View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by AIS Electronic Library (AISeL)

COMPETITION OF FIXED AND MOBILE BROADBAND – SEPARATE MARKETS, OVERLAP OR TAKEOVER?

Research-in-Progress,

Jochen Wulf
University of St.Gallen
Mueller-Friedberg-Strasse 8
CH-9000 St. Gallen, Switzerland
jochen.wulf@unisg.ch

Walter Brenner
University of St.Gallen
Mueller-Friedberg-Strasse 8
CH-9000 St. Gallen, Switzerland
walter.brenner@unisg.ch

Abstract

Mutual effects between fixed and mobile broadband technologies remain up to this date largely unexplored. The few studies on this subject produce partially contradictory results. Diffusion oriented analysis approaches focused on cross-product effects on growth. Mutual effects on the market potential level have not been studied. In this article we develop and apply two diffusion models, which cover partial market overlap and takeover. We carry out linear and nonlinear regressions with data on country-level broadband adoption. A comparison of the results provides two main implications. (1.) Mobile broadband adoption is stimulated by a high level of broadband adoption; reverse effects on fixed broadband growth are not significant. (2.) A portion of the fixed broadband market capacity is taken over by mobile broadband services. This reduces the untapped market potential of fixed broadband. The results motivate further analyses of moderators for cross-product effects such as demographic and market-oriented country characteristics.

Keywords: mobile broadband, fixed broadband, codiffusion, inter-platform competition

Introduction

The adoption of mobile broadband has strongly grown in many countries during the last years (OECD 2013). Mobile broadband uses cellular communication technology to connect to the internet via IP at high throughput rates. Fixed broadband services, in contrast, have long been in the market and most often reached high adoption rates (OECD 2013). Mutual effects between fixed and mobile technologies remain up to this date largely unexplored (Srinuan et al. 2012).

In many countries the access to fixed broadband technologies is regulated at a wholesale level (Cardona et al. 2009a). Access is required for alternative broadband service providers to be able to offer competitive services without the ownership of the underlying access infrastructure. Competition on the retail level, however, is equally taken into account by regulators, since competitive effects on the retail level influence the level of wholesale competition (Schwarz 2007). The increased adoption of mobile broadband potentially increases inter-platform competition (Distaso et al. 2006). A thorough understanding of the competitive effects between mobile and fixed broadband, therefore, facilitates the definition of regulation policies in broadband markets (Cardona et al. 2009b). Competitive effects between fixed and mobile broadband and the implications for regulators have presently only been addressed by few researchers (Srinuan et al. 2012).

Investments into access and backhaul broadband infrastructure, due to high costs and long-term planning horizons, are complex and highly strategic decisions (Sabat 2005). As proven by the grown competition between DSL and cable technologies, changing substitution effects on the retail level can significantly impact investment plans and competitive market positions (Höffler 2007). In the course of future investment strategies, particularly with regard to fiber-to-the-home, network operators must take into account potential substitution effects between fixed and mobile broadband (Jay et al. 2012). Potential complementarity effects and an uptake of mobile broadband can equally have a positive effect on aggregate broadband penetration (Lee et al. 2011).

Telecommunication service providers combine mobile and fixed broadband services in bundled offerings, so called quadruple-play services (Rokkas et al. 2009). The mutual effects between mobile and fixed broadband directly affect pricing and competitive strategies (Mellin 2009). In the case of complementarity, bundling could lead to sub-additive cost and super-additive value (Friedrich et al. 2010). In the case of substitutability, bundling could represent a means to avoid customer churn and revenue erosion (Rokkas et al. 2009).

Several IS researchers have dealt with diffusion of broadband technologies (Dobson et al. 2013; Niculescu and Whang 2012) without taking into account mutual effects between fixed and mobile broadband. Present codiffusion models merely focus on cross-product effects regarding the speed of adoption (Libai et al. 2009; Parker and Gatignon 1994). Their capabilities to analyze contingency effects at market potential level are limited (Peres et al. 2010). Our research therefore has the objective to, in a first step, design models which conjunctively capture cross-product effects regarding the speed of adoption and contingency effects at the market potential level. In a second step we analyze the degree to which the developed models explain country level panel data on broadband diffusion (ITU 2012, World Bank 2013) and more precisely describe mutual effects between fixed and mobile broadband.

