A Cross-Country Analysis of Fixed Broadband Deployment: Examination of Adoption Factors and Network Effect*

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Abstract

Broadband infrastructure is a key component of the knowledge economy. Employing a secondary data set, this study examines adoption factors of fixed broadband among OECD countries. The result of the regression analysis suggests platform competition, income, and education positively influence fixed broadband diffusion. Light form of Local Loop Unbundling (LLU) was positively associated with high levels of fixed broadband diffusion. Considering the result of the data analysis, it may be beneficial if countries pursue light-touch LLU regulation like bitstream access instead of a strong form of regulation. This study also suggests that network effects and the effects of platform competition co-exist in many OECD countries.

Continuous technological innovations in the telecommunication industry marked by convergence enable users to access high-speed Internet, wireless networks, and multimodal content and services. Broadband communications lie at the heart of this trend. Broadband infrastructure is a key component of the knowledge economy, and high-speed connections are becoming an important economic indicator.[1] Widespread and affordable broadband access encourages innovation, spurs economic growth and attracts foreign investment.[2] Although there are various definitions of broadband, the International Telecommunication Union (ITU) defines broadband as a network offering a combined speed of equal to, or greater than, 256 kilobit per second in one or both directions.[3] According to the International Telecommunication Union (ITU), the total number of fixed broadband subscribers has grown more than threefold, from about 150 million in 2004, to almost 500 million by the end of 2009.[4]

Research demonstrates that a number of factors including policy, industry, demographic, and Information and Communication Technology (ICT) variables may influence fixed broadband deployment.[5] To promote faster adoption of fixed-broadband, many countries considered local loop unbundling (LLU) and platform competition as important policy initiatives. The goal of LLU policy is to stimulate competition by opening up an incumbent fixed-broadband network for access. In contrast, platform competition aims to promote market competition among facility-based entrants in a given telecommunications segment.[6]

In spite of a growing body of literature on fixed-broadband diffusion and impacts of broadband policies, the effects of LLU and platform competition are still not clearly understood. For instance, implementation of LLU policy widely differs among countries. Types of LLU – full unbundling, line sharing and bitstream access — and LLU prices are different across

countries.[7] The effects of these different types of LLU policies are still not clearly understood through empirical studies. Furthermore, previous empirical studies of fixed-broadband diffusion use a comparatively small number of observations.[8]

In addition, previous empirical studies on fixed-broadband did not test important theoretical concepts like network effects, which may influence fixed-broadband diffusion in many countries.

Using 2001-2008 OECD (Organization for Economic Cooperation and Development) data, we examine the influential factors of fixed-broadband diffusion in OECD countries through regression analysis. Moreover, we examine whether there have been network effects in the diffusion of fixed broadband in OECD countries and assess the effects of different types of LLU policies such as full unbundling, line sharing, and bit-stream access as well as platform competition.

Current Status of Global Fixed-Broadband Deployment

While there has been a steady growth in worldwide fixed-broadband adoption, there also exists a wide range of fixed-broadband diffusion levels across nations. For example, the region of Europe trumped all other regions (Africa (0.2 percent), Asian (5.7 percent), and America (15.5 percent)) in fixed-broadband adoption with 23.9 percent fixed-broadband penetration in 2010.[9] It is evident that there are significant regional differences in fixed-broadband penetration. According to the OECD penetration data (December 2009), Netherlands, Denmark, Switzerland, Norway, and Korea are leading broadband economies among OECD countries (see Figure 1). For broadband connections either fixed, mobile, or portable Internet technologies may be employed. Fixed broadband is mainly implemented through technologies such as digital subscriber line (DSL), cable modem, and fiber- to- the- home (FTTH).[10] Thus far, among OECD

countries, for fixed broadband, the dominant platforms are DSL (60 percent) and cable modem (29 percent), while other platforms (e.g. FTTH) make up 11 percent.[11]

Figure 1-3 about here

Literature Review

Based upon the classification of existing research, diverse adoption factors such as policy/industry, demographic, Information and Communication Technology (ICT), and network effect may influence fixed-broadband deployment. Table 1 summarizes the main results of empirical studies on fixed-broadband deployment.

