TOWARDS A NATIONAL INFORMATION INFRASTRUCTURE INITIATIVE FOR THE UNITED STATES:

AN ANALYSIS OF GLOBAL BROADBAND DEPLOYMENT, ADOPTION AND POLICIES FOR ENHANCEMENT

Master of Arts in Law and Diplomacy Thesis

Submitted by Andrew S Bennett

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THE FLETCHER SCHOOL

TUFTS UNIVERSITY

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Abstract:

High-bandwidth Internet connectivity is proving to be critical infrastructure for the 21st Century and national leaders are looking to shape existing policies and identify new policy tools and initiatives to stimulate the enhancement and expansion of broadband infrastructure. There are a wide variety of national and market-specific factors thought to facilitate increased broadband deployment and adoption of the technology. Demand factors like levels of income, education, and age; supply factors like the existence of legacy infrastructure that can be converted to broadband or the local population density; factors related to the competitive market like price, quality of service, and the number of providers; and policy factors that might ease market entry or incentivize innovation and build-out of existing infrastructure are all potential drivers of broadband penetration. This thesis presents a broad survey of these factors through the existing econometric literature, next tests these factors through regression analysis, and then examines the broadband market at work in a case-study review of the impact of these factors. The concluding analysis answers the following question: what are the key market factors driving broadband penetration among the leading nations? What are the available policy tools that have been proven to positively stimulate the drivers of broadband deployment and adoption? Is there room for improvement in the United States when it comes to broadband and if so, how can policies that have proved successful in other nations be adapted and applied to the U.S. context?

Chapter I. Introduction and Research Framework

High-bandwidth Internet connectivity is proving to be critical infrastructure for the 21st Century. From access to markets, to knowledge sharing, to political participation, to efficient governance and beyond, so much already depends on access to the world wide web. The wealth of applications and services this network delivers is increasing by the day, driving demand for expanded bandwidth exponentially and driving home the need for widespread broadband connectivity. With so much demand and so much to gain, policy makers around the world have embraced affordable high-speed broadband as a valued national strategic policy goal.

National development of advanced Information and Communication Technology (ICT) is now seen by policy makers to be vital to any nation's global competitiveness. Additionally, broadband infrastructure is beginning to emerge as a key component of ICT development, economic competitiveness and national security. As a result, national leaders are looking to shape existing policies and identify new policy tools and mechanisms to stimulate the enhancement and expansion of broadband infrastructure.

Despite the fact that policy makers around the world have identified enhanced broadband services as a legitimate policy goal, many questions regarding what drives broadband deployment and adoption remain unanswered. This study seeks to answer some of the most prominent: What are the key market factors driving broadband penetration among the leading nations? What are the available policy tools that have been proven to positively stimulate the drivers of broadband deployment and adoption? Is there room for improvement in the US when it comes to broadband and if so, how can policies that have proved successful in other nations be adapted and applied to the US context?

Research Focus

This study will examine the current levels of broadband penetration among the OECD nations and will focus empirically on the dynamic supply, demand, and regulatory factors that influence deployment and adoption of broadband technology. The goal of this analysis will be to test predicted broadband drivers and to determine what role, if any, governments and regulatory bodies can play in facilitating the expansion of broadband penetration.

There are a wide variety of national and market-specific factors thought to facilitate increased broadband deployment and adoption of the technology, including demand factors like levels of income, education, and age; supply factors like the existence of legacy infrastructure that can be converted to broadband or the local population density, both of which lower deployment costs for suppliers; factors related to the competitive market like price, quality of service, and the number of providers; and policy factors that might ease market entry or incentivize innovation and build-out of existing infrastructure. This study will undertake a broad survey of these factors through the existing econometric literature, test these factors through regression analysis, examine the broadband market at work in case study analysis of the impact of these factors, and will conclude by considering the implications for the US broadband market and relevant policy makers.

Chapter 2 will provide the necessary background on the definitions of broadband technology, its impact on society, the state of broadband in the US, and an overview of strategies currently employed by policy makers to influence broadband markets. The goal of the review of the econometric literature in Chapter 3 will be to determine what factors have been found to be most influential on broadband penetration rates in the OECD countries and to develop meaningful, independent variables to test through regression analysis conducted in Chapter 4. A survey of select case-study data will then be undertaken in Chapter 5 to further test the correlation between theoretic drivers and broadband. The case study analysis will also serve as an opportunity to focus the analysis of the drivers determined to be significant in the regression models and examine

their impact in context. The concluding chapter will summarize the key findings of the study and these results will then be contextualized and analyzed within the scope of the broadband market and regulatory environments of the United States, and policy recommendations will be proposed.

Analytic Framework: Broadband Market Factors

The analysis throughout will focus on the independent variables driving broadband penetration, which can be effectively organized into four sets of factors: *Demand, Supply, Competition* and *Policy.* This segmentation is designed to model the dynamic broadband market, to aid policy makers' understanding of what drives broadband penetration, and to develop discrete areas of focus for policies that facilitate expansion. Within each segment are a number of variables that drive certain market factors. The factors that compose the focus of this research have been identified in the literature as the most common broadband drivers, though to varying degrees.

Many of these factors are common drivers of telecommunications infrastructure and even *network infrastructure* writ-large. The empirical research subsequently reviewed in this work does find unique levels of impact on broadband among certain factors as well as the emergence of new drivers unique to the household-computer age. The following framework should serve as a segmented model of a national broadband market, within which all of the possible variables impacting broadband penetration can be categorized:

- *Demand Factors*: Key market factors that positively impact demand for and adoption of broadband services include *income, age* and *education* levels, which are historically correlated with other telecommunications infrastructure as well. Additionally, computer ownership is thought to be a necessary pre-requisite for Broadband subscription in particular. Locally relevant online *content* is also thought to drive demand.

- *Supply Factors:* Include market factors that are correlated with high levels of broadband deployment. *Population density* and *urbanization* are two such variables that likewise provide favorable environments for other infrastructure where network effects dictate low marginal cost for providers. *Telecom density* is an additional supply factor for broadband because some broadband service technologies have historically utilized existing infrastructure designed for other telecommunications services, wire-line telephone being the most prominent.

- *Competitive Factors:* At the intersection of the supply and demand factors are competitive factors like *price* and quality of service indicators like connection *speed*. The level of *competition* in any market place will be considered a competitive factor as well that is predicted to be negatively correlated with price.

- *Policy Factors:* Laws, regulations, and initiatives that a government institution can employ in an effort to stimulate broadband competition, deployment, and/or adoption. However, these policies may not be explicitly designed to impact broadband services. Improving education and income levels, for example, are standard policy objectives for which enhanced broadband services may only be one benefit. Policies and strategies revealed in the literature to more explicitly target broadband deficits are of particular interest to this study, including *unbundling, inter-platform competition, Universal Service Obligation,* and *rights of way.*

The next section develops a taxonomy of available broadband policies and provides a framework for contextualizing all of the policy factors that will be subsequently employed in the analysis of and recommendations for broadband policy in the United States.