Prior Research

Competitive effects in diffusion theory

Many approaches for the analysis of product diffusion base on the work of Bass (1969), who models the number of adopters x_{t+1} of a product x, which has been newly introduced into a market, at time t+1 as a function of the number of adopters in t and the number of potential adopters $m_{x,t}$-x_t:

$$x_{t+1} = x_t + \left(p + q * \frac{x_t}{m_{x,t}}\right) * (m_{x,t} - x_t) \quad (1)$$

The market potential ($m_{x,t}$) is the overall market capacity for product x at time t and therefore the upper bound for diffusion. Internal influences (q) describe the degree to which adoption is affected by interactions between adopters and potential adopters. Bass (1969) assumes a linear relationship between the probability, that potential adopters adopt a product, and the existing number of adopters. External influences (p) describe the degree, to which adoption is affected by aspects other than internal market dynamics (such as marketing campaigns). Main assumptions of the Bass model are a single market monopoly and a homogeneous and fully connected social network of acquired and potential adopters. One area of research in diffusion is the extension of the Bass model for markets with competing products (Parker and Gatignon 1994). In the case of competing products, the diffusion of a specific product x is not only affected by within-product-communication (analog to q in the traditional Bass model) but also by cross-product communication. The number of adopters of a product x with cross-product communication can be modelled as follows (Libai et al. 2009; Savin and Terwiesch 2005):

$$x_{t+1} = x_t + \left(p + q * \frac{x_t}{m_t} + s * \frac{y_t}{m_t}\right) * (m_t - x_t - y_t) \quad (2)$$

The market potential m_t is the joint overall market capacity for the two products x and y at time t. The cross-product communication parameter s describes the degree to which adoption of x at time t is affected by interactions between potential adopters of the product x and the adopters y of the other product. The level of cross-product communication (s) is determined by three different phenomena: word of mouth (Peres et al. 2010), signals (Bourdieu 1984) and network effects (Goldenberg et al. 2010).

Cross-product effects do not only occur between substitutes but also between products which do not compete for the same customers. Cross-product effects between two products x and y from separate markets can be modelled as follows (Parker and Gatignon 1994). The individual market potentials of x and y at time t are given by $m_{x,t}$ and $m_{y,t}$ respectively.

$$x_{t+1} = x_t + \left(p + q * \frac{x_t}{m_{x,t}} + s * \frac{y_t}{m_{y,t}}\right) * (m_{x,t} - x_t) \qquad (3)$$

Fixed and broadband diffusion

The analysis of competitive effects between fixed and mobile telecommunication technologies has traditionally focused on the interaction between fixed and mobile voice services (fixed to mobile substitution) (Albon 2006). Vogelsang (2010) presents a comprehensive literature overview about this topic and at the same time calls for further research on the competitive effects between fixed and mobile broadband. It is of particular interest whether substitution effects between the two types of technologies will, comparable to the voice market, also emerge in the broadband market (Stumpf 2007).

There are two main methodological approaches to studying cross-product competition (Vogelsang 2010): the analysis of adoption based on diffusion theory and the estimation of cross-price elasticities of demand. Up to the present, only few scholarly studies are dedicated to the cross-product effects between fixed and mobile broadband. Two studies (Cardona et al. 2009a; Srinuan et al. 2012) calculate cross-price elasticities. Another two studies carry out regressions using adoption models (Lee et al. 2011; Wulf et al. 2013). With regard to competition between fixed and mobile broadband, the results of the studies are partially contradictory. The research of (Cardona et al. 2009a; Srinuan et al. 2012), at least in some geographical areas, suggest bilateral substitutability between the two technologies. Lee et al. (2011) and Wulf et al. (2013), come to the conclusion that fixed broadband stimulates growth of mobile broadband, reverse effects are not identified (unidirectional complementarity). Prior research, in summary, deduces implications on cross-technology growth and switching behavior. Contingency effects at market potential level have, up to this date, not been studied.

Model Development

The diffusion models (2) and (3) cover cross-product communication but do not take into account situations, in which the nature of competition has an influence on the products` market potentials. In the following we introduce two models, which allow the analysis of a partially shared market capacity (market overlap) and a market capacity reduction (market takeover).