Network Effect. Network effect is a theoretical concept that may inform fixed-broadband adoption. For certain type of services, the value of the services to each individual user may depend to some degree on the number of other individuals using those services.[12] Thus, network effect is the circumstance in which the net value of an action is affected by the number of agents taking equivalent actions.[13] With network effect, higher usage of broadband services simply makes them more valuable.

For services characterized by network effects, the decision by consumers regarding which network to join will depend not only on relative product characteristics and prices, but also the expected size of the network.[14] The role of the size of the existing installed base in determining the size of the network in the future arises because positive network effects give rise to positive feedback effects.[15] These positive feedback effects create a strong tendency for “the strong grow stronger ” in a virtuous cycle—the greater the installed base, the greater the network benefits; the more attractive the network to adopters, the greater adoption, the greater the installed base.[16] Given network effects, users may rationally choose a service or product with a large user base

over a competing service or product with a small user base even when the technical specifications of the smaller base service or product are better suited to their needs because the network benefits outweigh the benefits of service or product superiority.[17] If network effect exists in the use of fixed-broadband services, new subscribers joining a broadband network might influence the utility of current subscribers.[18] Network effects may lead to self-propelling or endogenous network growth, which suggests current subscription is positively correlated to previous subscription.[19] Previous research on network effect found that these network effects have influenced mobile telephony subscription.[20] Currently there is no empirical work to test the existence of network effects on fixed-broadband subscription.

Based on the literature reviewed, the following research question (RQ) is proposed:

RQ1: Have network effects positively contributed to the adoption of fixed-broadband services?

Policy/Industry Factors: LLU Policy and Platform Competition. Many countries have employed local loop unbundling (LLU) regulation as an important policy initiative to promote fixed-broadband deployment. Local loop unbundling (LLU) refers to the process by which incumbent carriers lease, wholly or in part, the local segment of their telecommunications network to competitors.[21] The goal of LLU regulation in fixed-broadband markets is to stimulate competition by opening up an incumbent fixed-broadband network for competitive access. Currently, many OECD countries adopt LLU policy in fixed-broadband markets. Implementation of LLU policy widely differs among countries.[22] Types of LLU – full unbundling, line sharing and bitstream access — and LLU prices are different across countries.[23] In many European countries, line sharing and bitstream access have been considered forms of LLU policies that

allows new entrants the ability to offer fixed-broadband services to end users without owning local networks, especially the first and last mile.[24]

There are many potential costs and benefits of LLU policy that must be weighed carefully. LLU may introduce intra-modal competition in the DSL markets and prices might fall when incumbent carriers are compelled to open up their networks to competitors.[25] Thus, LLU may bring consumer benefits in the near future through open access to competitors.[26] However, as Spulber and Yoo argue, LLU may reduce incentives for incumbents to invest in telecommunications infrastructure and retard broadband deployment.[27] Many incumbents now complain that LLU confiscates their property, essentially robbing them of incentives to invest in advanced telecommunication technologies.[28]

Some previous empirical studies on broadband deployment tested impacts of LLU policy on fixed broadband deployment. Employing logit regression analysis from selected ITU countries, Garcia-Murillo found unbundling an incumbent's infrastructure only results in a substantial improvement in broadband deployment for middle-income countries, but not for their high-income counterparts.[29] Distaso et al. found LLU price is an explanatory variable of fixed-broadband adoption, but competition in the market for DSL services does not play a significant role.[30] Through regression analysis of OECD countries' data, Grosso found LLU in general positively influences fixed-broadband deployment.[31]

Notwithstanding previous studies on broadband deployment, the effects of different types of LLU policy are still not clearly understood through empirical studies. Furthermore, previous empirical findings overall employed a comparatively small number of observations.

Based on the literature reviewed, the following research question (RQ) is proposed:

RQ2: Has any type of LLU policy positively contributed to the adoption of fixed-broadband services?