The Broadband Policy Menu

Specific policy mechanisms and frameworks are of course unique to national institutions and laws and are constrained or enabled to various degrees by political forces. The broadband policy tools used to stimulate competition in or build-out of the infrastructure are technical and complex in nature and can take on a variety of forms depending on implementation and environment. Despite this challenge, the research has had some success in developing metrics for the inclusion of policy variables like *unbundling* and *inter-platform competition* in quantitative analysis.

In the broadband market context, *unbundling* can best be defined as the regulated requirement that incumbent telecom providers lease access to the use of either their infrastructure, relevant facilities, or both to entrants at a competitive cost. Unbundling policies are designed to facilitate market entry for firms that may not own the infrastructure that connects directly to a consumers home. In the broadband segment, unbundling policies might be directed at legacy phone companies that own the wire line infrastructure that either has been or could be upgraded for high-speed Internet service. The policy can also induce incumbents that provide broadband through Cable TV or fiber technology to lease portions of their infrastructure to entrants.

Inter-Platform Competition refers to the degree to which infrastructure composed of different technological platforms is available on the household level. Inter-platform competition would be considered low in a market where broadband was only available to households through the single legacy telephone line that connected their home, and high where broadband could also be delivered to a consumer's home via Cable, wireless, or fiber infrastructure.

Inter-platform competition policy is more discrete than unbundling and is better considered to be a broad strategy that involves multiple policy measures. However, as a policy variable, the outcome of inter-platform competition is easily quantifiable based on the variety and market share of broadband platforms available to consumers. Of course, results regarding the impact of either of these

factors are not complete without case-study based analysis that can better capture the complex environment in which policies are implemented. For example, the *unbundling* dummy often employed in regression analysis does little to convey the variety of options available to strengthen or weaken unbundling policy.

Beyond unbundling and inter-platform competition policies, there are a number of policy initiatives identified in the case-study based literature that are not as easily quantified for regression analysis. This section explores and defines a number of these broadband policies and develops a contextual framework that will serve to further define and segment common policy tools.

Universal Service Obligations (USOs), are policies that, if in place at all, broadly determine the burden on current telecommunications subscribers to subsidize infrastructure build-out to markets that lack favorable demand and supply factors like income and population density. The *obligation* refers to the requirement that service providers, the government, or both entities facilitate the transfer of consumer surplus from markets receiving service to those who currently are not. By this broad definition, every nation utilizes USOs, but disparate institutions, laws and politics manifest diverse forms and effect the levels of expanding broadband availability.

Rights of way policies are also believed to be influential in determining incentives for providers to build new infrastructure.[1] Rights of way refer to the granting of permission for private sector providers to deploy infrastructure in a public space. From a policy perspective, rights of way are facilitated or constrained depending on the various legal requirements, rents and fees involved in infrastructure deployment. These may include franchise negotiations, permit acquisitions, municipal fees, and rents for public lands and equipment like publicly owned telephone poles. Policies restricting or facilitating rights of way agreements are

[1] Gillett (2004) and Melody (1999) reveal that rights of way is a commonly utilized policy tool in telecommunications and Distaso (2006) presents one of the few regression analyses to include a *rights of way* proxy (a dummy variable indicating delays in obtaining rights of way) and finds a predicted negative correlation, though only statistically significant in his fixed effects model.

highly localized and diverse across nations and even municipalities and towns within nations.

Broadband Strategies and the National Information Infrastructure Initiative

In the real world of policy making, it will be nearly impossible to implement or even imagine any of the above policies as discrete instruments. In fact, they are highly interdependent on each other, on local markets and politics, and on many other actors beyond the national policymakers. For the purposes of this analysis, the concept of the *National Information Infrastructure Initiative* (NIII) will serve as a cohesive framework to better model broadband policies, objectives, impacts and strategies for implementation.[2] The NIII refers to the network of policies, institutions, and actors determined and led by the efforts of national governments designed to contribute to progress in the broadband market place. The NIII is reflective of the large-scale efforts of national policy makers to instigate enhanced and expanded broadband penetration through the policies and strategies that compose it.

NIIIs are by nature diffuse, difficult to quantify, and are arguably in place in every nation. Distinguishing degrees between NIIIs from one nation to the next might involve a comparative analysis of the common components, like stated goals for a variety of broadband metrics, public investment in or subsidy of broadband infrastructure build-outs beyond USO, government spending on broadband focused research and development, or even national programs designed to enhance education in science and technology. Such analysis will not be attempted herein, but the salient components of NIIIs will be identified in the case study section and reforms for the US NIII will be considered in the concluding discussion.

The precise nature and impact of an NIII - and all of the available tools for policy makers seeking to enhance global competitiveness through the expansion of

[2] The term is borrowed from Kahin and Wilson (1997), who present a comprehensive examination of various national initiatives focused on transforming a nation's technological infrastructure in the interest of enhancing its global economic competitiveness. Chapters on Japan and Korea are particularly relevant to this analysis.

broadband infrastructure - hinges upon the unique market, institutional, and political character of a nation.[3] These factors also influence the objectives and potential impact of broadband policy. Given the disparate nature of broadband policy, outcomes, and context from nation to nation, it will be extremely useful to employ a model that defines and segments the strategies that compose a NIII. The categories below represent these strategies and the associated policies that are a part of each strategy are included.

- *The National Broadband Strategy*: Refers mainly to the responsibilities of national governments to set discrete goals for broadband expansion and innovation, to provide articulate a broad policy approach to be followed by regulatory bodies and other relevant actors, and to play a coordinating role in support of these efforts. The national broadband strategy is essentially the face of the NIII and effective public communication efforts articulating the broader NIII are part of the national broadband strategy. This includes goal-setting, data gathering, and reporting back to the public.

- *Open Infrastructure Strategy*: Refers mainly to regulatory efforts designed to enhance intra-platform competition through *unbundling* and *bitstream policies* that force incumbent providers to open up legacy infrastructure to entrants for interconnection at competitive rates.

- *Third Pipe Strategy*:[4] Refers mainly to the policy objective of enhanced *inter-platform competition* whereby new infrastructure technologies ("third pipes") like Cable, wireless or fiber could compete with DSL.[5] Policies to

[3] Fransman et al. (2006) presents extensive case study analyses that examine the success of Korea, Japan, and some European countries in broadband penetration and concludes that deep-rooted institutional processes are at work in determining the nature and impact of broadband policy. Fransman suggests that further research "develop more rigorous institution-based explanations of economic phenomena." While this work will not take on Fransman's cause, I do assume that local institutions and politics play a major role in broadband policy and its impact and that the literature has not yet been able to develop satisfactory empirical tests for this impact.

