Beyond Broadband Access: Developing Data-Based Information Policy Strategies

Richard D. Taylor (ed.), Amit M. Schejter (ed.)

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CHAPTER

4 Adoption Factors of Ubiquitous Broadband

Sangwon Lee, Justin S. Brown

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Abstract

This chapter focuses on the adoption factors of ubiquitous broadband that includes both fixed and mobile technologies. It first considers how both fixed and mobile broadband networks are increasingly recognized as indicators of the knowledge economy, and how technological innovation and higher bandwidth enable entry into the era of ubiquitous broadband access. It then emphasizes the importance of successful diffusion of fixed and mobile broadband for the provision of advanced Internet Protocol-based services such as VoIP (Voice over Internet Protocol), IPTV (Internet Protocol Television) mobile television, and 4G applications. It also presents the results of regression analysis suggesting that network competition between fixed and mobile broadband, platform competition in fixed broadband markets, and the multiple standardization policy in mobile markets are all significant factors of ubiquitous broadband adoption and deployment. Finally, it discusses the moral and ethical considerations underlying the social justification for government policy promoting access to information and communication technology.

Keywords: broadband adoption, ubiquitous broadband, fixed broadband, mobile broadband, knowledge economy, broadband access, multiple standardization policy, government policy, information and communication technology

Subject: Museums, Libraries, and Information Sciences

Broadband networks are widely recognized as an indicator of the knowledge economy. Employing secondary data, this chapter examines adoption factors of "ubiquitous broadband" that includes both fixed and mobile technologies. Along with other industry, ICT (Information and Communication Technology) and demographic variables, the results of regression analysis suggest network competition between fixed and mobile broadband, platform competition in fixed broadband markets and multiple standardization policies in mobile markets are all significant factors in ubiquitous broadband deployment. However, some of these ubiquitous broadband deployment factors vary between developed and developing countries. Among other conclusions, the results of this study imply that for the initial fourth generation (4G) mobile markets, in which fixed and mobile broadband networks will converge, governments need to be open to diverse competitive standards instead of government-mandated standards.

Background

Both fixed and mobile broadband networks are increasingly recognized as indicators of the knowledge economy. Technological innovation and higher bandwidth enable entry into the era of ubiquitous broadband access, which means broadband access anytime, anywhere, by anyone and anything through both fixed and mobile broadband.[1] After all, successful diffusion of fixed and mobile broadband is necessary for the provision of advanced IP-based services such as VoIP (Voice over Internet Protocol), IPTV (Internet Protocol Television) mobile television, and 4G applications.

p. 70 Initially broadband was defined as communication technologies that provide high-speed, always-on connections to the Internet for large numbers of residential and small-business subscribers.[2] However, this conception of broadband commonly emphasizes fixed broadband services such as DSL and cable modem service. Currently the International Telecommunication Union (ITU) defines broadband as a network offering a combined speed of equal to, or greater than, 256 Kbps in one or both directions, which may include more diverse broadband technologies such as mobile broadband and portable Internet.[3] In the near future fixed and mobile broadband technologies will be converged in the Next Generation Networks (NGN) to offer 4G services.[4]

In spite of this broader definition of broadband, many previous empirical studies on broadband focused only on fixed-broadband technology and did not readily analyze mobile broadband. Also, despite existing research efforts to better understand broadband deployment, previous empirical studies tended to employ limited numbers of independent variables with insufficient numbers of observations. In addition, only a few empirical studies focused on broadband factors directly related to developing countries.

Employing secondary data from the ITU, this chapter analyzes the determinants of global ubiquitous (total) broadband deployment. Specifically, this chapter examines whether network competition between fixed and mobile broadband has influenced broadband deployment. It also examines whether different policy types of platform competition in fixed broadband markets and standardization policy in mobile markets lead to different deployment levels of ubiquitous broadband. Finally, we examine whether there is any difference between developed and developing countries in terms of factors contributing to ubiquitous broadband adoption.