Platform competition is an important theoretical basis of this study. Platform competition occurs when different technologies compete to provide telecommunication services to end-users.[32] Platform competition in network industry involves competition among technologies that are not only differentiated, but also are competing networks.[33] Strong platform competition among different technologies may lead to lower prices, increased feature offerings, and more extensive broadband networks.[34]

A few studies argue that inter-modal competition (platform competition among different technologies) with other factors in the supply-side of the broadband market increase broadband adoption. Burnstein and Aron suggest that broadband availability in a state is driven by inter-modal competition and cost factors, but not by the raw availability of broadband services.[35] Through two different econometric analyses (time-series analysis and multiple-regression analysis) using data from 50 states, Lee suggests platform competition and the availability of different broadband platforms have positively influenced broadband diffusion in the United States.[36] Based upon analysis of data from 14 European countries, Distaso et al. demonstrate that inter-platform competition drives fixed-broadband adoption.[37] Cava-Ferreruela and Alabau-Muňoz also suggest high level of technological competition, low cost of deploying infrastructures, and prediction of the use of new technologies might be key factors for broadband supply and demand, respectively.[38] These previous studies suggest, that at least in the initial stage of broadband deployment, availability of different platforms such as DSL, cable modem, and FTTH may positively influence fixed-broadband penetration.

Based on the literature reviewed, the following research question (RQ) is proposed:

RQ3: Has availability of platform competition in fixed-broadband markets positively contributed to the adoption of fixed-broadband services?

Demographic Factors: Income, Education, and Population Density. Previous communication research has long identified the importance of demographic factors as antecedents in new media technology adoption. For instance, Rogers suggested that early adopters tend to have higher socio-economic status.[39] Some empirical studies on fixed-broadband deployment suggest demographic factors, such as income, education, and population density, have positively influenced fixed-broadband adoption. Through a nationwide U.S. survey, Savage and Waldman found that preference for high-speed access is apparent among higher income and college-educated households.[40] Chaudhuri et al. found the influences of traditional socio-demographic variables like income and education on broadband deployment are strong in the United States.[41] In examining demographic factors among different countries, Grosso found that a high level of income measured by GDP per capita is related to high broadband penetration rate among OECD countries.[42] Trkman et al. also found population density and education are influential demographic factors of fixed-broadband deployment in EU countries.[43] Through recent empirical work, Koutroumpis found high levels of income and education positively influence broadband diffusion.[44]

Based on the literature reviewed, the following research question (RQ) is proposed:

RQ4: Have high levels of income, education, and population density positively influenced the deployment of fixed-broadband services?

ICT Infrastructure Factor: PC Penetration. Previous studies on broadband diffusion contend the information and communication technology (ICT) factor like personal computer (PC) adoption has influenced fixed-broadband adoption. Through a comparative study of broadband deployment in Canada, Japan, Korea and the United States, Frieden argues the role of government in ICT incubation is important for rapid broadband deployment.[45] Through a factor analysis, Trkman et al. found that communication technology expenditure, household PC access rate, Internet penetration and fixed phone penetration are factors of fixed-broadband deployment in EU countries.[46]

Based on the literature reviewed, the following research question (RQ) is proposed:

RQ5: Have high levels of PC penetration positively influenced the deployment of fixed-broadband services?

Table 1 about here

Research Method

We utilize a secondary dataset to estimate a log linear regression model of fixed-broadband penetration. The data for the regression model of fixed-broadband diffusion covers the period from 2001 to 2008. For the regression analysis, 238 observations from 30 OECD countries were examined to assess the relationships between the proposed variables and the fixed-broadband penetration rates. Eight years observations were available for each OECD country.

Measurement and Data Sources. Table 2 shows the variables, their measurement, and the corresponding data sources for fixed-broadband deployment. The dependent variable, fixed-broadband deployment, was measured by the number of broadband subscribers per 100

inhabitants. As detailed in the literature review, many potential independent variables involving policy, industry, demographic, and ICT factors may influence fixed-broadband adoption.

