Broadband uptake in OECD countries

Policy lessons from comparative statistical analysis

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August 29, 2003

Paper prepared for presentation at the
31st Research Conference on Communication, Information and Internet Policy
September 19-21, 2003, Arlington, Virginia

Abstract

Broadband diffusion varies widely among the OECD countries. In the practical policy discourse, it has been taken for granted that measures such as the stimulation of competition or unbundling can accelerate the uptake of broadband service. This paper attempts to investigate the influence of important economic and policy variables on the diffusion patterns of broadband. The limited availability of data forces us to use a cross-national sample. We find that the preparedness of a nation and the cost conditions of deploying advanced networks are the most consistent factors explaining broadband uptake. The price of broadband, the price of dial-up Internet access service, competition, and the relative income position are either less or not significant at all. The results are not very robust, which seems to indicate that the causation patterns are more complex than captured by our multiple regression models. This suggests that there is not one but possible several configurations of economic and policy variables that can support rapid broadband diffusion.

1. Introduction

Access to broadband networks is widely considered a precondition to harness the benefits of the next generation of information services for economic growth and competitiveness. Narrowband networks constrain the ability of users to access more advanced information applications and hence the opportunities of information and application service providers to innovate. The productivity impact of broadband is not straightforward as these applications are often only higher-quality versions of existing services or they are network-based substitutes for other products (e.g., video streaming for videocassettes or DVDs). In this sense, broadband infrastructure may be a necessary but not a sufficient condition for a vibrant network-centric knowledge-based economy.

Regardless of these caveats, afraid to be left behind, many countries are seeking to implement frameworks that support a fast rollout of broadband networks. Policies are designed at two interrelated levels: the overall legal and regulatory framework in which broadband develops and more specific policy actions that are intended to accelerate adoption. The effect of policy choices on broadband deployment is only poorly understood theoretically and empirically. For example, opinions diverge on the likely effects of unbundling on broadband infrastructure investment and vertically related industries. International comparisons show substantial differences in the availability and uptake of broadband, a variance that could in principle be used to better understand the links between policy frameworks, specific policy measures and adoption.

This paper reports the results of such a cross-national study of broadband uptake in the 30 OECD countries in 2001.[1] It is organized as follows: the next section describes the status of broadband availability in the OECD countries. The third section briefly reviews previous research on broadband diffusion. Section four discusses the model and data employed in the paper and section five the main findings from the regression as well as

[1] It was motivated by a workshop at the U.S. Federal Communications Commission (FCC) in September 2002, during which several broadband policy issues were identified that needed further investigation. There was broad consensus that a cross-national study could shed light on the question as to whether the observable differences are the outcome of a specific set of factors.

factor analysis. We do not find a clear pattern of factors that consistently explain broadband penetration across the sample and conclude the paper with suggestions for additional research.

2. The status of broadband in the OECD countries

Broadband refers to a set of general-purpose electronic communications technologies rather than one specific technological solution. Common features include significantly higher bandwidth than dial-up networks, the reliance on some form of packet switching, and "always on" functionality.[2] Broadband networks are also superior to traditional networks in terms of latency (the time it takes to deliver a packet across the network) and jitter (the variance in latency).

No general definition of broadband is accepted among the 30 OECD countries. The U.S. Federal Communications Commission (FCC), as well as the Canadian Broadband Task Force, chose 200 kbps for downstream transmission as the minimum bandwidth for broadband service, although this is not a rigid number and may shift upward with changes in technology and uses (OECD 2002). The International Telecommunication Union (ITU) considers a transmission speed of 1.5 to 2 Mbps as broadband. The Computer Science and Telecommunications Board (CSTB) of the National Research Council (NRC) proposed a flexible definition capturing the dynamic evolution of broadband. The two-part approach defines broadband as transmission capacity in the local access link that is sufficient to not constrain a user's ability to run advanced applications. Moreover, broadband should provide sufficient performance and penetration of the potential user base to encourage the development of new services and applications (CSTB 2002). The CSTB approach suggests that as long as the computer technology supporting applications continues to advance, so must such a constraint-focused definition of broadband. Nevertheless, it is also true that for policies that must operate in

[2] The always-on feature is independent of bandwidth, but has come to be accepted as a defining characteristic of broadband.

both the near and longer terms, bright-line bandwidth criteria may be necessary to formulate policy goals in terms that can be implemented and to gauge progress in achieving them.