Global Broadband Deployment

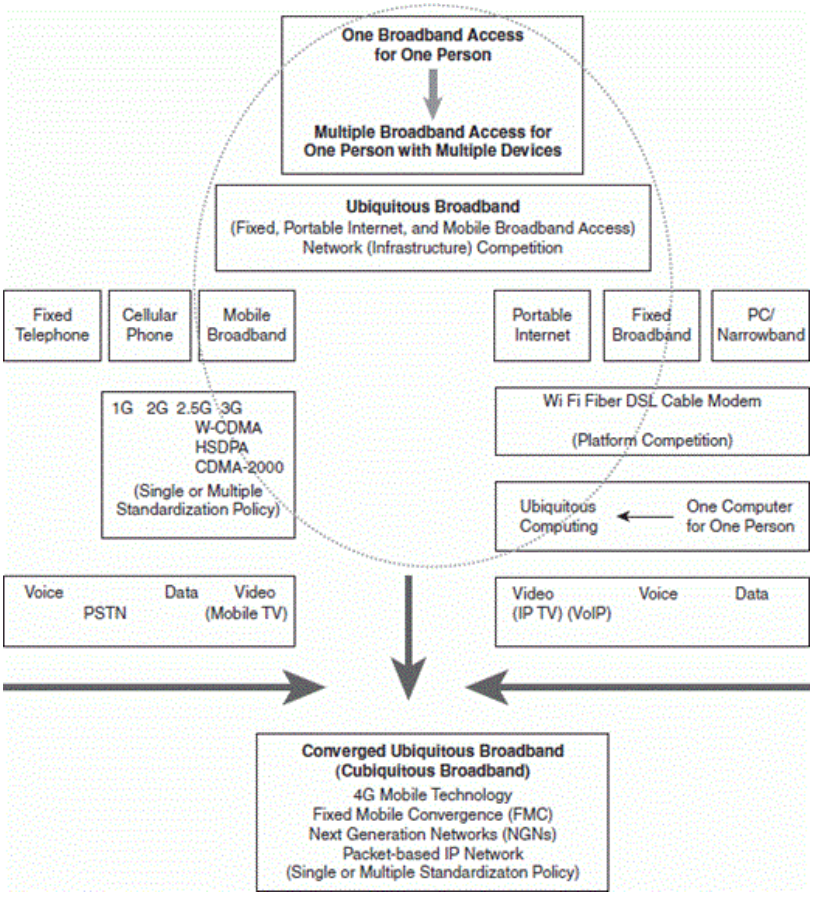
According to Organization for Economic Cooperation and Development (OECD) broadband penetration data (December 2008), Denmark, Netherlands, Norway, and Switzerland were the leading fixed broadband economies among OECD countries.[5] With respect to wireless, there exists a wide range of mobile broadband diffusion levels across countries. As of December 2007, Korea, Japan, and Italy were the top three mobile broadband economies among OECD countries in terms of mobile broadband penetration.[6] In terms of total broadband penetration rates that include both fixed and mobile broadband subscribers, as of December 2007, Korea, Japan, Italy, Sweden, and Switzerland were the top five broadband economies among OECD countries.[7]

p. 71 ## Concept of Ubiquitous Broadband

A primary purpose of our study was to examine adoption factors of ubiquitous (total) broadband. The concept of *ubiquitous computing* was first employed in 1991 by Marc Weiser. Weiser pointed to the "invisibility" of technology through the transformation of everyday items into small computers.[8] In the first paradigm of computing, mainframes were shared by many people (one computer for many people).[9] Now we are moving from the personal computer era (one computer per person) to proceed to the phase of the ubiquitous computing era (many computers per person).[10]

With the development of mobile technologies, this notion of ubiquitous computing can be applied to ubiquitous broadband access, which means an individual may use multiple forms of broadband access through a number of different devices. In the ubiquitous broadband environment, broadband access anytime, anywhere, by anyone and anything through both fixed and mobile technologies is possible (see Figure 4-1). For ubiquitous broadband, network competition between fixed and mobile networks may be a driver of broadband deployment. Further, for ubiquitous broadband, platform competition among different fixed broadband technologies and competition between different mobile standards as well as intra-modal competition are possible. These multiple modes of competition may suggest important policy and regulatory implications for nations wishing to expand their ubiquitous broadband infrastructure.

Figure 4-1.



Concept of ubiquitous (total) broadband.

In the near future, in the environment of the Next Generation Networks (NGNs) which will be achieved after fixed and mobile networks are converged by fully IP-based integrated systems, the notion of ubiquitous broadband could be replaced by *converged ubiquitous (cubiqutous) broadband* over a network (see Figure 4-1). In this NGN environment, single or multiple standardization policies are possible within a country. In this context, an examination of adoption factors of ubiquitous broadband is necessary.