Market Overlap

In a situation, in which a proportion α of the overall market capacity $m_{x,t}$ of a product x at time t is shared with a product y, we model the number of adopters $o_{x,t}$ of either product within the market overlap ($\alpha * m_{x,t}$) as follows:

$$o_{x,t} = p_{x,t} + p_{y,t}$$

We assume that the levels of overall adoption of the two products ($x_t/m_{x,t}$ and $y_t/m_{y,t}$) determine the numbers of adopters of the individual products in the market overlap ($p_{x,t}$ and $p_{y,t}$) such that:

- (assumption 1) the level of adoption within the market overlap equals the sum of the overall adoption levels of the two products and naturally has a maximum of 1

$$MIN\left(\frac{x_t}{m_{x,t}} + \frac{y_t}{m_{y,t}}, 1\right) \qquad (4)$$

- (assumption 2) and a product`s share of the market overlap is determined by the product`s overall adoption level and the sum of both adoption levels and is calculated as follows:

$$\frac{\frac{x_t}{m_{x,t}}}{MAX\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}},1\right)} \text{ and } \frac{\frac{y_t}{m_{y,t}}}{MAX\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}},1\right)} \quad (5)$$

Assumption 1 suggests that adoption within the market overlap does not differ from adoption within the exclusive market capacities up to full overlap adoption. Assumption 2 bases on the rational that overall market adoption of a product is a signal for its competitiveness in the market overlap. The number of adopters in the market overlap can hence be calculated as follows:

$$o_{x,t} = \alpha * \left(\frac{\frac{x_t}{m_{x,t}}}{MAX\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}},1\right)}\right) * m_{x,t} + \alpha * \left(\frac{\frac{y_t}{m_{y,t}}}{MAX\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}},1\right)}\right) * m_{x,t}$$

$$= \alpha * MIN\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}},1\right) * m_{x,t} \quad (6)$$

The number of adopters of the product x_t equals the sum of the adopters in the market overlap $p_{x,t}$ and the number of adopters in the exclusive market capacity $c_{x,t}$:

$$x_t = p_{x,t} + c_{x,t} \quad (7)$$

$c_{x,t}$ can hence be calculated as follows:

$$c_{x,t} = x_t - \alpha * \frac{\frac{x_t}{m_{x,t}}}{MAX\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}},1\right)} * m_{x,t} = x_t * \left(1 - \frac{\alpha}{MAX\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}},1\right)}\right) \quad (8)$$

Since the untapped market potential for the product x can be calculated by subtracting $o_{x,t}$ and $c_{x,t}$ from the overall market capacity $m_{x,t}$, the adoption of the product x at time t+1 can be calculated as follows:

$$x_{t+1} = x_t + \left(p + q * \frac{x_t}{m_{x,t}} + s * \frac{y_t}{m_{y,t}}\right) * (m_{x,t} - (\alpha * MIN\left(\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}}\right),1\right) * m_{x,t} + \left(1 - \frac{\alpha}{MAX\left(\left(\frac{x_t}{m_{x,t}}+\frac{y_t}{m_{y,t}}\right),1\right)}\right) * x_t)) \quad (9)$$

Market Takeover

Whereas in the model above we assume a market overlap, competition may also lead to a proportion of adopters of a product y viewing y as a substitute for x and therefore decreasing the number of potential adopters for product x. In contrast to the market overlap model, we assume a unidirectional substitution since x is not considered a substitute for y. This is for example the case, when a multi-purpose product (such as a smartphone) substitutes a single purpose product (such as a car navigation device). If α is the share of adopters of product y, which consider y to be a substitute for x, the number of adopters of the product x_{t+1} at time t+1 can be modeled as follows.

$$x_{t+1} = x_t + \left(p + q * \frac{x_t}{m_{x,t}} + s * \frac{y_t}{m_{y,t}}\right) * (m_{x,t} - x_t - \alpha * y_t) \qquad (10)$$

Data and Evaluation Methodology

Data

We used data on broadband adoption and population characteristics published by ITU (2012) and by World Bank (2013). ITU (2012) provides data on fixed and mobile broadband subscriptions for its member states. We included a total of 214 data sets with values for fixed and mobile broadband for two successive years in the time range of 2007-2011. Further information about the data is provided in Table 1.