<Insert Table 1 about here>

Some broadband access platforms are evolutions of existing networks whereas others require fully new networks. The different types of Digital Subscriber Line (DSL), cable modems, and powerline communications are upgrades of already existing network infrastructures. Fixed Wireless Access (FWA) technology and broadband wireless solutions require more significant network investment. For example, IMT 2000 or 3G wireless services can only be offered after the installation of a new radio access network. The investment costs of these different solutions vary widely as does the scalability of the networks. For example, DSL and cable modem services require a smaller sunk investment than satellite-based services and their capacities can be adjusted more easily to varying demand. Broadband access technologies therefore offer a range of cost-functionality combinations. The technological and cost characteristics are more similar at higher levels of the network – the middle mile and backbone networks – which typically use similar topologies and protocols.

Broadband access is expanding rapidly in the OECD area and annual growth rates are very high, albeit from a low starting level. During 2001, the number of broadband subscribers increased by 116 percent. At the end of 2001, 32.9 million people or 2.9 percent of the total population in the OECD area were hooked up via broadband (table 1). By June 2002 this number had grown to 42.9 million, equivalent to 3.8 percent of the population. With 19.1 percent broadband penetration, Korea had the highest penetration rate, followed by Canada, Sweden, and Denmark. The United States ranked fifth, although Belgium, Iceland, and the Netherlands seemed poised to pass it later in the year. The dominant broadband access platforms were DSL (51.3 percent) and cable modems (43.4 percent). Other technologies, such as satellite, fiber-to-the-home, Ethernet LANs and high-speed wireless access served the remaining 5.3 percent. The mix of cable modems and DSL varied widely between countries, depending on the status quo ante of the information network infrastructures, the specific regulatory conditions, and corporate strategies. For example, in the U.S. with wide cable TV availability, cable modems served nearly two thirds of all broadband subscribers. On the other hand, in countries with relatively low cable penetration, such as Germany or Italy, the ratio of cable to DSL ("skew") was highly in favor of the latter.

<Insert Figure 1 about here>

<Insert Figure 2 about here>

Broadband penetration does not reveal the structure known from other telecommunication services, although this conclusion is strongly dependent on a few atypical countries. For example, the known positive relation between income and service diffusion is not visible from figure 1 due to the presence of Korea and Luxembourg. Likewise, the expected negative relation between prices and service penetration is only weakly apparent from figure 2. Moreover, broadband is a relatively young technology; it is therefore likely that the longer-term diffusion rates are not yet achieved and therefore the links between income, prices, and penetration are not as solid. Nevertheless, apart from the two countries the known relations seem to be visible in a simple bi-variate correlation. However, as the relation is likely multi-variate, more powerful statistical tools need to be employed. Before we discuss the empirical approach chosen in this paper, the next section will briefly review the findings of other theoretical and empirical studies.

3. Studies of broadband access and diffusion

A relatively small but growing number of theoretical and empirical studies of broadband service is available. Faulhaber and Hogendorn (2000) developed a game-theoretic model of infrastructure deployment and used engineering cost data and assumptions about the demand side to explore the equilibrium market structure of the broadband market. Based on their simplifying assumptions and a purely conceptual analysis, they conclude that broadband markets would likely allow some limited competition if left unregulated. However, a universal service obligation imposed on suppliers could render the market monopolistic. The model is static and thus does not capture the dynamic evolution of the broadband market. It also does not take into account possible economies of scope with the provision of other communication services, such as cable TV or voice telephony. Woroch (2002) analyzes a conceptual model in which different providers are engaged in a race to deploy broadband. In this model, open access rules delay either the first or second deployment of broadband facilities and thus reduce the intensity of competition. Based on an empirical test of the sensitivity of cable modem prices to dial-up prices Hausman, Sidak, and Singer (2000) found that narrowband access did not constrain the ability of cable systems to increase prices. In contrast to Woroch they conclude that open access provisions would be welfare enhancing.

