links to the end user are 1) access software, such as a web browser; 2) internet server and the corresponding website; and 3) internet connection. The web browser or other program (iTunes, Skype, etc.) takes the input and delivers the output. This is the most salient part of the value chain to the consumer. On the other side of the equation, the web server receives input and provides output; a process which is invisible to the end user. Browser and related technologies follow and set certain standards. Internet servers follow and set standard protocols.

The field study data provide answers about the role rapid ICT obsolescence plays the wireless internet adoption decision-making process. In this study, end users consider information and communication technology to be short-lived and consequently do not concern themselves with lock-in. Therefore, the rapid change within the ICT industry weakens the role network effects play in the adoption of consumer internet access technology.

User attitudes provide insight into the likelihood of coexisting technologies versus a "winner-take-all" scenario. The participants view the broadband market as one with many substitutable technologies. As a result, consumer preferences increase the likelihood of a broadband market that supports multiple internet service technologies and providers.

Data provide insight as to whether network externalities exist with the current system when competing technologies are all compatible with the internet. In general, end users focus on the company providing the service, not the delivery technology. They are concerned with the market share of the respective companies, not the market strength of the technologies. As such, the network effects have material impact at the organizational level but much lower impact at the technological level.

The Participants view broadband access technology as a "black box" and a commodity, providing answers to the final research question. As a commodity, ISP technology does not experience many common network effects, such as technological monopoly or lock-in. As a result, consumer preferences encourage the broadband market to support multiple internet service technologies and providers.

The results of this study suggest that internet access technology does not matter, providing specific empirical data that support conceptual arguments by Frand [15], and McMahon and Pospisil [33].

By providing empirical research and theoretical grounding to a commonly observed phenomenon, this research adds to the body of knowledge about the role network externalities play in the diffusion and adoption of wireless information and communication technology. It makes several contributions. First, it illustrates how consumer attitudes about the rapid obsolescence of technology can affect the role of network externalities in a technological decision. In this case, the expectation that internet access technology will quickly be supplanted by something better mitigates technological lock-in concerns. Participants expect to adopt different standards at every decision point. Second, it demonstrates that network externalities play little role in the adoption of competing proprietary technologies within an open network. No matter how participants connect to the internet, they have full access to the services and communication channels available on the internet. Therefore, the actual connection becomes unimportant as long as it works. Third, it adds to the study of network externalities by elaborating on the effect of black boxing on a category of technology within a networked system. In general, the participants do not understand differences among technologies and therefore make decisions based on the brand value of the provider rather than make decisions based on technology.

The implications are important to further research and to industry. The data support the need for wireless data solutions to be marketed less on specific technologies (such as 3G vs. WiMax), as argued by Prasad and Skouby [40]. In a consumer commodity market, wireless broadband providers must differentiate their offering from the wire-to-WiFi paradigm. They must highlight the mobility aspect. At the same time, many potential adopters may not see the usefulness of mobility over WiFi's portability. Industry may need to educate the consumers so that "wireless" comes to mean "mobile," rather than the current perception in which mobile broadband for computers is lumped into the broad category that includes WiFi routers connected to cable and DSL connections.

While this study provides insight into the applicability of network externalities, further research is required. The selection of a single market for research may limit the generalizability of the results. Quantitative research with larger samples may be able to validate the findings of this study. Another potential avenue for future research is to compare the attitudes of young ICT users to older individuals to determine the significant differences in the way they view technology and approach technology decisions.

ACKNOWLEDGMENTS

This work was in part supported by the DREAMS project via a grant from the Danish Agency of Science and Technology (grant number 2106-04-0007) and by Copenhagen Business School. I also want to thank the anonymous reviewers and the members of CAICT who provided their constructive comments.