[4] The term "third pipe" is borrowed from Atkinson (2007) who frames the policy options in terms of "keeping the same number of pipes" and choosing a hands-off regulatory policy vs. spurring the development of more pipes through policies that incentivize inter-platform competition vs. regulating "open pipes" through policies like unbundling.

[5] It should be noted that Open Infrastructure and 3rd Pipe strategies are considered to have a unique relationship among the policy strategies modeled here. Some policy makers view these two strategies as part of a zero-sum game, whereby 3rd pipe strategies are facilitated in large part by forbearance of open infrastructure policies. However, recent analysis of policy in Europe by Distaso (2007) that is further explored in chapters 5 and 6 of this work, shows that open infrastructure policies can have positive synergies with a 3rd pipe strategy.

facilitate or restrict *Rights of way* are also considered to be a component of the 3rd pipe strategy.

- *Rural Expansion Strategy*: Refers mainly to policies designed to facilitate the expanded deployment of broadband infrastructure into "unserved" areas. Policies impacting *Universal Service Obligations,* and national and local grant and loan programs would be key to this strategy set.

Each of the above strategies involve distinct groupings of the policy factors already reviewed. The framework below integrates these strategies, their component policies and relevant actors, and provides a strategic map for policy makers seeking to target and impact the potential drivers of broadband penetration.

Figure 1: The NIII Framework

Broadband Strategies	Policy Factors	Impact Sectors	Targeted Broadband Drivers	Notes on Implementation	Key Actors
Open Infrastructure	OPEN ACCESS	Competitive	*Competition *Inter-Platform *Price	Define and enforce open access spectrum rules.	National and Local Regulators
	UNBUNDLING	Competitive	*Competition *Price	Regulate and unbundle local loop; enforce facilities sharing; regulate bit stream access.	
3rd Pipe	INTER-PLATFORM COMPETITION	Competitive/Supply	*Inter-Platform Competition	Encourage inter-platform entrants.	National and Local Regulators, Governments, and Relevant Institutions
	PUBLIC INVESTMENT	Supply/Competitive	*Availability *Inter-Platform Competition	R&D; incentives for emergent infrastructure build-out; spectrum allocation.	
	RIGHTS OF WAY	Supply/ Competitive	*Availability *Competition *Inter-Platform Competition	Increase and ease rights of way access; franchising reform; expedite dispute resolution process.	
Low-Income/ Rural Expansion	UNIVERSAL SERVICE	Supply	*Availability	Universal Service Reform; improve grant and loan programs.	National and Local Governments and Private Sector
	PUBLIC INFRASTRUCTURE	Supply/Competitive	*Availability *Inter-Platform Competition	Public access points; public-private partnerships.	
National Broadband Strategy	INVESTMENT IN USERS	Demand	*Computer Ownership *Education	Programs to improve ICT skill-sets; investments in hardware for low-income; private sector incentives.	National and Local Governments, Civil Society, and Private Sector
	PUBLIC BUY-IN	Demand/Supply/ Competitive	*Addressable Market *Content *Availability *Speed	Marketing of broadband initiatives and facilitating partnerships designed to motivate enhanced supply and demand.	
	PUBLIC INFRASTRUCTURE	Supply/Competitive	*Availability	Investment beyond USOs, including redundant infrastructure to meet security concerns.	

This framework serves to model broadband strategies that might be transferable from nation to nation and can be used to broadly define the policies at work as well as their designed objectives. These strategies are not meant to be zero sum – they will overlap, they will be linked by common policy tools, and they will most likely compliment each other and sometimes require each other.

Most importantly though, this framework is designed to simplify and mitigate the local impact of markets, institutions, and politics so that policy makers might better understand how they can transpose and adapt best practices learned from the experiences of other nations seeking to improve global competitiveness through policies designed to enhance and expand broadband infrastructure.

These strategies, therefore, will play an important role in this work, which seeks to develop policy options for improving broadband penetration in the US based on empirical analysis of the experiences of OECD nations.

Chapter II. Background: Broadband in the United States

U.S. Internet traffic has been growing steadily at approximately 60% per year over recent years and the level of data transmitted in 2011 is expected to quadruple that of 2006.[6] The demand for high-quality video, voice, and file-sharing applications and the convergence of these applications to a single medium is a major driver behind the unprecedented expansion of data transmitted over the World Wide Web.[7] Likewise, the availability of data-rich applications drives demand and is one of the reasons more than a billion people were using the Internet in 2007.

In this era of unprecedented digital information transfer, a new technological infrastructure is required to meet the demand. Broadband infrastructure is currently the dominant mode for consumer and business connectivity in the world's largest economies. Broadband surpassed dial-up in this respect in the United States in 2003. In OECD nations, broadband household penetration has increased by at least 60% every year since 2001, and the rate has yet to plateau.[8]

This chapter seeks to define broadband infrastructure, the technologies that compose it, and examine existing data on the state of broadband services and policies in the United States.

Broadband Defined

For the purposes of this thesis, I will consider broadband technology to be any "always-on" household Internet connection that enables a download speed of 256 Kilobytes Per Second or higher. These terms are in line with those of the OECD and are designed, mainly, to distinguish Broadband connections from dial-up, which, due to techno-physical constraints, can rarely exceed speeds of 256

[6] Swanson (2007).
[7] The Commission of the European Communities (2007) cites broadband as the fastest growing ICT industry segment and notes the trend towards bundled products over IP-based platforms as a substitute for traditional segregated services.
[8] See Appendix 1: Historical Broadband Penetration Rates in the OECD

Kilobytes Per Second.[9] Additionally, subscribers restricted to dial-up connectivity must utilize a modem-to-modem connection over the landline telephone network that is only routed to the Internet when a modem is "called" or "dialed." Meanwhile, broadband technology is a direct connection to the Internet that is, in effect, "always on."

In this study, the term "Broadband penetration" refers to residential household subscriber data, unless otherwise noted. A household subscription to any of the below broadband technologies or "lines" (which may include wireless technologies) to the home defines *penetration*, which will also serve as the dependent variable in regression models for this study (Chapter 4) and many of the studies cited in the literature review (Chapter 3). However, Broadband *availability* or *access* refers simply to the deployment of a broadband "line" to the home that is available for subscription, also known as *adoption*.

Broadband Technologies

This thesis is concerned with household penetration of broadband infrastructure. As a result, the analysis of broadband infrastructure herein will be restricted to the common "last-mile" broadband technologies that are available to consumers in OECD nations. The broadband technologies include:

*Digital Subscriber Line (DSL) technology: Enables high-speed Internet Protocol (IP) transmission over traditional copper land-line.