Table 2 about here

By using a linear regression model with double-logarithmic transformation, this study also tests whether previous broadband subscription has influenced current broadband subscription. If network effect exists, current subscription might be positively correlated with the previous subscription of new media.[47] With network effect, new fixed-broadband subscribers joining a broadband network increase the utility of current fixed-broadband subscribers, which may lead to self-propelling or endogenous network growth. [48]

LLU (Local loop unbundling) might be a key driver of the fixed-broadband deployment.[49] Some previous studies used a dummy variable as a measure of LLU.[50] To capture the effects of different types (full unbundling, line sharing, and bitstream access) of LLU and LLU price regulation (regulatory approval for line rental charges), dummy variables (1 for with full unbundling 0 for otherwise; 1 for with line sharing 0 otherwise; 1 for with bitstream access 0 for otherwise; 1 for with price regulation 0 for no price regulation) are employed. There could be 16 different combinations of 4 dichotomous variables. However, many OECD countries, in general, have two major types of LLU policy, out of these 16 combinations. One major form of LLU policy was LLU Policy Type I, which has full unbundling, line sharing, and bitstream access without price regulation. The other major form of LLU policy in OECD countries was LLU Policy Type II, which has full unbundling, line sharing, and no bitstream access with price regulation. Thus, for the actual empirical model of regression, interaction variables between these LLU policy dummy variables are used.

Platform competition is an important variable in which the broadband market is served by different facility-based providers. In previous studies, platform competition could be measured by dummy variable (1 for different fixed-broadband platforms are available, 0 for otherwise).[51] This study employs a single dummy variable to measure the availability of different fixed-broadband platforms in broadband markets.

Demographic variables, such as income, education, and population density might influence fixed-broadband deployment. For the measurement of income, GDP per capita is used. Many studies employed GDP per capita for the measurement of income.[52] Level of education is measured by the United Nations Development Program (UNDP) education index. UNDP education index measures a country's relative achievement in both adult literacy and combined primary, secondary and tertiary gross enrollment ratio. Data were collected from the ITU, OECD, United Nations and World Bank. Table 2 provides variables, measurement, data sources, and expected direction of relationship between variables (expected sign) from data analysis.

The Empirical Model. To capture diverse determinants of global fixed-broadband deployment, a multiple regression analysis is implemented. To examine the influences of quantifiable variables on the diffusion patterns of fixed-broadband, this study formulates the following linear regression model. Since the distribution of dependent variable and many independent variables in this linear regression model is positively skewed, data transformation with logarithm was employed. Also, this study employs a fixed effect model, which controls for the unobserved heterogeneity among countries and time factor.

$$\begin{aligned}\mathbf{Ln\ Y_t\ (BPR)} = {} & \beta_0 + \beta_1(\text{ln Income})_{it} + \beta_2(\text{ln PC Penetration})_{it} + \beta_3(\text{LLU Policy I})_{it} + \\ & \beta_4(\text{LLU-Policy II})_{it} + \beta_5(\text{ln Population Density})_{it} + \\ & \beta_6(\text{Platform Competition-Dummy})_{it} + \beta_7(\text{Education})_{it} + \\ & \beta_8(\text{ln Previous Broadband Penetration})_{it} + \gamma_t\alpha_t + \delta_i Z_i + \varepsilon_{it} \qquad (1)\end{aligned}$$

The empirical model (1) for multivariate analysis was a composite model from previous empirical studies. In the model, the dependent variable (Y_t) is fixed-broadband diffusion. For independent variables, policy variable such as LLU-Policy I, and LLU-Policy II, industry competition factor such as platform competition, demographic factors such as income, education, population density, and ICT infrastructure factors such as PC penetration were included in the empirical model. The fixed-broadband penetration from previous years in a country was also included in the empirical model to test network effect.

In the empirical model β_0 is constant, $\gamma_1\alpha_t$ represents time-dummies, and $\delta_i Z_i$ represents country-dummies.

Results and Analysis

Descriptive Statistics and Correlations. For the regression model of fixed-broadband deployment, a total of 238 observations were available from 30 OECD countries, which covers data from 2001 to 2008.[53] Table 3 provides descriptive statistics of the untransformed variables that were employed for regression analysis. Mean of the fixed broadband penetration among OECD countries between 2001 and 2008 is 12.53 per 100 inhabitants and the standard deviation for the fixed broadband penetration is 10.08.

Table 4 presents the correlation matrix of the variables. Using the .70 benchmark to evaluate the strength of correlations, between the independent variables, income and PC infrastructure, were highly correlated. Note that the collinearity statistic showed that there was no independent variable to reach a Variance Inflation Factor (VIF) value above 10.