Several studies examined the characteristics of demand for broadband services. Madden and Simpson (1997) conducted a consumer survey to explore the prospective demand for broadband among Australian households and found significant effects of education, region of origin, and age on preferences. Rappoport et al. (2003) used a logit model to estimate the demand of households for broadband service. Segmenting their observations into three areas (availability of dial-up only; dial-up, ADSL or cable modem; dial-up, ADLS and cable modem), they were able to calculate direct and cross-price elasticities. Their results indicate that cable and ADSL were substitutes for dial-up but that for broadband customers dial-up did not matter. However, ADSL and cable modems were clear substitutes for each other. Whereas at low penetration rates the price elasticity of ADSL and cable modems was high, it was lower at higher penetration levels.

Gabel and Kwon (2000) expanded their analysis to include cost and demand factors. With regard to demand variables, they found that age and median income affected the presence of broadband at wire center locations. On the supply side, they found that teledensity and the cost of routing traffic to the backbone networks were statistically significant determinants of broadband availability. Burnstein and Aron (in press) focused on the effect of competition between DSL and cable modems on broadband penetration. Based on a reduced form model that captures important supply and demand-side factors, they found a significant effect among others of direct competition in addition to education, Internet access, and cost factors.

A handful of studies addressed broadband diffusion from a cross-national or comparative perspective. The OECD (2001) provided the first comprehensive review of the status of broadband deployment among industrialized countries. The report highlighted the importance of competition and unbundling for the speed of broadband uptake. Howell (2002) used a simple bi-variate approach to test this latter claim. He concluded that a positive effect of unbundling on broadband uptake could not be detected among the OECD countries. In addition, several papers have explored empirically or conceptually the spatial dimensions of broadband markets and the presence of a digital divide in broadband. Grubesic (2003) found that income, education, age, location and competition from alternative broadband platforms influenced infrastructure investment. Prieger (2003) found limited evidence of unequal access among Native American and Asians. His study also showed that market size and education were positively correlated with broadband availability whereas rural locations were negatively related.

The factors shaping broadband investment and take-up are complex and cannot be captured easily in econometric work. An increasing number of studies, therefore, has relied on case study methods to shed light on the nexus between broadband policy and diffusion. Aizu (2002), comparing Korea, Hong Kong, Singapore, and Japan notes that social and cultural factors were potent explanatory factors for the widely differing diffusion rates in these nations. An (2002) reviewed the Korean DSL policy in detail. He concludes that unbundling of the local loop in combination with the unique conditions of the Korean market environment help explain the high broadband penetration rate.

4. Modeling supply and demand

Our main interest was to study the main factors influencing broadband penetration at an aggregate, national level. For this purpose, we utilized a supply and demand framework and derived a reduced form model, which then was used in the econometric analysis. We began by defining a supply and a demand relation for local broadband access markets:

$$q^D = f(\text{price, price of substitutes, income, preparedness}) \quad (1)$$
$$q^S = f(\text{price, competition, cost conditions}) \quad (2)$$

In equilibrium, the following holds

$$q^D = q^S \quad (3)$$

with

q^D … local demand for broadband

q^S … local supply of broadband

We do not specify the stages of a local broadband supply decision as Faulhaber and Hogendorn (2000) did but are only interested in the factors that influence the resulting penetration patterns. It is reasonable to assume that local supply will be positively related to the price of broadband, which is equivalent to a move along a supply curve. In addition, two shift factors are important. A negative relation exists between the intensity of local competition and the position of the supply curve, i.e. competition shifts the entire supply curve down. A positive relation exists between the local cost of building a network and supply, i.e. higher cost are reflected in an upward shift of the supply curve. Local demand is a function of the price of broadband, the price of substitutes (e.g., dial-up Internet service), income, and "preparedness" factors such as education or attitude towards information technology. Like in the case of supply, own price variations correspond to movements along the demand curve whereas the other factors result in shifts of the entire demand relation.