*Cable: High-speed IP transmission over coaxial cable wires that are also capable of transmitting cable television signals. DSL and Cable speeds vary but the technologies are often considered to be comparable in terms of speed and quality.

*Optical Fiber: Glass or plastic optical fiber cables that are deployed either directly to the consumer's home or to a location near the home (at which point

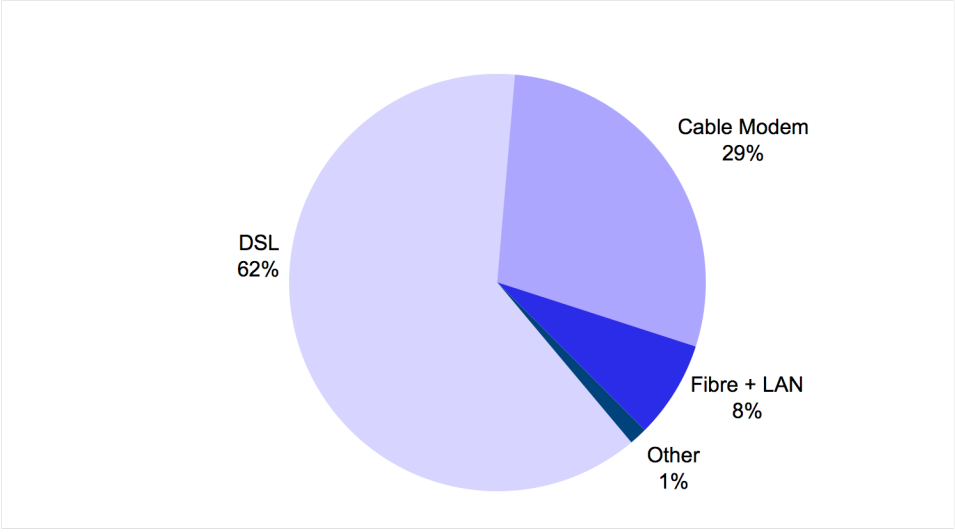
[9] It should be noted that 256 KB/S is a nominal threshold metric and that many broadband technologies enable speeds of at least 10 Megabytes Per Second, or approximately 40 times faster than that of dial-up. Also, the OECD measure does not consider the upload speed of the technology, which can be significantly slower than the download speed for some broadband technologies – even slower than 256 KB/S – but can be equal to that of some of the fastest download speeds for other broadband technologies.

existing technology like DSL is utilized). Deploying fiber even near the home can enable higher transmission speeds than DSL or cable, and Fiber to the home is considered to be optimal contemporary household broadband infrastructure for overall speed and quality.

*Other Broadband Technologies: A variety of wireless technologies broadcasting over different wireless spectrums are capable of delivering broadband communications, including *Wimax*, and *Satellite*. Also, emerging technologies like *Broadband Over Powerline (BPL)* contribute to the OECD data. However, the OECD data does not track *WiFi* connections that are utilized for connectivity in many urban areas but are not a significant household consumer technology.

The vast majority of household broadband connections in OECD nations are supplied by either DSL or Cable technologies. The chart below represents aggregate percentage share of broadband subscriptions by technology across OECD nations as of June 2007.

Figure 2: Total Share of Broadband Subscriptions By Technology in the OECD[10]



Adoption of Fiber technology appears to be on the rise in many OECD markets. Its market share grew to 8% from 6% in just the first two quarters of 2007. The

[10] All OECD subscription data herein is based on residential household data and does not include business services.

Fiber penetration rate doubled in the US in 2007 and Fiber now accounts for more than 30% of the broadband market in both Japan and Korea.

Broadband Impact and Importance

Demand for high-speed broadband connectivity is emerging, not coincidentally, in an era when the amount of data transmitted in a single quarter of 2007 from the video site YouTube.com exceeds that of the entire Internet for the year 2000.[11] But scholars', international organizations', and policy makers' concern for broadband penetration rates is not simply focused on meeting insatiable consumer-entertainment demands. In fact, a growing body of research reveals significant economic benefits that are correlated with broadband penetration.

The work of Lehr et al. (2005) finds that communities in the US with ubiquitous access to broadband realized additional employment growth rates of approximately 1%; 6% gains in additional property values; and .5% additional business growth. Crandall et al. (2007) examines state employment impacts in the United States and projects .2 to .3 percent per year growth in employment in multiple non-farm industries for every one percentage point increase in broadband penetration and finds a statistically significant positive correlation between regional broadband penetration levels and output growth in the service industry.

Additionally, recent studies conducted as a part of state and local broadband expansion projects in the US promise many benefits. The Sacramento Regional Research Institute (2007) finds a positive relationship between connectivity and employment and posits that California stands to gain 1.8 million new jobs over 10 years through a 3.8 annual percentage point increase in broadband deployment and adoption. Further benefits have been cited by research that posits a positive relationship between broadband access and decreased carbon emissions through increased telecommuting, ecommerce, and teleconferencing.[12]

[11] Steve Lohr, "Video Road Hogs Stir Fear of Internet Traffic Jam." *New York Times*. March 13, 2008. Last accessed on April 14, 2008. Available at: http://www.nytimes.com/2008/03/13/technology/13net.html

[12] Fuhr and Pociask (2007).

Policy makers and consumers alike realize that broadband is emerging as the dominant communications medium in highly developed countries and beyond. The majority of global data transmissions are already made over broadband and an increasing share of voice and video transmissions are converging on this medium as well. Broadband is proving essential for a range of modern services in the spheres of public health, education, and government services.

Broadband Challenges in the US

With so much demand and so much to gain, policy makers should be just as concerned as leading telecom firms with enhancing broadband household penetration rates and spurring the deployment of the highest quality digital infrastructure at the lowest possible cost to citizens. But connecting Americans to affordable broadband on a large-scale is proving to be a significant challenge. According to the OECD, the US broadband penetration rate - the percentage of households subscribing to high-speed Internet – currently stands at 22.1%, a statistic that ranks the US 15th among wealthy nations.

The United States, the birthplace of the Internet, is the largest market for broadband subscribers in the world, but its penetration rates have consistently dropped relative to other nations over the last decade.