Name and source	Definition	Data description
Total fixed (wired) broadband Internet subscriptions (ITU 2012)[1]	"Total fixed (wired) broadband Internet subscriptions refers to subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s. This can include for example cable modem, DSL, fibre-to-the-home/building and other fixed (wired) broadband subscriptions." (ITU 2012)	Mean: 5.44E+06 Standard Deviation.: 1.73E+07
Terrestrial mobile wireless subscriptions (ITU 2012)	"Sum of active mobile broadband subscriptions and dedicated mobile data subscriptions… Standard mobile subscriptions are mobile subscriptions with advertise data speeds of 256 kbit/s or greater and which have been used to make an Internet data connection via IP in the previous 3 months. ….Dedicated mobile data subscriptions are subscriptions to dedicated data services over a mobile network." (ITU 2012)	Mean: 8.39E+06 Standard Deviation: 2.55E+07
Population (WorldBank 2013)	"Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin." (WorldBank 2013)	Mean: 4.51E+07 Standard Deviation: 1.37E+08
Households (ITU 2012)	Number of households per country. A household consists of one or more persons living together in the same dwelling and sharing accommodation. (ITU 2012)	Mean: 1.33E+07 Standard Deviation: 4.00E+07

Table 1. Regression data (n=214)

Evaluation Methodology

We used linear as well as nonlinear regressions to test the fit of the proposed models with regard to the broadband data set. Whereas linear regression guarantees global optima, nonlinear regression requires more processing know how and for this reason is discussed in more detail in the following. Nonlinear regression algorithms use iterative approaches to estimate optimal solutions for nonlinear models, which cannot be linearized (Greene 2000). A main challenge in nonlinear regression is the setting of starting

[1] Due to simplicity reasons terrestrial fixed wireless and satellite technologies have not been taken into account. According to OECD (2013) these technologies only account for a small fraction of the broadband market in the OECD countries.

values for the independent variables. There are no general rules except that they should be as close as possible to their final values (Greene 2000). There are three measures we undertook to secure the identification of global optima: a preliminary simplification of the model to calculate plausible starting values, a plausibility check of parameter start values, and the iterative processing with varied starting values. We used the values from the separate market model (equation (3), estimated through classical linear regression) as starting values for the regression of equations (9) and (10). In further regression iterations, we modified each starting value using upper and lower value bounds identified through confidence intervals of the preparatory linear regressions. Per model, we carried out six regressions, all of which per model provided equal results. For model regression we used sequential quadratic programming with a step limit of two and optimality tolerance of 10^{-6}. The goodness of fit of the global model is rated by the coefficient of determination (R^2) (Greene 2000). F-tests are, in contrast to linear regression, not meaningful. The quality of the individual parameter estimations can be evaluated by looking at the 95% confidence intervals.

Results

In the following we analyze competitive effects between fixed and mobile broadband by testing the different models introduced above. An analogy with mobile and fixed telephony services (ITU 2013) suggests that the upper bound for broadband diffusion in a country is oriented at the population size (for mobile broadband) and the number of households (for fixed broadband) respectively. Therefore we set the country specific market capacity for fixed broadband to the number of households in this country. Following the argumentation of Niculescu and Wang (2012) we set the country specific market capacity for mobile broadband to the country`s population size. Since in many countries the sum of fixed broadband adopters relative to the number of households and mobile broadband adopters relative to population size exceeds 100%, absolute product substitution between fixed and mobile broadband can be precluded. Some adopters use both services in parallel. The single market competition model (as modeled in equation 2) can therefore be excluded from the analysis. Table 2 provides an overview of the results for the separate markets model (equation 3), the market overlap (equation 9) and market competition (equation 10). We limit the following discussion to the models` results with respect to the cross-product effects on growth and on market potentials.