As technology continues to evolve, it is logical to extend the definition to ubiquitous broadband—the total network offering across various types of platforms—including the simultaneous access of fixed and mobile services.[11]

Platform/Network Competition

Platform competition might be a key driver of broadband adoption. Platform competition occurs when different technologies compete to provide telecommunication services to users.[12] Platform competition in network industries involves competition between technologies that are not only differentiated, but also are competing networks.[13] Strong platform competition among different technologies may lead to lower prices, increased feature ↳

offerings, and more extensive broadband networks.[14] Some empirical studies find that platform competition (intermodal competition) positively influences broadband deployment.[15]

Relating to ubiquitous broadband, which includes both fixed and mobile broadband, platform competition may be related to the competition between fixed and mobile networks. Competition between networks might lead to lower prices, improving the quality of service, increasing the number of customers, and promoting investment and innovation.[16]

Research on Broadband Adoption Factors

Policy Factors: Previous studies suggest *standardization* policy plays a significant role in the success of
p. 73 wireless communication.[17] Specifically, multiple ↳ standardization policy might be positively related to rapid mobile broadband deployment. Though multiple standardization policy might lead to limited network externalities and economies of scale, multiple standards and different types of services across technologies enable the existence of diverse competing systems which may lead to better and differentiated services in the market.[18] Based on previous studies, it is also expected that both platform (network) competition in fixed broadband markets and multiple standardization policy in mobile broadband markets might lead to higher levels of ubiquitous broadband diffusion.

The institutional environment might also influence broadband deployment. For example, Andonova suggests political rights and civil liberties are correlated with Internet deployment.[19] Despite this research, there is no empirical study that specifically tests the influences of institutional environmental factors such as political and economic freedom on ubiquitous broadband diffusion.

Industry Factors: Previous empirical studies find that industry factors like price, speed, and competition influence broadband deployment. Cava-Ferreruela and Alabau-Munňoz suggest technological competition and low cost of deploying infrastructures might be drivers for broadband deployment.[20] Employing regression analysis, Lee and Brown determined platform competition, broadband speed, and content contribute to global broadband adoption.[21] They also contend the impact of platform competition is strong when market share of dominant technology and nondominant technology is similar.[22]

Recently some studies found low fixed broadband price is correlated with a higher level of broadband diffusion.[23] Higher bandwidth also might be correlated with broadband adoption. Growth in demand for higher capacity is a key driver of broadband diffusion.[24] Fransman suggests that bandwidth capacity of broadband is a measure of national performance in broadband.[25] Growth in demand for higher capacity and telecommunication infrastructure investment from private and public sectors might lead to higher levels of broadband diffusion,[26] but thus far empirical research has yet to analyze this contention.

Demographic Economic Factors: Previous studies on new media technology adoption suggest higher levels of income, education, urban population share, and population density might be positively correlated with the higher levels of fixed broadband and mobile diffusion.

Grosso found income measured by GDP per capita is related to broadband penetration among OECD countries.[27] An empirical study suggests high levels of income contributed to high levels of mobile adoption.[28] Ahn and Lee, in their study of the determinants of demand for mobile telephone networks,
p. 74 argued that the probability of subscribing to the mobile telephone ↳ networks was positively correlated with per capita GDP.[29] Using a panel data set of fifty-six countries to investigate the economic factors influencing the growth of mobile phone services, Madden et al. concluded that higher income and a larger user base tend to promote mobile diffusion.[30] In a separate empirical study about the same topic, Andonova also found GDP per capita to be a major contributing variable to mobile diffusion.[31]

Some previous empirical studies on fixed broadband deployment suggest that high levels of education are positively correlated with broadband penetration.[32] Through a nationwide U.S. survey, Horrigan demonstrates younger age, higher education and income, and urban living share of population may lead to greater broadband adoption.[33]

Some empirical studies on fixed broadband contend a high level of population density is related to rapid fixed broadband deployment.[34] Through data analysis of approximately one hundred countries, Garcia-Murillo revealed that population density has positive effects on the number of broadband subscribers.[35] Trkman et al. found population density and education are influential demographic factors of fixed broadband deployment in EU countries.[36]

Most of the studies on the telecommunications sector suggest a younger population is correlated with greater levels of new media technology adoption. Some previous studies found age is negatively correlated with broadband adoption in OECD countries.[37] Specifically, de Ridder determined the 35–39 and 40–44 year-old groups were positively correlated with fixed broadband adoption.[38] Based on this previous OECD study, it is interesting to examine whether age groups such as 35–44 year-olds are correlated with ubiquitous broadband diffusion.

Information and Communication Technology (ICT) Factors: Recent studies on fixed broadband deployment demonstrate ICT factors such as PC infrastructure and teledensity have influenced broadband penetration.[39] Denni and Gruber found that teledensity has been an influential factor in broadband deployment in the United States.[40] More recently, through a factor analysis, Trkman et al. found that communication technology expenditures, household PC access rate, Internet penetration, and fixed phone penetration are factors of fixed broadband deployment in EU countries.[41]

Research Questions

Even though there is a growing body of comparative scholarship concerning broadband deployment, many existing empirical studies use a limited number of independent variables with an insufficient number of observations. In addition, previous studies focus on fixed broadband and exclude mobile technology, a key
p. 75 to understanding the concept of ubiquitous (total) broadband. ↳ Furthermore, only a few empirical studies contain broadband policy implications for developing countries. Prior research also neglects some important independent variables such as network competition between fixed and mobile networks, institutional environment, bandwidth, and telecommunication infrastructure investment.