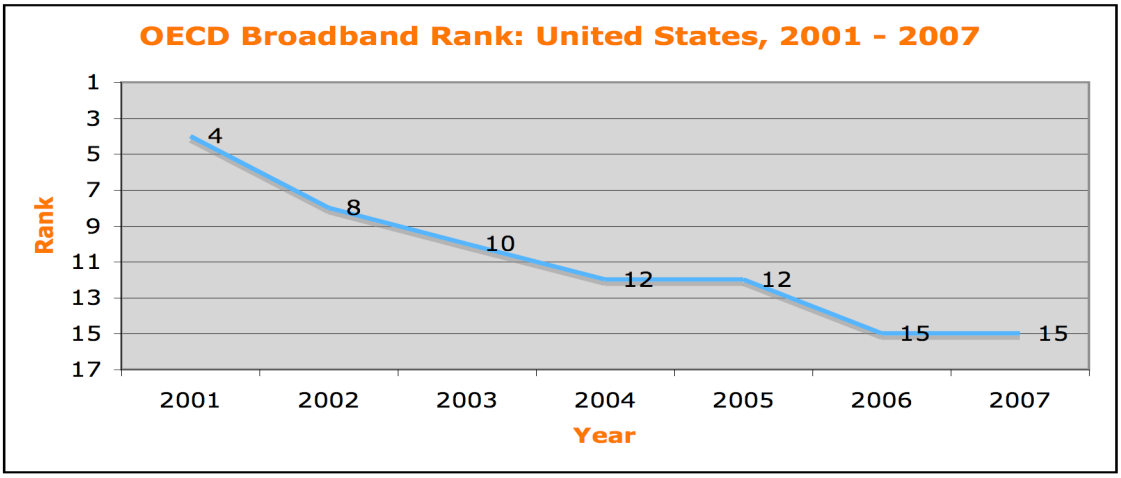
Table 1: OECD Broadband Rankings, 2007

OECD Broadband Ranking

OECD Broadband subscribers per 100 inhabitants, June 2007

Rank		Total	Total subscribers
1	Denmark	34.3	1 866 306
2	Netherlands	33.5	5 470 000
3	Switzerland	30.7	2 322 577
4	Korea	29.9	14 441 687
5	Norway	29.8	1 388 047
6	Iceland	29.8	90 622
7	Finland	28.8	1 518 900
8	Sweden	28.6	2 596 000
9	Canada	25.0	8 142 320
10	Belgium	23.8	2 512 884
11	United Kingdom	23.7	14 361 816
12	Australia	22.7	4 700 200
13	France	22.5	14 250 000
14	Luxembourg	22.2	105 134
15	United States	22.1	66 213 257
16	Japan	21.3	27 152 349
17	Germany	21.2	17 472 000
18	Austria	18.6	1 543 518
19	Spain	17.0	7 483 790
20	New Zealand	16.5	683 500

Figure 3: Historical Ranking



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[13] The OECD ranking is based on penetration rates or the percentage of households in a country with access to Digital Subscriber Loops (DSL), coaxial Cable lines, or other broadband-capable infrastructure including high-speed fiber, wireless, or satellite connectivity.

The descent of the United States in the world broadband rankings[14] and what it might mean in terms of the nation's global competitiveness is beginning to concern many policy makers and experts and has sparked considerable debate over whether and how to respond. A recent manifestation of this debate was a September 26, 2007 Senate Committee hearing where Senator John Kerry cited the above data and warned that "we are lagging behind the rest of the world."[15] At the same hearing, Federal Communications Commissioner (FCC) Jonathan Adelstein expressed concern "that the lack of a comprehensive broadband communications deployment plan is one of the reasons that the U.S. is increasingly falling further behind our global competitors" and posited that the development of a clear national broadband strategy "must become a greater national priority for America than it is now."[16] Months before, Senator John Rockefeller introduced Senate Resolution 191 that calls for the development of "the first U.S. national broadband policy by the end of 2007."[17]

The US' standing according to other broadband metrics like consumer price and quality of service has troubled policy makers as well. As Tables 4 and 5 demonstrate, the US ranks poorly in terms of broadband price (11th) and speed (14th).

As technologies converge and demand for additional broadband services like video and voice increases, speed and affordability become more salient problems and quality offered by technologies like fiber become more valuable. In this regard, the US deficit in fiber broadband deployment may also concern policy makers as studies have overwhelmingly demonstrated that optical fiber cable offers the highest quality and transmission speeds.[18]

[14] While the OECD rankings are the most widely cited and transparent, other rankings that consider global broadband connectivity beyond the 30 members of the OECD placed the US as low as 25th globally in April 2007: http://www.websiteoptimization.com/bw/0704/

[15] John Kerry opening statement available at: http://sbc.senate.gov/record.cfm?id=284220

[16] Johnathan Adelstein testimony available at: http://sbc.senate.gov/testimony/070926-Adelstein-testimony.pdf

[17] Rockefeller (2007).

[18] Dhliwayo (2005) reports speeds of up to 2 Terabits per second and presents extensive support for the value of fibre over other technologies; Gambling (2000) also explores in-depth; and telecom legal experts Jim Baller and Casey Lide present the case for a fiber-based national broadband network (2005).