Table 3-4 about here

Result of Regression Analysis. Table 5 provides the result of the multiple regression analysis. Note that the dependent variable and independent variables were transformed using logarithmic function since data were positively skewed. Initially, all eight independent variables were included for the multiple regression analysis. Multicollinearity issues might occur when independent variables are highly correlated. Based on the result of correlation analysis, PC penetration was removed from the initial model. Table 5 provides the result of the overall model and the reduced model. Both models were statistically significant, for the overall model, $F(15.193)=195.28$, $p<.001$, and for the reduced model, $F(14.194)=210.15$, $p<.001$. In both models, previous broadband penetration was statistically significant at the .01 level. This result suggests network effects exist in the diffusion of fixed-broadband. In both models, LLU Policy type I was statistically significant at the .1 level. LLU policy type I was positively associated with fixed-broadband deployment. However, LLU policy type II was not statistically significant at the .1 level. In both models, platform competition was statistically significant at the .01 level, which suggests platform competition is an important factor of fixed-broadband deployment in OECD countries. In both models, income and education were significant at the .05 level, but population density was not statistically significant at the .1 level. This result suggests high level of income and education are drivers of fixed- broadband diffusion. In the overall model, PC penetration was not statistically significant at the .1 level. All statistically significant independent variables were positively associated with the dependent variable (broadband deployment). R-squared for the both models was .938.

Table 5 about here

Discussion and Conclusion

Employing a large secondary data set, this study examined adoption factors of fixed-broadband among OECD countries. The result of both models provides similar results. Considering high R-squared (0.938), the result of the data analysis seems robust.

One of the main goals of this study was to examine the effects of platform competition on broadband deployment. Using OECD countries' secondary data, this study tested the impacts of platform competition between cable modem, DSL and other platforms on fixed-broadband penetration. The result of the data analysis suggests competition among different fixed-broadband platforms is an influential factor of fixed-broadband deployment in OECD countries. This result implies that regulatory policy across different platforms should be as competitively neutral as possible for sustaining strong platform competition. Strong platform competition among different technologies may lead to lower prices, increased feature offerings and more extensive broadband networks.[54]

This study also examined whether network effects are involved in the diffusion of broadband. For the test of network effect, a long period of observations with a sufficient number of data is necessary. Using OECD countries' data from 2001 to 2008, this study tested whether previous subscription of fixed-broadband is a significant factor contributing to current subscription in the linear regression model of fixed broadband. As expected, previous fixed-broadband penetration was an influential factor in current fixed-broadband deployment. Considering impacts of platform competition in OECD countries, it appears that network effects and the effects of platform competition co-exist. This result suggests, for fixed broadband, new subscribers joining a broadband network might influence the utility of current subscribers. This network effect in fixed-broadband markets might become significant after a certain broadband

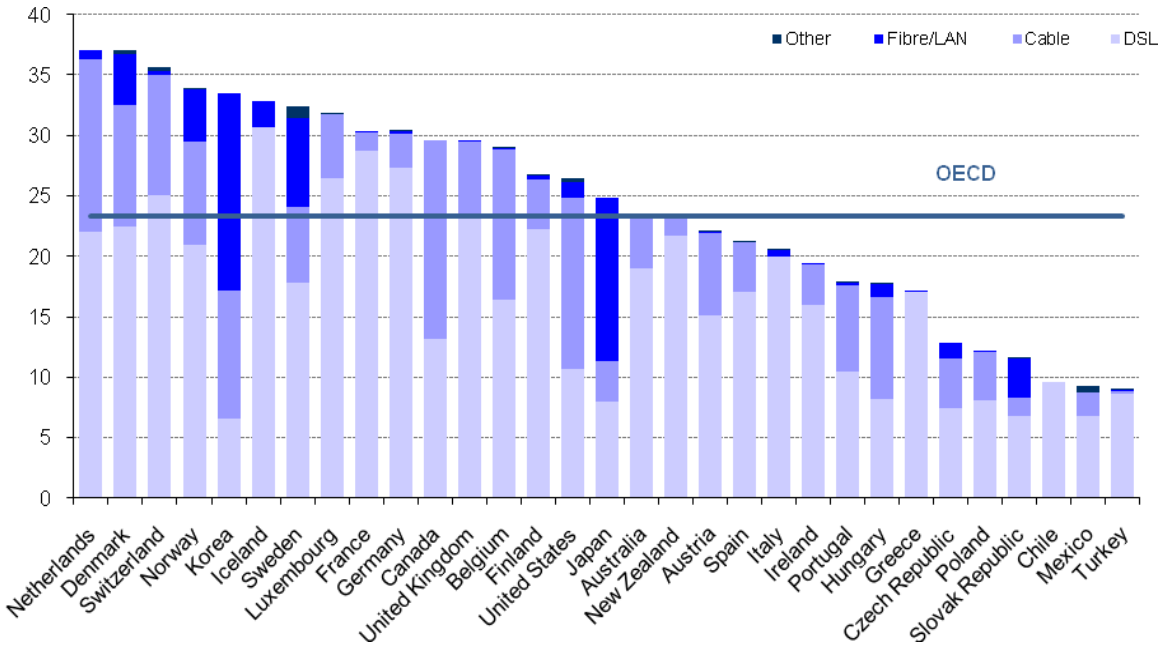
subscription percentage has achieved critical mass. This study has not examined the critical mass point for fixed-broadband deployment; however, network effect and critical mass points may be captured in fixed-broadband deployment patterns in some countries like Korea, Japan and the UK.[55] Research should continue to examine network effects and the effects of platform competition, thereby capturing how broadband diffusion patterns change over time.