By employing secondary data from the ITU, this empirical study examines determinants of global ubiquitous broadband deployment. Based on the above-cited studies, we propose the following research questions:

- Has network competition between fixed and mobile broadband networks influenced the deployment of ubiquitous (total) broadband?
- Have policy factors—different types of platform competition in fixed broadband markets and standardization policies in mobile markets and institutional environment (political and economic freedom)—affected the deployment of ubiquitous (total) broadband?
- Have industry factors—specifically fixed-broadband price, broadband speed, bandwidth, telecommunication infrastructure investment, and mobile service price—influenced the deployment of ubiquitous (total) broadband?
- Have demographic/economic factors—specifically income, education, urban population share, population density, and age—influenced the deployment of ubiquitous (total) broadband?
- Have ICT factors—specifically PC penetration, content, Internet usage, and teledensity—influenced the deployment of ubiquitous (total) broadband?
- Is there any difference between developed and developing countries in adoption factors of ubiquitous (total) broadband?

The Empirical Model

To examine determinants of total broadband deployment, we employ a log linear regression model. The linear regression model employs approximately 216 observations of broadband services from ITU member countries.

To examine the influences of quantifiable variables on total broadband deployment, we formulate the following log linear regression model. Since the distribution of many variables in this linear regression model is positively skewed, data transformation with logarithm was utilized.

Ln Yt (BPR) = β_0 + β_1(ln Network Competition (or Standardization Policy Type) +

β_2(ln Speed) + β_3(ln Political Freedom) + β_4(ln Economic Freedom) +

β_5(ln Fixed Broadband Price) + β_6(ln Mobile price) +

β_7(ln Bandwidth) + β_8(ln Telecommunication Investment) +

β_9(ln Income) + β_{10}(ln Education) + β_{11}(ln Population Density) +

β_{12}(ln Urban Population) + β_{13}(ln Age Group) + β_{14}(ln PC Penetration) +

β_{15}(ln Content) + β_{16}(ln Internet Usage) +

β_{17}(ln Teledensity) + ε_t

This empirical model for multivariate analysis was a composite model from previous empirical studies about fixed and mobile broadband deployment. In the empirical model, the dependent variable (Y_t) is broadband deployment that accounts for both fixed and mobile services. Independent variables are policy factors such as standardization policy type, political freedom, and economic freedom. Three different standardization policy types are examined in the model—policy type I: platform competition for fixed broadband without mobile broadband services; policy type II: platform competition with single standard for mobile broadband services; and policy type III: platform competition with multiple standards for mobile broadband services. The model also incorporates industry factors such as speed, network competition, telecommunication infrastructure investment, fixed broadband price, bandwidth, and mobile service price. In addition, demographic factors such as income, education, population density, urban population, and age, as well as ICT factors such as PC penetration, Internet usage, content, and teledensity are contained in the model. Since some of the standardization policy types might be conceptually and empirically correlated, only one variable (network competition or policy types for standardization policy) was included in an empirical model.

Data and Measurement

Table 4-1 shows the variables, their measures, and the corresponding data sources used to analyze ubiquitous broadband adoption. Broadband services can be deployed through fixed and mobile networks. Therefore we examine adoption factors of ubiquitous (total) broadband deployment (fixed plus mobile). Ubiquitous (total) broadband is obtained by summing the total number of fixed and mobile broadband connections and is measured by the total number of broadband lines per one hundred inhabitants.[42]

Table 4-1 Variables, Measurement, and Data Sources for Total Broadband Deployment