Figure 4: OECD Broadband Price

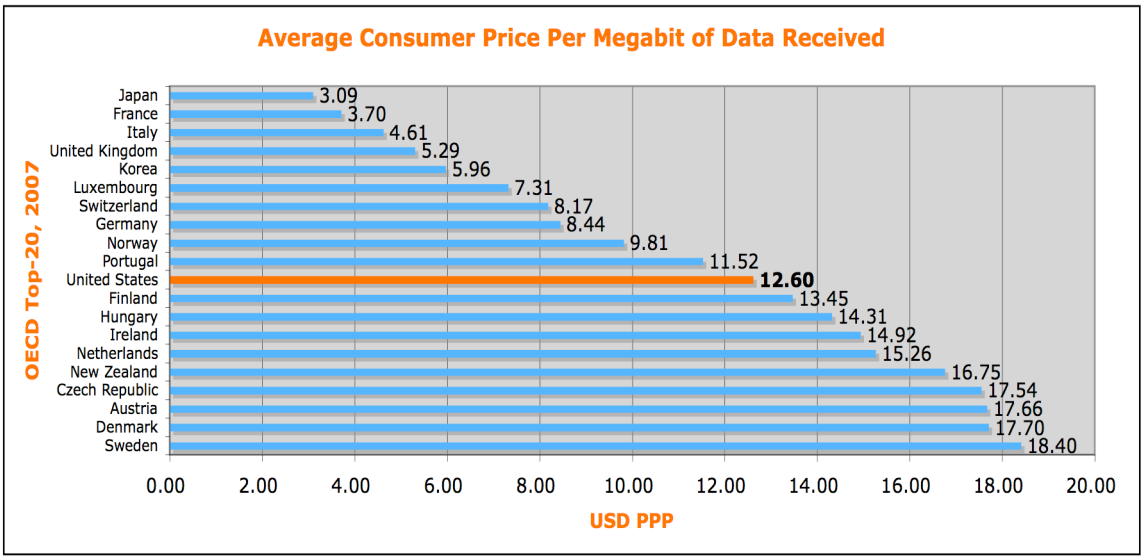
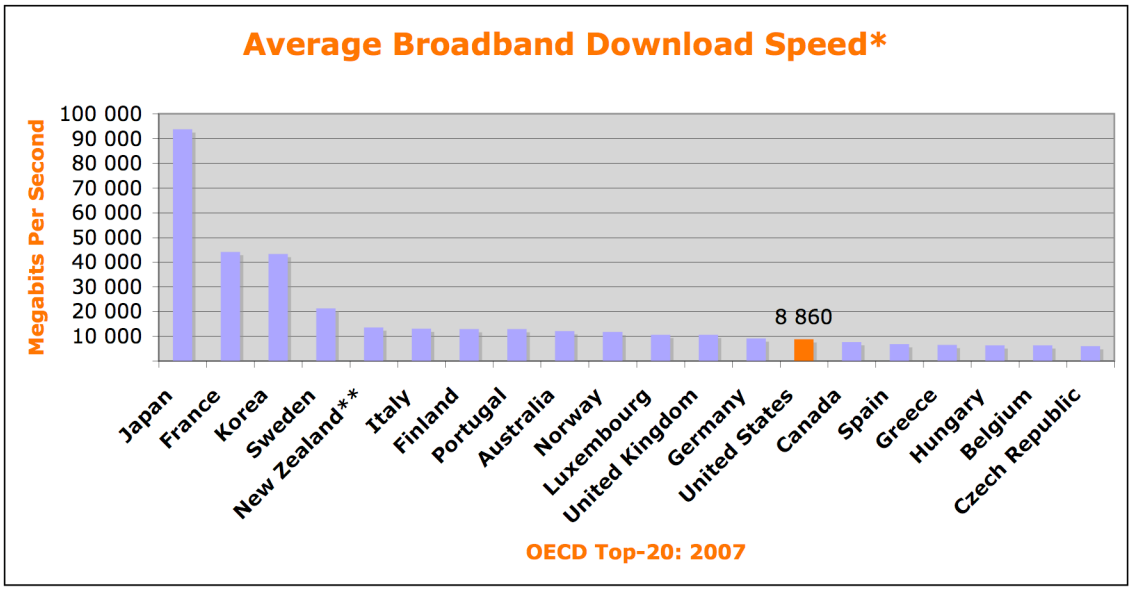
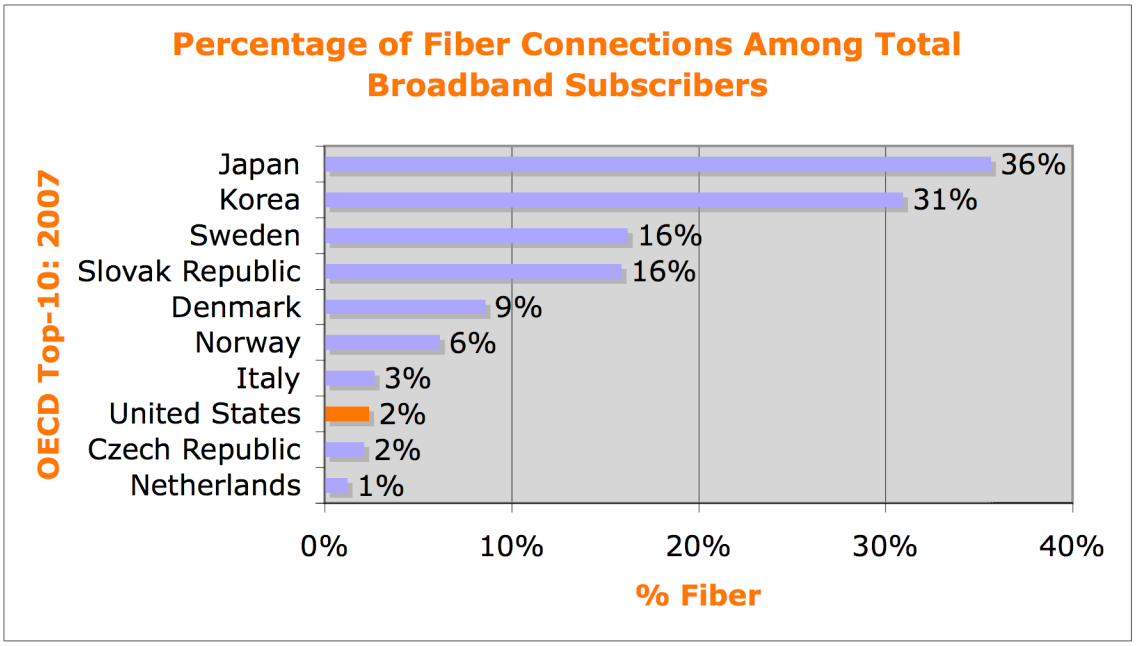


Figure 5: OECD Broadband Speed[19]



[19] "Note (*): Advertised speeds are typically the theoretical maximum for the employed technologies. Users commonly have lower speeds. Also, often only limited parts of a country have been upgraded to allow for faster speeds. Note (**): New Zealand's download speeds are not typically advertised. Figures were imputed using technological maximum speeds for ADSL 2+ offers," (OECD, 2007).

Figure 6: OECD Broadband Fiber



The Debate Over US Broadband Policy

There is a legitimate debate in the United States among policy makers, analysts, pundits, and politicians about whether or not a broadband deficit exits, in comparison to other nations. FCC commissioner Robert McDowell sums up the dissenting opinion by positing that the OECD's "methodology is flawed," and reminds other policy makers that "Forty-three American states have a higher household broadband adoption rate than all but five EU countries." The Commissioner rejects assertions that there are any failures in the broadband services market in the US and asserts that supply for bandwidth will grow in lock-step with demand.[20]

On the other hand, Mr. McDowell's fellow Commissioner Michael J. Copps claims that "too few of us have broadband connections, and those who do pay too much for service that is too slow"[21] and cites additional statistics from the International Telecommunications Union that rank the US 20th globally in its *digital opportunity*

[20] Roger M. McDowell, "Broadband Baloney," *Wall Street Journal* (Eastern edition), New York, N.Y.: Jul 24, p. A.15.
[21] Michael J Copps 2006. "America's Internet Disconnect." *Washington Post*, November 8: page A27.

index.[22] Likewise, the Pew Internet and American Life Project, which specializes in survey data of Internet use, presents criteria distinct from the OECD and finds that half of all Americans will have a broadband connection by the end of 2007, but is troubled by the slow growth in both deployment and uptake.[23] Even Commissioner McDowell concedes that "video applications are tugging hard on America's broadband infrastructure" and that "while America is on the right track, we can and will do more."[24]

This analysis does not seek to become mired in the debate over US broadband rankings, rather, I hope to test the potential drivers of broadband penetration and the policies that facilitate and enhance these drivers in order to equip policy makers with a better understanding of the broadband market. However, this study is also concerned with testing the policy instruments and initiatives that might facilitate and/or enhance the factors driving broadband penetration. With a focus on the United States, it will be useful to review the components of the current US NIII to provide context for empirical testing of the broadband drivers. The analysis will return to the US case in order to examine opportunities for policy reforms in light of the empirical research.