As cross-national data are only available at an aggregate level, we need to employ an aggregation rule. We derive national level relations as

$$Q^D = \Sigma_i q^D \tag{4}$$

$$Q^S = \Sigma_i q^S \tag{5}$$

$$Q^D = Q^S \tag{6}$$

Due to this linear aggregation rule, the aggregate supply and demand relations remain functions of the prices and competitive conditions etc., appropriately defined as national averages. Utilizing the equilibrium condition (6), we can derive the reduced form to explain broadband penetration from this system of structural equations.

$$Q = f\,(\text{price, price of substitutes, income, preparedness, competition, cost conditions}) \tag{7}$$

From economic analysis, we would expect the following signs of the relations: price (−), price of substitutes (+), competition (+), cost (−), income (+). In the group of socio-economic factors we would, for example, expect the following signs: education (+), enthusiasm for IT (+).

5. Empirical model and data analysis

For estimation, the reduced form of the conceptual model needed to be translated into an appropriate empirical model. Since the model was to be tested using historical data, the main constraints were related to the availability of data. An international cross-section model raises other potential problems. Most importantly, the existence of unique national conditions may undermine the assumption that the same process links independent and dependent variables. This problem could be handled best using cross-sectional time-series data, which would allow estimating fixed-effect specifications that control for such factors. Unfortunately, relevant and consistent data on broadband were only available recently. We were thus forced to use a simple cross-sectional design based on the observations for the year 2001. The issue is likely mitigated by the fact that some of the national differences are captured by the socio-cultural and policy variables included in our model. We used a multivariate OLS regression method to estimate model parameters.[3] Based on our theoretical model in (7), we formulated the following empirical model:

$$BP = CONS + \beta_1 {*} PBB + \beta_2 {*} PDIAL + \beta_3 {*} INC + \beta_4 {*} PREP + \beta_5 {*} COMP + \\ + \beta_6 {*} POPD + \beta_7 DPOL + \varepsilon \qquad (8)$$

with

BP ….	broadband penetration
CONS ….	intercept (constant)
PBB ….	price of broadband
PDIAL ….	price of dial-up service
INC …	income
PREP	preparedness
COMP	competition
POPD	population density
DPOL	dummy reflecting policy regimes
ε	random error term

Data sources and definitions are summarized in table 5 in the appendix. The dependent variable (BP) was defined as the total broadband penetration rate in a country, which is the number of DSL, cable modem and other broadband subscribers as percentage of the total population. As the dependent variable captured total broadband penetration, the price of broadband (PBB) was calculated as the weighted average of the price of monthly price of either service, including a share of any fixed setup charges. To prorate the setup charge, we assumed that it would be depreciated over a period of five years. Although broadband might be considered a Veblen good during the early stages of adoption (in

[3] Factor analysis and cluster analysis methods were used in studying the structure of the observations and relations between possible measures for the independent variables.

which case the individual demand curve would be upward sloping), this does not seem to apply in the aggregate. The price of substitutes was captured in PDIAL, the price of dial-up service. In most countries, dial-up service was still measured. Where this was the case, assuming that broadband users would be heavy Internet users, we chose the price for 30 hours of dial-up service, consumed at peak and off-peak times. It is improbable that broadband would be considered an inferior service; increased in income should therefore result in higher demand for it. We approximated income (INC) as the GDP/capita, measured at US$. As broadband is more widely adopted among higher income households, it would have been desirable to use income distribution data, which are notoriously difficult to come by and could not be produced with sufficient accuracy.