Variables	Measurement	Data Sources
Total Broadband Deployment	Total number of broadband lines per 100 inhabitants	ITU (2004–2005)
Policy I	Dummy (1 for with platform competition in fixed broadband markets and no standardization in mobile broadband markets, 0 for otherwise)	ITU (2004–2005)
Policy II	Dummy (1 for with platform competition in fixed broadband markets and single standardization policy in mobile broadband markets, 0 for otherwise)	ITU (2004–2005)
Policy III	Dummy (1 for with platform competition in fixed broadband markets and multiple standardization policy in mobile broadband markets, 0 for otherwise)	ITU (2004–2005)
LLU	Dummy (1 for with LLU, 0 for no LLU)	OECD (2004–2005)
Economic Freedom	Index of economic freedom	Heritage Foundation (2004–2005)
Political Freedom	Inverse of the score on civil liberties	Freedom House
Network Competition	Dummy (1 for DSL and cable modem for fixed broadband and multiple standards for mobile broadband are available, 0 for otherwise)	ITU (2004–2005)
Price of Fixed Broadband Service	Broadband monthly charge (USD)	ITU (2004–2005)
Mobile Service Price	Per minute local call (USD) peak charge	ITU (2004–2005)
Income	GDP per capita	ITU (2004–2005)
PC Infrastructure	Estimated PCs per 100 inhabitants	ITU (2004–2005)
Education	UNDP Education Index	UNDP (2004–2005)
Population Density	Population density (per km^2)	ITU (2004–2005)
Internet Usage	Internet user per 100 inhabitants	ITU (2004–2005)
Urban Population	Percentage of urban population	Euromonitor (2004–2005)
Telecommunication	Annual telecommunication investment	ITU (2004–2005)
Infrastructure		ITU (2004–2005)
Investment		ITU (2004–2005)
Teledensity	Main telephone lines per 100 inhabitants	World Bnak (2004–2005)
Age	Percentage of age between 35–44	
Content	Internet hosts per 10000 inhabitants	ITU (2004–2005)
Bandwidth	International Internet bandwidth (bits per inhabitant)	ITU (2004–2005)
Speed	Broadband speed (Kbps)	ITU (2004–2005)

Policy factors. Three different types of categories were used to measure standardization/platform competition policy: platform competition only in fixed broadband markets and no mobile broadband
p. 77 services (policy type I); ↳

p. 78 ↳
platform competition in fixed broadband markets and single standardization policy in mobile broadband markets (policy type II); and platform competition in fixed broadband markets and multiple standardization policy in mobile broadband markets (policy type III). Political freedom is measured by the inverse of the score on civil liberties.[43] For the measurement of economic freedom, the index of economic freedom is employed.

Industry factors. Competition between fixed and mobile networks might be an influential factor of ubiquitous broadband deployment. Ubiquitous broadband access means broadband access that is unconstrained by time, place, and location through either fixed or mobile broadband.[44] In the empirical model, network competition is measured by a dummy variable (1 for DSL and cable modem is available for fixed broadband and multiple standards for mobile broadband, 0 for otherwise). We adopted the per-minute local call (USD) peak charge to measure the cost of mobile services in each country. Regarding the factor of nonvoice mobile applications, the cost of short message services (SMS) is used as the price proxy for mobile broadband relevant applications. Fixed broadband price is measured by broadband monthly charge (in USD). Telecommunication infrastructure investment is measured by annual telecommunication investment. For the measurement of bandwidth, international Internet bandwidth (bits per inhabitant) is utilized.

Demographic/Economic factors. In terms of demographic variables, level of education could be measured by illiteracy rate and average education/degree level. For the measurement of education, we employed the UNDP education index. A share of urban population is used to measure the demographic aspect of population density.[45] We measure population density by population per km^2. Age is measured by percentage of population between thirty-five to forty-four years old. For the measurement of income, the GDP per capita is used.

ICT factors. To measure the PC infrastructure, estimated PCs per 100 inhabitants are used. Teledensity is measured by main telephone lines per 100 inhabitants. For the proxy measurement of content, Internet hosts per 10,000 inhabitants is employed. Internet usage is measured by Internet users per 100 inhabitants.

Most of the secondary data has been collected from the ITU, OECD, World Bank, Heritage Foundation, and Freedom House. We employ the statistical analyses of linear regression analysis to assess the influential factors of ubiquitous broadband deployment.

Results of Regression Analysis of Total (Ubiquitous) Broadband Deployment

A total of 216 observations were analyzed employing multiple regression analysis. For ubiquitous broadband
p. 79 deployment, we examined both the model ↳ with network competition variable and the model with different platform completion-standardization policy type variable.[46] Extended and reduced models were identified from the data analysis for both models. Note that the dependent variable and independent variables were transformed using logarithmic functions since data were positively skewed. The results of both models show similar results.

Model with network competition variable. In the initial model, seventeen independent variables were included in the multiple regression analysis. Because a multicollinearity problem might occur when independent variables are highly correlated, a correlation analysis was conducted to check potential multicollinearity problems. To assess the strength of correlations, the criterion of .80 Pearson correlations was employed. PC penetration, teledensity, Internet use, and bandwidth were removed from the initial model because of high correlation with other independent variables. The extended regression model was significant at the .01 level.

Specifically, network competition, income, and content were statistically significant at the .01 level. Fixed broadband price, speed, and political freedom were statistically significant at the .05 level. Other variables such as mobile price, education, population density, urban population, age (35–44), telecommunication investment, and economic freedom were not statistically significant. R-squared for the extended model was .81.