The Current US National Information Infrastructure Initiative

This chapter concludes with a broad survey of the current US broadband strategies that compose its NIII. It is based on the official policies, laws and regulations implemented by the national Executive and Congressional branches and by the FCC and local regulators. Government rhetoric and public messaging is also considered a factor, especially in regard to the national broadband strategy. This "map" of the US NIII provides the backdrop for cross-national analysis and comparisons in Chapters 3 to 5. I will return to the US case in the concluding chapter

[22] The *digital opportunity index* considers aggregate data based on a variety of criteria including price, delivery speed, and access and is available at http://www.itu.int/ITU-D/ict/doi/index.html
[23] Pew (2007).
[24] Roger McDowell, "Broadband Baloney".

National Broadband Strategy

In the spring of 2004, the Bush administration announced a series of policy goals and steps for achievement in the area of technology and innovation that included "expand[ed] access to high-speed Internet in every part of America."[25] The values, objectives, and approaches proposed in these policy statements and subsequent findings and policy recommendations by the National Telecommunications and Information Administration (NTIA) constitute the current national broadband strategy. The key components of this strategy are best outlined in the NTIA's report "Networked Nation: Broadband in America 2007." The NTIA's *Broadband Strategy For the 21st Century* highlights a "pro-competitive and deregulatory" approach that seeks to "clear away regulatory obstacles that could thwart the investment that fuels development – and deployment – of new technologies." In support of this strategy, the report cites the following government policies: technological neutrality that does not favor any products or vendors; the opening up of wireless spectrum to accelerate broadband deployment; moves to "modify legacy regulation" in order to expand incentives for private sector upgrading of infrastructure; and tax relief in order to facilitate growth in the broadband marketplace.[26]

The administration also cites specific examples of some of the policy mechanisms designed to support this strategy, including targeted economic benefits on both the supply and demand side like allowances for capital depreciation of investments in broadband infrastructure and extending a moratorium on Internet taxes respectively and incentives for build-out by broadband providers have probably aided some initiatives like those of select telecom firms to build fiber to the home or to housing developments (FTTX).[27]

A notable component of the US National Broadband Strategy is the data and metrics for success in broadband services and policies. The FCC measures competition on a zip-code basis and considers satellite to be sufficient for

[25] President Bush's Technology Agenda (2004): *Promoting Innovation and Economic Security Through Broadband Technology*. June 24. Last accessed on: April 14, 2008. Available at: http://www.whitehouse.gov/infocus/technology/economic_policy200404/chap4.html
[26] From NTIA (2008), *Executive Summary*.
[27] President Bush's Technology Agenda (2004).

broadband connectivity and consequently concludes that 100% of US citizens have access, with most households existing in competitive markets served by three or more carriers. However, none of the other data sources cited in this analysis consider satellite to be sufficient broadband connectivity because of its slower speeds, high degree of signal latency, and significantly higher prices compared to other technologies. Many analysts also take issue with the FCC's zip-code criteria that does not differentiate between consumer and business-class service and also skews data in areas where the entire zip code may not served.[28]

Current Open Infrastructure Strategy

Removing barriers and legacy regulations governing telecom infrastructure in the interest of incentivizing extended deployment of incumbent infrastructure while facilitating inter-platform entrance is the stated approach to open infrastructure strategy currently being employed. This is manifest largely in the administration's support of FCC decisions to forbear or forego regulations originally stipulated in the 1996 Telecommunications Act ('96 Act) initially designed to instigate competition through unbundling policies that would force incumbent providers to sell access to infrastructure to market entrants at reduced rates. From 1999 to 2002, the open infrastructure strategy was embraced to a greater degree by US policy makers and unbundling was enforced in the DSL sector. Then policy makers began to change course in favor of a 3rd pipe strategy that allowed cable broadband to remain unregulated. Following this decision, incumbent telecom operators effectively battled open infrastructure policies that were effectively over-turned by 2005. However, recent decisions to apply open infrastructure rules to the 2008 wireless spectrum auction may signal another change of course for US policy makers.

Current 3rd Pipe Strategy

3rd Pipe is the salient strategy currently employed in the US. By lifting legacy regulations described above, US policy makers hope to incentivize both the

[28] For an in-depth analysis of issues regarding broadband definitions, speeds, and satellite connectivity, see Committee on Broadband Last Mile Technology, Computer Science and Telecommunications Board, National Research Council, 2002, Chapter 2 available at: http://www.nap.edu/html/broadband/ch2.html

deployment of new infrastructure - like fiber, wireless and broadband over power line (BPL) – and incumbent build out, all through the promise of de-regulation. Additionally, the Department of Commerce has invested directly in R & D to further develop these technological platforms, particularly BPL. The FCC has also made available wide swaths of wireless digital spectrum and recently completed a large-scale auction in which the bulk of the broadband-ready national spectrum was secured by incumbent telephone companies and DSL providers.[29] Additional tax incentives are available for firms developing or deploying "3rd pipes" and technical institutions have sought to improve interoperability and standards in wireless broadband technologies. Reforms aimed at enhancing *rights of way* have also been an important part of 3rd pipe strategy: in 2004 the administration set out to "streamline the process for broadband providers to get access to Federal lands to build high-speed infrastructure."[30]

Current Rural Expansion Strategy

In the 2004 Technology Policy Agenda, President Bush set a goal of universal broadband availability by 2007. The NTIA confirmed that this goal had in fact been met and that, according to FCC data, broadband was available to over 99% of the country as of December 31, 2006.[31] While this achievement and the metric used to define it are highly problematic (as discussed above), the universal service goal-setting is a notable component of rural expansion strategy.

The primary national policy tools and initiatives facilitating rural broadband expansion are the Department of Agriculture's (USDA) *Rural Broadband Access Loan* program and the *Universal Service Fund* administered by the FCC. The USDA program provides below-market rate loans and loan guarantees for the construction and improvement of broadband facilities and equipment in rural areas. The FCC administered Universal Service Fund (USF) - funded by USOs applied to private sector providers - applies to a range of telecommunications services and does not explicitly provide for broadband. Still, moneys are

[29] Paul Taylor, "Wireless Spectrum Bids Top $19 Billion," *Financial Times*, March 19, 2008: pg. 19.
[30] President Bush's Technology Agenda (2004).
[31] FCC (2006), available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-277784A1.pdf - last accessed on April 19, 2008.

allocated to broadband services through programs that fund information infrastructure for schools, libraries, and health care facilities in both low-income and rural areas.