Some countries might be more prepared than others to adopt broadband; we reflected this in the variable PREP, an index measuring factors such as the attitude of a nation towards advanced information technology and the availability of complementary technologies, such as computers. As discussed in section three of this paper, competition can be considered one of the main drivers of broadband deployment (Burnstein and Aron, in press; Faulhaber and Hogendorn, 2000). In a more mature market, one would expect that the competitive situation is reflected in the price of broadband. This may not be the case in a market in its early stage of development, where companies may compete using other dimensions, such as service quality, initial free trials and the like, without reducing the eventual service price. However, a potential endogeneity problem exists between the competition and the price variable. One of the strongest factors influencing the cost of broadband deployment is population density. We therefore included it as a means to reflect differing cost conditions across nations. It would have been desirable to use the distribution of the population between urban and rural areas but this measure could not be produced.

We also wanted to test whether public policy had any noticeable influence on broadband diffusion. As several dimensions of policy are potentially relevant, we used cluster analysis to identify homogenous subgroups of countries with similar policy characteristics to reduce the number of independent variables. For this purpose, information on three factors—unbundling, the separation of cable and telephone company ownership, and the availability of government funding to support broadband deployment—was collected. This yielded three clusters (see table 3). Membership in a cluster was translated into a dummy variable and used in several of the empirical models. The main results are summarized in the next section.

6. Main findings

Overall, the empirical results allowed identifying important factors that influence the observable pattern of broadband uptake. Table 2 summarizes the results of five alternative model specifications. The fully specified reduced form model only yielded significant parameter estimates for two variables, population density and preparedness. The price of broadband had the expected negative sign but it did not have a significant impact on broadband penetration. Income, the price of dial-up, and competition were not significant. Moreover, they had unexpected signs. In the case of the dial-up access price this is a fairly robust finding. It seems to indicate that at the aggregate level, broadband and dial-up access move in parallel. However, this observation could be the outcome of competitive rivalry between the providers of these services in a mutually dependent market. Given the small sample size, we tried to find more parsimonious models with better or comparable explanatory power. Model 2 introduced dummy variables to capture the policy conditions. Model 3 had better overall explanatory, although two variables (price for dial-up, income) were not significant at acceptable levels. Model 4 included the price of broadband but not income as an independent variable. Model 5 dropped preparedness and uses price and cost variables; although all estimates were significant, the model explained less of the overall variance.

<Insert Table 2 about here>

There were some recurrent observations from these models. Preparedness and population density most consistently were statistically significant factors. The effect of these two variables also was relatively robust. Preparedness can be interpreted as a measure of the attitudes of a population towards information technology as well as its savvy to use it. Population density was an important cost factor and the variable had the expected positive sign, indicating that lower deployment cost correlate with higher penetration.

Contrary to widely held beliefs, at least in this sample, the price of broadband service had a less decisive influence on uptake, although, with the exception of model 2, it usually had the expected negative sign. The price for dial-up service consistently had a negative sign although it was only significant in the last two parsimonious models. Therefore, at our level of aggregation, a higher price for dial-up did not seem to induce a shift to broadband. In line with the findings of other studies, this could indicate that the two services are less substitutable than commonly thought.[4] Income per capita always had a negative effect on broadband penetration, although it was not consistently significant. At first glance, this might be caused by the presence of Korea, a country with a high broadband penetration but relatively low income per capita compared to the rest of the OECD. However, estimates without Korea also showed a negative effect of income per capita once other factors were taken into account. One possible explanation is a path dependency effect: higher income countries could adopt dial-up earlier but did not migrate to broadband. This could be compounded by a leapfrogging effect if late adopter countries chose an Internet access mix that is more heavily slanted towards broadband.