In the reduced model, nonsignificant variables such as mobile price, education, age (35–44), telecommunication investment, and economic freedom were removed. The reduced model was significant at the .01 level. In the reduced model, income and political freedom were statistically significant at the .01 level. Fixed broadband price, speed, content, urban population, and network competition were statistically significant at the .05 level. Also, population density was statistically significant at the .1 level. R-squared for the reduced model was .79. Table 4-3 provides the results of the regression analysis.

Table 4-3 Results of Regressions of Total Broadband Deployment for Developing and Developed Countries

Variable	Developing Countries				Developed Countries			
	Extended Model		Reduced Model		Extended Model		Reduced Model	
	Coefficients B	t-stat	Coefficients B	t-stat	Coefficients B	t-stat	Coefficients B	t-stat
Constant	−2.71	−1.12	−3.48	−6.57	−1.53	−.75	−.20	−5.73***
Speed	.08	.33	–	–	.13	1.69*	.14	2.15**
Fixed Broadband Price	−.18	−1.60	−.11	−1.11	−.04	−.25	–	–
Income	.57	2.62**	.79	4.24***	.30	1.19	–	–
Mobile Price	.17	1.08	–	–	−.05	−.65	–	–
Education	–	–	–	–	.41	.21	–	–
Content	–	–	–	–	.07	.95	–	–
Political Freedom	−.03	−.12	–	–	−.23	−.96	−.29	−2.18**
Age (35–44)	−.94	.84	–	–	–	–	–	–
Telecom Investment	.01	.31	–	–	.004	.07	–	–
Economic Freedom	.11	.10	–	–	−1.25	−1.22	–	–
Population Density	–	–	–	–	.14	2.94***	.09	2.58**
Urban Population	.12	.35	–	–	.24	.44	–	–
Teledensity	.25	1.02	−.001	−.005	–	–	–	–
PC Penetration	.05	.29	–	–	–	–	–	–
Internet Use	–	–	–	–	.86	2.90***	.91	3.65***
Bandwidth	.31	2.62**	.25	2.96***	.14	1.3	.21	3.05***
Network Competition	–	–	–	–	–	–	–	–
Policy I	.23	1.86*	.19	1.74*	.37	1.85*	.25	1.75*
Policy II	.36	2.66***	.33	2.73***	.29	1.50	.23	1.72*
Policy III	.36	1.96*	.39	2.13**	.59	2.94***	.54	4.01***
R–Squared	0.69		0.56		0.79		0.77	
Number of Observations	94		120		69		73	

* Statistically significant at the 10% level.

** Statistically significant at the 5% level.

*** Statistically significant at the 1% level.

Model with platform competition-standardization policy variable. The main interest of this model is to analyze the effects of different platform competition-standardization policy types. We categorized three different types: platform competition only in fixed broadband markets and no mobile broadband services (policy type I); platform competition in fixed broadband markets and single standardization policy in mobile broadband markets (policy type II); and platform competition in fixed broadband markets and multiple standardization policy in mobile broadband markets (policy type III). For the extended model, initially, all nineteen independent variables were included in the multiple regression analysis. A correlation analysis was conducted to check potential multicollinearity issues. Based on the benchmark of .80 Pearson correlations, PC penetration, teledensity, Internet use, and bandwidth were removed from the initial model because of high correlation with

p. 80 other independent variables. Also, for the extended model, other insignificant independent variables such as mobile price, education, age (35–44), and economic freedom were removed from the initial model. The extended model was significant at the .01 level.

In particular, policy type III (platform competition in fixed broadband markets and multiple standardization policy in mobile broadband markets) and income were statistically significant at the .01 level. Policy type II (platform competition in fixed broadband markets and single standardization policy in mobile broadband markets), speed, political freedom, and population density were statistically significant at the .05 level. Policy type I (platform competition only in fixed broadband markets and no mobile broadband services) was significant at the .1 level. Other independent variables such as fixed broadband price, content, telecommunication investment, and urban population were not statistically significant. R-squared for the extended model was .80.

To check the stability of results in the empirical study, the nonsignificant independent variable telecommunication investment was removed from the reduced model. The reduced model is significant at the .01 level. In the reduced model, policy type III, income, and political freedom were statistically significant at the .01 level. Policy type II, speed, and population density were statistically significant at the .05 level. Policy type I, fixed broadband price, and urban population were significant at the .1 level. Content was not statistically significant. R-squared for the reduced model was .80. A total of 190 observations were available for this model. Table 4-2 provides the results of the reduced models used in the regression analysis.