d. v.[b]	fixed broadband			mobile broadband		
model result	separate markets	market overlap	market competition	sep. m'ts	market overlap	market competition
s	-.15*	-.01 (-.15/-.1/-.2 /-.15/-.15/-.2)[a]	-.06 (-.15/-.1/-.2 /-.15/-.15/-.2)[a]	.19*	.13* (.19/.1/.1 /.3/.19/.19)[a]	.13* (.19/.1/.1 /.3/.19/.19)[a]
α	/	.41* (.14/.39/0 /.14/.39/0)[a]	.11* (0/1/0 /1/0/1)[a]	/	.00 (.13/1/0 /.13/1/0)[a]	.00 (0/1/0 /1/0/1)[a]
p	.02*	.01 (.02/.04/.01 /.01/.02/.02)[a]	.01* (.02/.04/.01 /.01/.02/.02)[a]	-.02	.00 (0/.2/0 /.2/0/.2)[a]	.00 (0/.2/0 /.2/0/.2)[a]
q	.25*	.30* (.25/.25/.3 /.2/.2/.25)[a]	.29* (.25/.25/.3 /.2/.2/.25)[a]	.48*	.52* (.48/.48/.6 /.6/.35/.35)[a]	.52* (.48/.48/.6 /.6/.35/.35)[a]
R^2	.953	.959	.956	.728	.723	.723
*95% confidence interval excludes 0; [a] starting values per iteration (1st/2nd/3rd/4th/5th/6th); [b]dependent variable						

Table 2. Summary of results

With regard to mobile broadband adoption, all three models come to the same conclusion. Fixed broadband does not reduce the market potential of mobile broadband. Cross-product communication even suggests partial complementarity. All three models support significant positive effects of the level of fixed broadband adoption on mobile broadband growth. The slightly different model results are due to the lower bound of p=0 we included only in the nonlinear regressions but not in the linear regression for the separate markets model. With regard to fixed broadband adoption, the models come to different conclusions. The separate markets model reports a significant negative cross-product effect on growth. In the market overlap and the market competition models, in contrast, this cross-product effect becomes insignificant. In addition, the latter two models report a cross-product effect on market potential. With regard to model quality, the market overlap and the market competition models have a slightly higher goodness of fit. The market overlap model bases on the assumption that a portion of the products\` overall market capacities is shared. Whereas an application of this model to the data for fixed broadband adoption reports a market overlap, the application for mobile broadband adoption does not. As a consequence, the model produces contradictory results. The market competition model, in contrast, produces novel and consistent insights. The regression results suggest a unidirectional partial takeover of fixed broadband market capacities by mobile broadband. Since the market competition model has only a slightly better goodness of fit than the separate markets model, the results have to be interpreted with precaution. The implication of a partial market takeover, however, is in line with the results of other researchers with different research perspectives. Hauge et al. (2010) argue that usage of fixed and mobile broadband, in terms of the accessed services and the content, show similar consumption patterns. Since mobile technology, following this argumentation, enables mobility and location based services in addition to the content also accessible via fixed broadband, this could be an explanation for a unilateral market takeover. With a focus on service provisioning and usage, Prieger (2013) similarly reports that, particularly in rural areas, mobile broadband helps to fill in coverage gaps of fixed broadband.

Discussion, limitations and further research

The contribution of our work is twofold. Firstly, we produce novel insights about the characteristics of mutual effects between fixed and mobile broadband services. Due to the growing capabilities of mobile broadband services, such knowledge increasingly is required by telecommunication service providers for service pricing and bundling (Bauer 2007). Secondly, we develop diffusion models, which newly cover cross-product effects on the market potential level. The models may further be applied for the analysis of cross-product effects in a multitude of other IS contexts (such as mobile devices or approaches to software provisioning).

Main limitations of our study are associated with the diffusion models applied and the model assumptions. The diffusion models in our analysis only model interaction effects between adopters and non-adopters and do not take into account alternative explanations for broadband growth, such as broadband coverage. The models further focus on first-time adoption and do not cover cross-product customer churn. The strategic relevancy of customer churn is particularly high in saturated markets (Kim et al. 2004) . Since the 80%-quantile for the level of adoption in the broadband markets in our data is at 68% saturation for fixed and at 35% for mobile broadband, it seems reasonable to focus on first-time adoption in a first step. With regard to the specification of the overall market potential we used the number of households and the population size per country. Penetration of mobile telephony markets in some countries exceeds population size due to the ownership of multiple SIM cards. Following the argumentation brought forward by Niculescu and Wang (2012), penetration rates of over 100% are due to low fixed costs associated with service usage. According to a survey carried out by Cisco (2012) for the Western European market, a majority of consumers consider usage-based billing for mobile broadband as unfair and use data plans. Since such data plans, in comparison to usage-based billing, generally incur higher fixed costs, we assume single connections only. This assumption is supported by our data: maximum mobile broadband penetration is at 98.7%, the median is 11.9%.