<Insert Table 3 about here>

Interestingly, competition did not have a statistically significant effect. Moreover, it was negative, implying that more intense competition in the telecommunications market correlated with a lower broadband penetration rate. This finding contradicts other studies of broadband diffusion. One explanation is that competition in broadband is a local phenomenon and that it is not as easily measured at a national level. Its effect might also be captured in the price variable. However, it could also point to the oligopolistic

[4] Hausman, Sidak, and Singer (2000) found that the price of dial-up has no effect on the price of broadband. Rappoport et.al. (2003) found that dial-up was no substitute for broadband although broadband was one for dial-up.

structure of broadband in which a more open market structure could lead to market fragmentation and lower deployment.

<Insert Table 4 about here>

A segmentation of the sample into the three groups identified by cluster analysis yielded a few more insights. The statistical analysis revealed that the combination of policy factors present in the first group had a positive but not significant impact on broadband development. In contrast, the combination characteristic for the second group was detrimental to broadband development, although the effect also was not statistically significant.

Models run at the level of country sub-groups (see table 4) revealed that the overall pattern was particularly visible in the first group of countries. In this group, competition was correlated negatively with broadband diffusion and preparedness did not exhibit any significant effect. Within the countries in the third group, competition had the opposite effect and was positively related to broadband diffusion. The relations were weakest among the countries in the second group. Overall, the empirical analysis did uncover key drivers of broadband development but it also provided hints that several constellations of factors may exist that can be conducive to broadband development. However, different tools, such as diversity analysis, will need to be employed to track this question.

6. Conclusions

The main goal of this paper was to examine cross-national data for regularities that could explain the observable patterns of broadband penetration. For this purpose, a market model for local broadband development capturing important economic factors shaping supply and demand decisions was proposed. Using an aggregation condition, a conceptual model was formulated for broadband penetration at the national level and translated to an empirically tractable form. Data were only available for the 30 OECD member states for the year 2001.

This paucity of the data constrained the empirical analysis but nevertheless allowed first insights. The most consistent factors explaining the level of broadband uptake were the cost conditions of network deployment and the preparedness of a nation. The price of broadband also affected its diffusion, but a higher price of dial-up service was correlated to a lower broadband penetration, indicating that the two markets moved together. Unexpectedly, income also showed a negative correlation with broadband diffusion, which could have to do with path dependency and leapfrogging. Other variables that were deemed relevant based on our theoretical model did not show any statistically significant relation with broadband penetration or were not very robust. These include competition in the telecommunications industries and dummy variables to capture the effects of different policy regimes.

Our analysis does not reveal a panacea as to how policy-makers could facilitate broadband development. However, it points to the importance of factors that are often overlooked in broadband policy, namely the general preparedness to use advanced technologies. It would be desirable to develop the analysis in several ways. First, a larger sample of observations would reduce some of the constraints of the present paper. As more information becomes available, more detailed models may be developed. Second, the results provided hints that a simple causal relation may not exist and therefore different methods, such as diversity analysis, may be required to detect the true underlying structures. Lastly, it would be helpful to conduct cross-national studies at a less aggregated level, perhaps using cross-sectional time-series analysis methods.

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Table 1
Broadband penetration and prices in the OECD (2001)