Table 4-2 Results of Regressions of Total Broadband Deployment

Variable	Model 1 (with Network Competition Variable)				Model 2 (with Policy I, II, III)			
	Extended Model		Reduced Model		Extended Model		Reduced Model	
	Coefficients B	t-stat	Coefficients B	t-stat	Coefficients B	t-stat	Coefficients B	t-stat
Constant	−.4.74	−.3.50***	−.4.11	−.7.74***	−.4.61	−.7.64***	−.4.41	−.8.29***
Speed	.23	2.16**	.25	2.55**	.22	2.03**	.23	2.36**
Fixed Broadband Price	−.19	−.2.11**	−.17	−.2.11**	−.12	−.1.45	−.13	−.1.69*
Income	.67	5.65***	.71	7.48***	.76	7.42***	.79	8.32***
Mobile Price	−.04	−.491	–	–	–	–	–	–
Education	−.89	−.1.16	–	–	–	–	–	–
Content	.20	3.05***	.12	2.34**	.09	1.62	.07	.17
Political Freedom	−.37	.18**	−.50	3.27***	−.40	−.2.42**	−.50	−.3.35***
Age (35–44)	.32	.43	–	–	–	–	–	–
Telecom	.02	.03	–	–	.03	1.08	–	–
Investment	.06	.08	–	–	–	–	–	–
Economic Freedom	.08	1.54	.09	1.96*	.11	2.24**	1.2	2.48**
Population Density	.40	1.50	.49	2.05**	.41	1.64	.45	1.96*
Urban Population	–	–	–	–	–	–	–	–
Teledensity	–	–	–	–	–	–	–	–
PC Penetration	–	–	–	–	–	–	–	–
Internet Use	–	–	–	–	–	–	–	–
Bandwidth	.23	2.67***	.18	2.32**	–	–	–	–

Network Competition	–	–	–	–	.18	1.86*	.16	1.84*
Policy I***	–	–	–	–	.25	2.46**	.21	2.28*
Policy II*** Policy III***	–	–	–	–	.56	4.33**	.53	4.33**
R-Squared	0.81		0.79		0.80		0.80	
Number of Observations	169		191		177		191	

* Statistically significant at the 10% level.

** Statistically significant at the 5% level.

*** Statistically significant at the 1% level.

**** Policy I: Cable modem-DSL platform competition + no standardization policy for mobile broadband/Policy II: Cable modem-DSL platform competition + single standardization policy for mobile broadband/Policy III: Cable modem-DSL platform competition + multiple standardization policy for mobile broadband.

Results of Ubiquitous Broadband Deployment for Developed and Developing Countries

A total of 73 observations were analyzed employing multiple regression analysis for developed countries and a total of 120 observations were analyzed for developing countries. R-squared for the final reduced model for developed countries was .77, and R-squared for the final reduced model for developing countries was .56. To examine effects of different platform competition-standardization policy types, policy types I, II, and III were included in the model. Dependent variables and independent variables were transformed using a logarithmic function since data were positively skewed.

Regression analysis, developed countries. In the initial model, all nineteen independent variables were included in the multiple regression analysis. PC penetration was removed from the initial model because of its high correlation with other independent variables. Also, for the extended model, some insignificant
p. 81 variables like teledensity and age were removed from the model. ↳

p. 82 ↳

p. 83 ↳

In the reduced model, other insignificant variables such as fixed broadband price, income, mobile price, education, content, telecommunication investment, urban population, and economic freedom were also removed from the model. Table 4-3 provides the ANOVA table of the reduced regression model, which illustrates the model's significance at the .01 level (P <. 001). In the reduced model, policy type III, bandwidth, and Internet use were statistically significant at the .01 level. Speed, political freedom, and population density were statistically significant at the .05 level. Also, policy types I and II were significant at the .1 level in the developed countries.

Regression analysis, developing countries. Initially, all nineteen independent variables were included for the regression model. Some insignificant variables such as education, content, and population density, which have unexpected signs, were removed from the model. In the reduced model, other insignificant variables such as Internet usage, speed, political freedom, age (35–44), telecommunication investment, economic freedom, urban population, and PC penetration were removed from the model. Table 4-3 provides the results of the extended and reduced regression model.

The result of the analysis for developing countries was different from the result for developed countries. In the reduced model, policy type II, income, and bandwidth were statistically significant at the .01 level. Policy type III was statistically significant at the .05 level. Policy type I was significant at the .1 level in the developing countries. Considering the significance level of policy types II and III, it appears that in the developing countries policy type II (platform competition in fixed broadband market and single standard for mobile broadband market) is more effective than policy type III (platform competition in fixed broadband market and multiple standards for mobile broadband market). In the developed countries, policy type III was more significant than policy type II.