REFERENCES

1. Andreozzi, L., "A note on critical masses, network externalities and converters." International Journal of Industrial Organization, 2004. 22(5): p. 647-653.
2. Arthur, W.B., "Increasing returns and path dependence in the economy." 1994: University of Michigan Press. 224.
3. Artle, R. and C. Averous, "The telephone system as a public good: Static and dynamic aspects." The Bell Journal of Economics and Management Science, 1973. 4(1): p. 89-100.
4. Barbour, R.S., "Making sense of qualitative research making sense of focus groups." Medical Education, 2005. 39(7): p. 742-750.
5. Bergman, S., "The adults of generation y in the U.S.: Hitting the demographic, lifestyle and marketing mark," in Meerman, Tatjana. 2008: New Orleans.
6. Besen, S.M., G. Saloner, R.W. Crandall, K. Flamm, "The economics of telecommunications standards," in Changing the rules: technological change, international competition, and regulation in communications." 1989, Washington, D.C.: Brookings Institution. p. 177-220.
7. Business Wire. "IDC forecast anticipates decline in total voice revenue in 2008-2009 for the U.S. Consumer wireless industry." 2006 [cited 2008 November 10]; Available from: http://www.allbusiness.com/media-telecommunications/5385030-1.html.
8. Callon, M. and B. Latour, "Unscrewing the big leviathan: how actors macro-structure reality and how sociologists help them so" in

Advances in social Theory and Methodology: Toward an Integration of Micro and Macro Sociologies. London: Routledge, 1981.