	Number of subscribers					Monthly price (US$)	
	DSL	Cable	Other	Total	Per 100	DSL	Cable
Australia	65000	110000	5000	180000	0.90	51.78	53.40
Austria	101000	192000		293000	3.60	54.63	51.49
Belgium	230000	201000	3674	434674	4.20	61.30	43.06
Canada	1060000	1670000		2730000	8.80	32.71	35.02
Czech Republic	100	12000		12100	0.10	.	.
Denmark	151775	87500		239275	4.50	64.84	52.27
Finland	43500	24500		68000	1.30	40.66	39.56
France	430000	189343		619343	1.00	45.01	46.95
Germany	1870000	34500	34000	1938500	2.40	43.48	0.00
Greece	72	0		72	0.00	.	.
Hungary	6200	17419	2460	26079	0.30	86.79	38.61
Iceland	9978	0	500	10478	3.70	60.04	0.00
Ireland	300	100		400	0.01	105.26	0.00
Italy	390000	0	25000	415000	0.70	47.71	0.00
Japan	1524348	1303000	12000	2839348	2.20	56.83	49.64
Korea	5178323	2936280	31398	8146001	17.20	38.52	33.32
Luxembourg	1215	15		1230	0.30	66.36	0.00
Mexico	29854	15000		44854	0.05	0.00	41.84
Netherlands	138000	400000	200	538200	3.40	66.93	43.46
New Zealand	25579	2000		27579	0.70	43.40	37.69
Norway	36137	45339	6379	87855	1.90	107.08	53.45
Poland	1796	10000		11796	0.03	71.58	0.00
Portugal	3300	93836		97136	1.00	94.41	42.54
Slovak Republic	0	420		420	0.01	.	.
Spain	375816	98466		474282	1.20	94.64	76.33
Sweden	242100	115500	126600	484200	5.40	28.96	33.55
Switzerland	35124	98753		133877	1.90	68.43	49.11
Turkey	2818	7897		10715	0.02	209.93	0.00
United Kingdom	140000	208000	2000	350000	0.60	62.71	30.15
United States	3947808	7050000	1785406	12783214	4.50	49.95	45.78
OECD	16040143	14922868	2034617	32997628	2.90	N/A	N/A

Source: OECD (2001), (OECD 2003a).

Table 2
Estimation results
(dependent variable broadband penetration in 2001, t-statistic in italics)

	Model 1	Model 2	Model 3	Model 4	Model 5
PBB	-0.00078	0.00685		-0.01003	**-0.03472
	-0.038	*0.306*		*-0.535*	*-1.973*
PDIAL	-0.07429		-0.07866	**-0.11642	**-0.10734
	-1.374		*-1.631*	*-2.755*	*-2.304*
INC	-.0.00013	**-0.00024	-0.00011		
	-1.274	*-2.725*	*-1.344*		
POPD	*0.00889	0.00602	**0.00907	**0.01078	**0.01197
	1.991	*1.349*	*2.139*	*2.583*	*2.610*
PREP	**0.27442	***0.34614	***0.25607	**0.15735	
	2.453	*3.083*	*0.004*	*2.480*	
DG1		2.02116			
		1.277			
DG2		-0.46877			
		-0.271			
DG3		dropped			
COMP	-1.42584	-5.12968			
	0.624	*-1.484*			
CONSTANT	-6.97270	-9.29829	-7.38333	-2.70161	***6.91722
	-1.170	*-1.652*	*-1.997*	*-0.617*	*3.076*
Prob>F	***0.0075	**0.0163	***0.0012	***0.0062	**0.0104
R^2	0.5527	0.5722	0.5471	0.5162	0.3809
Adj. R^2	0.4185	0.4059	0.4648	0.4282	0.3002

Note: * … significant at 90% level; ** … significant at 95% level; *** … significant at 99% level.

Table 3
Country clusters based on policy conditions

Group 1	Group 2	Group 3
UK, US, Austria, Netherlands, Spain, Japan, Korea, Canada, Ireland, Italy, Sweden, Australia, Denmark, Hungary	New Zealand, Switzerland, Turkey, Poland, Slovak Republic, Belgium, Greece, Iceland, Czech Republic, Germany	Norway, Portugal, Finland, France, Luxemburg, Mexico

Table 4
Estimation results, country groups
(dependent variable broadband penetration in 2001, t-statistic in italics)

	Group 1	Group 2	Group 3
PBB	*-0.08752	0.01001	
	-1.979	*0.638*	
PDIAL	**-0.18967		
	-2.707		
INC			
POPD	*0.01270		
	2.232		
PREP		0.14209	**0.03058
		1.884	*3.447*
COMP	*-12.8436		**1.68479
	-1.997		*3.783*
CONSTANT	***25.0547	-6.2774	**-2.0420
	3.492	*-1.264*	*-3.916*
Prob>F	**0.0183	0.1555	**0.0206
R^2	0.7005	0.6058	0.9249
Adj. R^2	0.5673	0.4086	0.8749

Note: * … significant at 90% level; ** … significant at 95% level; *** … significant at 99% level.