In terms of policy implications, this study examined the effects of LLU policy on fixed-broadband diffusion. Many debate the effects of LLU policy, but the form of LLU policy and LLU price are very different across countries. The result of regression analysis in this study suggests that LLU policy type I was positively associated with fixed broadband diffusion in OECD countries. However, LLU policy type II was not statistically significant. The main differences between LLU policy type I and LLU policy type II are whether a country has bitstream access (the weakest type of LLU regulation) and LLU price regulation or not. Considering LLU policy type I includes light-touch regulation (bitstream access and no LLU price regulation), it appears that, if a country employs more lighter-touch type LLU regulation, it is more effective in promoting broadband. LLU policy is important in generating consumer benefits in the near future because it provides open access to competitors.[56] However, LLU might reduce an incumbent's incentive to invest in new telecommunication technologies.[57] Considering the result of this study and the costs and benefits of LLU policy, it may be beneficial, if countries pursue light-touch regulation like bitstream access instead of a strong form of regulation. This result is consistent with a previous study, which suggests the uptake of light forms of LLU have been relatively successful.[58]

The significance of some demographic variables such as income and education imply that higher levels of income and education, as well as better economic climate are also drivers of broadband diffusion in OECD countries.

This study does possess some limitations. Because of data availability, more diverse independent variables were not included for the regression model. Moreover, the impact of network effects on fixed broadband was not tested in the nonlinear regression model. When more data and observations over a longer period are available, more refined analysis on the impact of network effects will be possible.

Figure 1
OECD fixed-broadband subscribers per 100 inhabitants (December 2009)



Source: Organization for Economic Co-operation and Development (OECD)

Table 1
Main results of empirical studies on fixed-broadband deployment

Study	Countries/Number of observations	Significant variables
Kim et al. (2003)	30 countries 30 observations	Preparedness of a nation Population density
Garcia-Murillo (2005)	Approximately 100 countries Number of observation varies depending on the model (18-92)	Price Income Population density Competition Unbundling (for middle-income countries)
Distaso et al. (2006)	EU countries 158 observations	Inter-modal competition LLU price
Cava-Ferreruela and Alabau-Muňoz (2006)	30 countries 90 observations	Technological competition Cost of deploying infrastructures Economic indicators Demographic indicators
Grosso (2006)	30 Countries 177 observations	Competition Income Unbundling
Trkman et al. (2008)	25 Countries 23 observations	Communication technology expenditures Household PC access Internet penetration Income Fixed phone penetration Population density Education
Koutroumpis (2009)	22 countries 132 observations	Income Price Education