9. Clements, M.T., "Direct and indirect network effects: are they equivalent?" International Journal of Industrial Organization, 2004. 22(5): p. 633-645.
10. David, P. and S. Greenstein, "The economics of compatibility standards: An introduction to recent research." Economics of Innovation and New Technology, 1990. 1(1): p. 3-41.
11. Dekleva, S., "M-business: Economy driver or a mess?" Communications of the AIS, 2004. 2004(13): p. 111-135.
12. Economist Intelligent Unit, Country profile 2007: Denmark. 2007.
13. Eldering, C.A., M.L. Sylla, J.A. Eisenach, TP Ltd, "Is there a Moore's law for bandwidth?" IEEE Communications magazine, 1999. 37(10): p. 117-121.
14. Eynon, R., "The use of the internet in higher education: academics' experiences of using ICTs for teaching and learning." Aslib Proceedings, 2005. 57(2): p. 168-180.
15. Frand, J.L., "The information-age mindset changes in students and implications for higher education". Educause Review, 2000. 35: p. 14-25.
16. Hong, S., "From Marconi's black-box to the audion." 2001, The MIT Press: United States of America.
17. IBISWorld.Inc, "Outlook: internet service providers in the US." IBISWorld Industry Report, 2009.
18. IBISWorld.Inc, "Wireless telecommunications carriers in the US." IBISWorld Industry Report, 2009.
19. Janssen, M. and E. Mendys-Kamphorst, "Evolution of market shares with repeated purchases and heterogeneous network externalities". Journal of Evolutionary Economics, 2007. 17(5): p. 551-577.
20. Katz, M.L. and C. Shapiro, "Network externalities, competition, and compatibility." American Economic Review, 1985. 75(3): p. 424.
21. Katz, M.L. and C. Shapiro, "Technology adoption in the presence of network externalities". Journal of Political Economy, 1986. 94(4): p. 822-841.
22. Katz, M.L. and C. Shapiro, "Systems competition and network effects." Journal of economic perspectives, 1994. 8(2): p. 93-115.
23. Kim, S.H. and V. Srinivasan, "A conjoint-hazard model of the timing of buyers' upgrading to improved versions of high-technology products." Journal of Product Innovation Management, 2009. 26(3): p. 278-290.
24. Kitzinger, J., "Qualitative research: introducing focus groups." BMJ (British Medical Journal), 1995. 311(7000): p. 299-302.
25. Krueger, R.A. and M.A. Casey, Focus Groups: a Practical Guide for Applied Research. 3 ed. 2000, Thousand Oaks, CA: SAGE Publications, Inc.
26. Lee, J., J. Lee, and H. Lee, "Exploration and exploitation in the presence of network externalities." Management Science, 2003. 49(4): p. 553-570.
27. Lemley, M.A. and D. McGowan, "Legal implications of network economic effects." California Law Review, 1998. 86(3): p. 479.
28. Liebowitz, S.J. and S.E. Margolis, "Network externality: an uncommon tragedy." Journal of economic perspectives, 1994. 8(2): p. 133-150.
29. Lim, B.L., M. Choi, and M.C. Park, "The late take-off phenomenon in the diffusion of telecommunication services: network effect and the critical mass". Information Economics and Policy, 2003. 15(4): p. 537-557.
30. Malhotra, A. and A.H. Segars, "Investigating wireless web adoption patterns in the U.S." Communications of the ACM, 2005. 48(10): p. 105-110.
31. McBride, N., "Actor-network theory and the adoption of mobile communications". Geography, 2003. 88(4): p. 266-276.
32. McFarland, D.J., "The role of age and efficacy on technology acceptance: implications for e-learning," in World Conference on the WWW and Internet Proceedings. 2001: Orlando, Florida.
33. McMahon, M. and R. Pospisil. "Laptops for a digital lifestyle: millennial students and wireless mobile technologies." in Proceedings of the Australasian Society for Computers in Learning in Tertiary Education. 2005.
34. Morgan, D.L., Focus groups as qualitative research. 2 ed. 1997, Thousand Oaks, CA: SAGE Publications, Inc.
35. Morris, M.G. and V. Venkatesh, "Age differences in technology adoption decisions: implications for a changing work force." Personnel Psychology, 2000. 53(2): p. 375-403.
36. Newell, S., J.A. Swan, and R.D. Galliers, "A knowledge-focused perspective on the diffusion and adoption of complex information technologies: The BPR example." Information Systems Journal, 2000. 10(3): p. 239-259.
37. Oblinger, D., "Boomers, gen-Xers, and millennials: understanding the 'New students'." Educause Review, 2003.
38. Oxman, J., "The FCC and the unregulation of the internet." United States. Federal Communications Commission. Office of and Policy. 1999: Office of Plans and Policy, Federal Communications Commission.
39. Porter, M.E., "Strategy and the internet." Harvard Business Review, 2001. 79(3): p. 164-164.
40. Prasad, R. and K.E. Skouby, "Beyond 3G research: can the Nordic and Baltic countries (re)emerge among the world leaders?" Nordic and Baltic Journal of Information and Communications Technologies, 2007. 1(1): p. 6-11.
41. Prensky, M., "Digital natives, digital immigrants." On the horizon, 2001. 9(5): p. 1-6.
42. Rickard, W. and D. Oblinger, "Higher education leaders symposium: the next-generation student." Redmond, WA. Retrieved December, 2003. 14: p. 2005.
43. Rohlfs, J., "A theory of interdependent demand for a communications service." Bell Journal of Economics & Management Science, 1974. 5(1): p. 16.
44. Scarbrough, H., "Blackboxes, hostages and prisoners." Organization Studies (Walter de Gruyter GmbH & Co. KG.), 1995. 16(6): p. 991.
45. Shapiro, C. and H.R. Varian, "The art of standards wars". California Management Review, 1999. 41(2): p. 8-32.
46. Shapiro, C. and H.R. Varian, Information rules: A strategic guide to the network economy. 1999: Boston: Harvard Business School Press.
47. Sim, J., "Collecting and analysing qualitative data: Issues raised by the focus group." Journal of Advanced Nursing, 1998. 28(2): p. 345-352.
48. Suarez, F.F., "Network effects revisited: The role of strong ties in technology selection." Academy of Management Journal, 2005. 48(4): p. 710-720.
49. Swann, G.M.P., "The functional form of network effects." Information Economics & Policy, 2002. 14(3): p. 417.
50. Varian, H., "5 habits of highly effective revolutions." (cover story). Forbes, 2000. 165(4): p. 73.
51. Weitzel, T., D. Beimborn, and W. Koenig, "A unified economic model of standard diffusion: the impact of standardization cost, network effects, and network topology." MIS Quarterly, 2006. 30: p. 489-514.
52. Yang, F. and S.M. Li. "Development of information support system for the application of new maize variety based on smartphone." in 1st International Conference on Computer and Computing Technologies in Agriculture (CCTA 2007). 2007. Wuyishan, China: Springer.