Table 5
Variables, definitions, and sources

Acronym	Variable	Definition	Source
BP	Broadband penetration (independent variable)	% broadband subscribers in total population	OECD (2003a)
PBB	Price of broadband service in US$	Weighted sum of price of DSL and cable modem service in US$	OECD (2001, 2003a)
PDIAL	Price of dial-up service	Price of 30 hours dial-up service, 50% at peak and 50% at off-peak times in US$	OECD (2001, 2003a)
INC	Income	GDP per capita in US$	OECD (2003b)
PREP	Preparedness	Mobile/Internet index as calculated by the ITU	ITU (2002)
COMP	Competition	Competitive conditions in DSL, cable and ISP sectors	(Arquette 2002)
POPD	Population density	Inhabitants per square kilometer	ITU (2002)
DPOL	Policy conditions	Dummy variables reflecting unbundling, cable-telco cross ownership, and government funding for broadband	OECD (2001, 2003a)

Table 6

Summary statistics (full model)

Variable	Observations	Mean	Std. Dev.	Min	Max
BP	30	2.40	3.48	0.00	17.20
PBB	27	58.72	34.31	30.75	209.93
PDIAL	29	36.15	13.19	10.85	61.29
INC	30	19951.70	11100.53	3111.00	42743.00
POPD	30	131.13	123.67	3.00	485.00
PREP	30	53.96	10.55	29.11	65.61
COMP	30	0.80	0.22	0.33	1.00

Table 7
Correlation matrix (full model)

	PBB	PDIAL	INC	POPD	PREP	COMP
PBB	1.0000					
PDIAL	-0.2128	1.0000				
INC	-0.2454	0.4841	1.0000			
POPD	-.01224	0.1518	-0.0134	1.0000		
PREP	-0.5560	0.2008	0.7222	0.1725	1.0000	
COMP	-0.3069	0.0407	-0.0167	0.0781	0.2777	1.0000

Figure 1
GDP/capita and broadband penetration

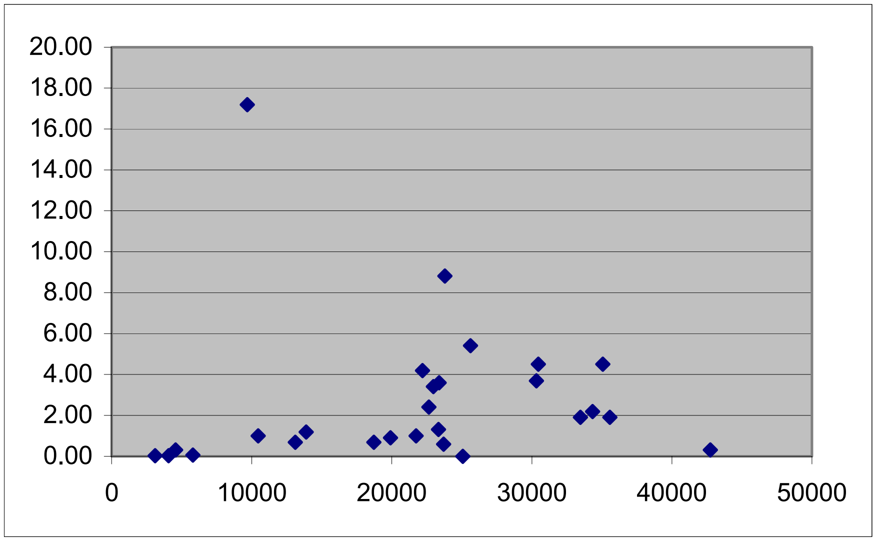

Figure 2
Weighted price and broadband penetration