Table 2

Description of variables

Variables	Measurement	Data Sources	Expected sign
Fixed-broadband deployment	Fixed-broadband subscribers per 100 inhabitants	OECD (2001-2008)	Dependent variable
Income	GDP per capita	ITU (2001-2008)	+
PC Infrastructure	Estimated PCs per 100 inhabitants	ITU (2001-2008)	+
LLU-Policy I	Interaction of Policy Dummy (1 for with full unbundling, line sharing, bitstream access, no LLU price regulation, 0 for otherwise)	OECD (2001-2008)	+
LLU-Policy II	Interaction of Policy Dummy (1 for with full unbundling, line sharing, no bitstream access, with LLU price regulation, 0 for otherwise)	OECD (2001-2008)	+
Population density	Population density (per km^2)	ITU (2001-2008)	+
Platform competition	Dummy (1 for different fixed-broadband platforms are available, 0 for otherwise)	OECD (2001-2008)	+
Education	UNDP Education Index	UNDP (2001-2008)	+
Previous fixed broadband penetration	Previous year's fixed-broadband subscribers per 100 inhabitants	OECD (2000-2007)	+

Table 3

Descriptive Statistics

	N	Mean	Min	Max	S.D.
Fixed-broadband deployment	270	11.25	.00	36.80	10.19
Income	270	29312.70	2191.00	113794.00	17964.61
Education	240	.9551	.77	.99	.04365
Population Density	270	132.41	2.00	491.00	122.00
Platform Competition	270	.909	0	1	.288
Previous Fixed Broadband Penetration	240	9.71	.00	34.29	9.31
LLU Policy I	270	.50	.00	1.00	.501
LLU Policy II	270	.64	.00	1.00	.482
PC Infrastructure	240	38.16	3.28	87.60	21.16

Table 4

Correlation Matrix

	Fixed-broadband deployment	Income	Education	Population Density	Platform Competition	Previous Fixed Broadband Penetration	LLU Policy I	LLU Policy II
Income	.653							
Education	.430	.447						
Population Density	.198	-.031	.024					
Platform Competition	.332	.214	.267	.066				
Previous Fixed Broadband Penetration	.983	.616	.383	.215	.281			
LLU Policy I	.320	.293	.455	.075	.221	.258		
LLU Policy II	.368	.337	.364	.303	.128	.318	.437	
PC Infrastructure	.725	.744	.536	.040	.258	.696	.296	.244

Table 5

Results of regressions of fixed broadband diffusion (fixed country and time effects)

Variable	Overall Model Coefficients B	t-stat	Reduced Model Coefficients B	t-stat
Constant	-8.974	-1.35	-8.797	-1.35
Income	.509	2.23**	.511	2.24**
Education	3.653	2.21**	3.650	2.21**
Population Density	1.037	.76	1.011	.75
Platform competition	.507	4.51***	.509	4.55***
Previous penetration	.638	13.54***	.640	13.73***
PC infrastructure	.028	.15	--	--
LLU Policy Type I	.222	1.73*	.225	1.75*
LLU Policy Type II	-.068	-.53	-.069	-.54
R-Squared	0.938		0.938	
Number of observations	238		238	

*p < .1; **p < .05; ***p < .01

NOTES

1. International Telecommunication Union, *Digital.life* (Geneva: Author, 2006).
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20. Madden, Coble-Neal, and Dalzell, "A Dynamic Model of Mobile Telephony Subscription Incorporating a Network Effect,"133-44.

21. Organization for Economic Co-operation and Development, *Development in Local Loop Unbundling*.

22. Organization for Economic Co-operation and Development, *Development in Local Loop Unbundling*.

23. Full unbundling (physical access to raw copper) exists where an incumbent provides full access to its raw copper. With full unbundling new entrants take full control of the copper pairs and can provide both voice and DSL services. However, the incumbent still retains ownership of the unbundled loop and is responsible for maintenance. Line sharing (shared access) allows an incumbent to maintain control over copper pairs while new players can lease part of the copper pair spectrum for data services including Integrated Services Digital Network (ISDN) and DSL. However, there are some technical concerns such as line noise. Bitstream access (wholesale access) is a type of wholesale arrangement in which new entrants have no managing control over the physical lines and are not allowed to install their own equipment. The new entrants generally do not favor this type because, unlike full unbundling and line sharing, they can only provide the services that the incumbent designates; See Organization for Economic Co-operation and Development, *Development in local loop unbundling*.

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