Broadband adoption is influenced by many country specific, market specific and customer specific aspects (such as price, age and urbanization) (Ford 2008), which deserve further attention. In the next research step, in order to further validate and explain our macro-level results, we plan to conduct a survey at the micro-level of individual customers on the competitive effects of broadband services with a specific focus on micro-level aspects such as service requirements and multiple (mobile) connections. We further plan to include selected macro-level aspects (e.g., broadband coverage) into the proposed diffusion models as potential moderators of cross-product effects.

References

Albon, R. 2006. "Fixed-to-Mobile Substitution, Complementarity and Convergence," Agenda (13:4), pp. 309-322.

Bass, F.M. 1969. "A New Product Growth for Model Consumer Durables," Management Science (15:5), pp. 215-227.

Bauer, J. 2007. "Bundling, Differentiation, Alliances and Mergers: Convergence Strategies in Us Communication Markets," Available at SSRN 978372).

Bayus, B.L., Kim, N., and Shocker, A.D. 2000. "Growth Models for Multiproduct Interactions: Current Status and New Directions," in New-Product Diffusion Models, V. Mahajan, E. Muller and Y. Wind (eds.). Boston: Kluwer Academic Publisher, pp. 141-163.

Bourdieu, P. 1984. "Distinction: A Social Critique of the Judgement of Taste Harvard University Press," Cambridge, MA).

Cardona, M., Schwarz, A., Yurtoglu, B.B., and Zulehner, C. 2009a. "Demand Estimation and Market Definition for Broadband Internet Services," Journal of Regulatory Economics (35:1), pp. 70-95.

Cardona, M., Schwarz, A., Yurtoglu, B.B., and Zulehner, C. 2009b. "Substitution between Dsl, Cable, and Mobile Broadband Internet Services," in Telecommunication Markets. Springer, pp. 95-111.

Cisco. 2012. "Moving toward Usage - Based Pricing. A Connected Life Market Watch Perspective ". Cisco Internet Business Solutions Group.

Distaso, W., Lupi, P., and Manenti, F.M. 2006. "Platform Competition and Broadband Uptake: Theory and Empirical Evidence from the European Union," Information Economics and Policy (18:1), pp. 87-106.

Dobson, P., Jackson, P., and Gengatharen, D. 2013. "Explaining Broadband Adoption in Rural Australia: Modes of Reflexivity and the Morphogenetic Approach," MIS Quarterly (37:3), pp. 965-991.

Ford, G.S. 2008. "The Broadband Efficiency Index: What Really Drives Broadband Adoption across-the Oecd?," Phoenix Center Policy Paper Number 33).

Friedrich, R., Knott, M., Ward, J., and Hyde, V. 2010. "Mobile Operators' Move to Fixed - Protecting the Value of Mobile Assets," Booz & Company Inc. .

Goldenberg, J., Libai, B., and Muller, E. 2010. "The Chilling Effects of Network Externalities," International Journal of Research in Marketing (27:1), pp. 4-15.

Greene, W.H. 2000. "Econometric Analysis, Prentice Hall," Upper Saddle River, NJ).

Hauge, J.A., Jamison, M.A., and Marcu, M.I. 2010. "Consumer Usage of Broadband Internet Services: An Analysis of the Case of Portugal," Adoption, Usage, and Global Impact of Broadband Technologies: Diffusion, Practice, and Policy), p. 198.

Höffler, F. 2007. "Cost and Benefits from Infrastructure Competition. Estimating Welfare Effects from Broadband Access Competition," Telecommunications Policy (31:6), pp. 401-418.

ITU. 2012. "World Telecommunication/Ict Indicators 2012." International Telecommunication Union.