Conclusion

In this empirical study we examined potential factors that influence the deployment of ubiquitous (total) broadband including both fixed and mobile services. The results of regression analysis suggest that there are positive effects of network and platform competition and a multiple mobile standardization policy on ubiquitous broadband deployment. This result may imply, at least in the initial broadband markets, regulation across different platforms (or networks) should be as competitively neutral as possible. In spite of the result of this empirical study, considering the effects of network externality, it is still important to note that concepts of efficiency and ease of integration are important for future broadband markets.[47] These

p. 84 discussions on broadband deployment have policy implications for the diffusion of 4G ↳

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mobile technologies (or pre-4G mobile technologies). The result of this study implies that in the initial 4G mobile markets, governments need to be open to diverse standards for competition instead of government-mandated standards. In the long term, as Noam suggested, industry-wide coordination and mutual learning processes are important.[48] In this cooperative voluntary standard-setting environment, compatibility is achieved by agreeing to a standard.[49] In doing so, in the long term, broadband service providers may suppress competition between networks in favor of competition on a network.

The log linear regression results of ubiquitous broadband penetration for all countries also suggest that both the interactions of DSL-cable platform competition availability in fixed broadband markets and single and multiple standardization policy significantly contribute to the diffusion of ubiquitous broadband penetration (see Table 4-2). However, one may question whether the results of log linear regression for ubiquitous broadband penetration for all countries may be applied equally to both developed and developing countries. The log linear regression results of ubiquitous broadband penetration for developed countries suggest that the interaction variable (policy type II) of DSL-cable platform competition availability in fixed broadband markets and single standardization policy in mobile broadband markets was not statistically significant (see Table 4-3). However, the interaction variable (policy type III) of DSL-cable platform competition availability in fixed broadband markets and multiple standardization policy in mobile broadband markets was statistically significant (see Table 4-3). In the developing countries, the situation seems different. In the developing countries both interaction variables (policy types II and III) were statistically significant (see Table 4-3). Considering that in most developed countries currently DSL-cable modem platform competition is available, the results of this empirical study at least suggest that in the initial status of mobile broadband deployment, market-mediated standardization policy is more effective for developed (high income) countries, in which basic ICT infrastructure is already deployed and might have a more mature mobile industry and consumers. It appears that, in developed countries, technological diversity, in a new medium's early stage, is likely to foster innovative applications and better consumer choices, which initially lead to faster deployment of technology like mobile broadband.[50]

We also found that high levels of political freedom, which is measured by the level of civil liberty in a country, is associated with greater ubiquitous broadband diffusion. This result suggests that in the diffusion of 4G mobile technology political freedom might be an influential factor.

The result of log linear regression analysis also suggests that download speed, which is measured by the Kbps, is a significant factor of ubiquitous-broadband

p. 87 deployment (see Table 4-2). The result suggests that fast download speeds could lead to more broadband subscribers in the market. This result also may imply consumers who want fast broadband speed will more readily migrate to costly broadband services, if there are higher levels of throughput speed offered by broadband service providers.[51]

Higher levels of population density and urbanization are considered as supply factors for broadband diffusion.[52] The results of the linear regression analysis of ubiquitous broadband shows population density is also a significant factor of ubiquitous broadband deployment. This result may imply more densely populated countries have advantages in the cost conditions for network deployment. Also, higher levels of urban population share are associated with higher levels of ubiquitous broadband deployment, which may imply that more urbanized countries also have better cost conditions for broadband deployment.

In terms of limitations, the sample used in our study contained a comparatively small number of observations. Also, with a relatively short period, the nonlinear nature of ubiquitous broadband diffusion was not easily captured. When different multiple measurements for ubiquitous broadband deployment and data become available, improved research for the diffusion of ubiquitous broadband deployment, which has greater implications for 4G mobile deployment, will be possible. It is therefore recommended that scholars examine the factors that lead to ubiquitous broadband.

Even though we measured the concept of ubiquitous broadband, scholars should also continue to pursue comparative research that examines fixed or mobile broadband deployment as their own unique dependent variables. The concept of ubiquitous (total) broadband is relatively new and certainly there are still many important implications that may be learned about the factors that lead to fixed or mobile broadband diffusion.

Finally, we could not readily include any impact of socio-cultural variables and other policy variables on broadband deployment in a given country. For instance, a country's culture such as lifestyle and unique policy factors such as cross-ownership regulation may be influential factors of broadband deployment that are unique compared to other nations. When more refined measurement and data for these types of variables are available, they may be included in future empirical research.

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