ITU. 2013. "Ict Facts and Figures 2013." Retrieved 2013/08/20, from http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013.pdf

Jay, S., Neumann, K.-H., and Plueckebaum, T. 2012. "The Cost of Nationwide Fibre Access in Germany," Communications & Strategies:85), pp. 169-188.

Joshi, Y.V., Reibstein, D.J., and Zhang, Z.J. 2009. "Optimal Entry Timing in Markets with Social Influence," Management Science (55:6), pp. 926-939.

Kim, M.-K., Park, M.-C., and Jeong, D.-H. 2004. "The Effects of Customer Satisfaction and Switching Barrier on Customer Loyalty in Korean Mobile Telecommunication Services," Telecommunications Policy (28:2), pp. 145-159.

Lee, S., Marcu, M., and Lee, S. 2011. "An Empirical Analysis of Fixed and Mobile Broadband Diffusion," Information Economics and Policy (23:3), pp. 227-233.

Libai, B., Muller, E., and Peres, R. 2009. "The Role of within-Brand and Cross-Brand Communications in Competitive Growth," Journal of Marketing (73:3), pp. 19-34.

Mellin, J. 2009. "Creating Competitive Advantage from an Fmc Strategy in a Traditional Telecoms Environment," Journal of Telecommunications Management (2:1), pp. 14-19.

Niculescu, M.F., and Whang, S. 2012. "Research Note—Codiffusion of Wireless Voice and Data Services: An Empirical Analysis of the Japanese Mobile Telecommunications Market," Information Systems Research (23:1), pp. 260-279.

OECD. 2013. "Oecd Communications Outlook 2013," OECD Publishing.

Pandey, M.S., Kumar, M., Panwar, A., and Singh, I. 2013. "A Survey: Wireless Mobile Technology Generations with 5g," International Journal of Engineering (2:4).

Parker, P., and Gatignon, H. 1994. "Specifying Competitive Effects in Diffusion Models: An Empirical Analysis," International Journal of Research in Marketing (11:1), pp. 17-39.

Peres, R., Muller, E., and Mahajan, V. 2010. "Innovation Diffusion and New Product Growth Models: A Critical Review and Research Directions," International Journal of Research in Marketing (27:2), pp. 91-106.

Prieger, J.E. 2013. "The Broadband Digital Divide and the Economic Benefits of Mobile Broadband for Rural Areas," Telecommunications Policy (37:6), pp. 483-502.

Rokkas, T., Varoutas, D., Katsianis, D., Smura, T., Renjish, K., Heikkinen, M., Harno, J., Kind, M., Von Hugo, D., and Monath, T. 2009. "On the Economics of Fixed-Mobile Convergence," info (11:3), pp. 75-86.

Sabat, H.K. 2005. "The Network Investment Economics of the Mobile Wireless Industry," Information Systems Frontiers (7:2), May 2005, pp. 187-206.

Savin, S., and Terwiesch, C. 2005. "Optimal Product Launch Times in a Duopoly: Balancing Life-Cycle Revenues with Product Cost," Operations Research (53:1), pp. 26-47.

Schwarz, A. 2007. "Wholesale Market Definition in Telecommunications: The Issue of Wholesale Broadband Access," Telecommunications Policy (31:5), pp. 251-264.

Srinuan, P., Srinuan, C., and Bohlin, E. 2012. "Fixed and Mobile Broadband Substitution in Sweden," Telecommunications Policy (36:3), 2012, pp. 237-251.

Stumpf, U. 2007. Regulatory Approach to Fixed-Mobile Substitution, Bundling and Integration. Bad Honnef: Wiss. Inst. für Infrastruktur und Kommunikationsdienste.

Vogelsang, I. 2010. "The Relationship between Mobile and Fixed-Line Communications: A Survey," Information Economics and Policy (22:1), pp. 4-17.

WorldBank. 2013. "World Development Indicators 2013." World Bank.

Wulf, J., Zelt, S., and Brenner, W. 2013. "Fixed and Mobile Broadband Substitution in the Oecd Countries--a Quantitative Analysis of Competitive Effects," System Sciences (HICSS), 2013 46th Hawaii International Conference on: IEEE, pp. 1454-1463.