This survey on the state of broadband in the US and the current broadband policy strategies should serve as the backdrop as the analysis now turns to empirical research on the factors driving increased broadband penetration across the OECD nations.

Chapter 3. Literature Review: Broadband Drivers and Cross-National Comparisons

The expansion of broadband deployment and adoption is now a major objective for policy makers around the world. Consequently, research focused on the drivers of expansion is burgeoning. This section examines the empirical research on the factors influencing broadband penetration rates. The review of this literature is organized by the broadband factor categories reviewed in Chapter 1: *Demand, Supply, Competition and Policy*.

Demand Factors

The variables predicted to drive broadband demand include income, education and computer ownership as well as the relevance of online content for a particular population and the size of the addressable broadband market based on historical adoption of dial-up Internet technology.

Income

While higher income is found to be generally correlated with broadband penetration around the world, when the data-set is restricted to high-income OECD nations, results are mixed regarding the marginal impact of higher levels of income among this wealthy group of nations. For example, Wallsten (2006) finds significant empirical results, but the cross-national analysis by both Garcia-Murillo (2005) and De Ridder (2007) fail to find a statistically significant impact within OECD nations. Scholars have theorized that the lack of correlation could be due to path-dependent lock-in to dial-up technology among wealthy early adopters (Bauer, 2003); or that there is simply a threshold national income for broadband above which higher-income can not induce any more adoption (Garcia-Murillo); or that GDP is simply not a dynamic enough measure of income for cross-national comparisons of this sort (De Ridder).

Table 2: Summary of Econometric Literature

	Econometric Research (Years Refer to Data Sources) *US only								
Independent Variables:	Gruber & Denni, 1999 – 2004*	Garcia-Murillo, 2001[32]	De Ridder, 2005	Distaso 2000 - 2003	Floyd and Gabel, 2001*	Cava-F & Alabau-M., 2000 - 2002	Wallsten, 1999 - 2003	Aron & Burnstein, 2002 and earlier*	Bauer, 2001 - 2003
Competition									
Competition[33]	Yes	Yes	No		No	No			No
Price		No	Yes			No			No
Speed		No	Yes						
Demand									
Addressable Market/ Dial-Up		Yes	Yes			Yes	No		
Income		Yes[34]	No		Yes	Yes	Yes		No
Education			No			No		Yes	Yes
Computer Ownership		Yes							Yes
Content		Yes				No			
Age			No						
Supply									
Telecom Density	Yes						Yes	Yes	
Availability						Yes		Yes	
Population Density		Yes	Yes		Yes		Yes		
Policy									
Unbundling		Yes	Yes	Yes	No	No	Yes		
Inter-Platform Competition	Yes		No	Yes	Yes	Yes		Yes	
Rights of Way				No					

Age

Adoption rates of many technologies, including broadband, are thought to be higher among younger age cohorts. A Pew Internet study finds the 50 to 64 year old age group to exhibit slow growth in broadband adoption in the US that is comparable to the impact of income.[35] OECD 2007 data reveals that while the trend is mitigating in some nations, overall, broadband adoption consistently

[32] ITU Data that considers as many as 100 nations in some models.
[33] Competition refers to the correlation between a lower concentration of market share for incumbents, while Inter-Platform Competition refers to the concentration of market share for a single technology.
[34] Garcia-Murrillo finds income to be a factor across the entire data set, but not when restricted to OECD nations.
[35] Pew Internet and American Life (2007), "Home Broadband Adoption 2007."

declines above the age of 40.[36] Only De Ridder has utilized age as an independent variable for regression analysis of broadband penetration rates, but the author does not find the proxy of total population aged 35-44 to be statistically significant in the model.

Education

While survey data often shows higher-education to be correlated with higher levels of Internet use,[37] cross-national empirical data show both a positive relationship (Aron & burnstein (2003) and Bauer (2003)) and none at all (Cava-Ferreruela and Alabau-Munoz (2006), herein: "C-F & A-M"). De Ridder (2007) uses "the share of the population aged 25-64 that has received tertiary education" as a proxy but does not find statistically significant results either. While education is suspected to be a driver in its own right – under the assumption that there are certain trainable skills required for enhanced demand of Internet services as well as additional utility for broadband in higher education and among the highly educated – the factor is of course also anticipated to be highly correlated with the other demand factors, particularly income.

Content

Results are mixed regarding the impact of locally relevant Internet content as a driver of demand for broadband. The number of Internet hosts in the country is the most common proxy for locally relevant content. This metric is based on the number of domain names ending with a specific country code (*.jp* for Japan or *.uk* for the United Kingdom, for example) and is thought to be reflective of the level of content directed to a specific population. Garcia-Murillo finds a significant correlation between Internet hosts and broadband penetration while more recent data used by C-F & A-M does not.

Computer Ownership

Computer ownership is often presumed to be a prerequisite for broadband adoption or perhaps even a composite good, and this may be one reason why it

[36] For data on Australia, Canada, Denmark, France, Korea and Norway see OECD (2007), "Broadband and ICT Access and Use By Households and Individuals," p47.
[37] Pew Internet and American Life (2007).

is not included in many of the models in the literature. Regression analysis of the relationship between computer ownership and broadband penetration has only been undertaken by Bauer (2003) and Garcia-Murillo, but both find statistically significant and positive results.

Addressable Market

Many scholars have attempted to quantify the level of latent demand in the broadband market as an additional broadband driver. That is, if there is already a high subscription rate for dial-up Internet, for example, then there should be a higher probability that demand for more robust Internet services like broadband will exist. Garcia-Murrillo and C-F & A-M, using early data on dial-up subscribers, provide empirical results that support this notion. De Ridder also finds a statistically significant correlation between the percent of the population with Internet (including dial-up) and broadband penetration through lagged statistics. However, Wallsten (2006) finds evidence that narrowband and broadband services compete in the US and warns that the presence of dial-up may actually slow broadband adoption in some markets and cites additional survey data that finds that 80% of dial-up subscribers have no intention of switching to broadband.

But as broadband subscription levels begin to eclipse dial-up, it becomes more of a leap to use the *addressable market* proxy as a measure for the anticipated growth-rate of broadband penetration. Also, localized demand factors like *content* and supply factors like packaged broadband service offers (with Voice over IP and Cable TV for example) may induce leap-frogging beyond dial-up service straight to broadband.

Supply Factors

A number of supply factors are predicted to drive broadband penetration, including population density, telecom density, and availability. Telecom density and availability are proxies for the supply of existing infrastructure, while population density is considered a supply driver because high-density urban areas that offer positive network effects are expected to lower costs for suppliers.

Population Density

A positive correlation between population density and broadband penetration is to be expected and multiple empirical studies do in fact find this to be the case. Both Garcia-Murillo and Wallsten (2006) find a statistically significant and positive correlation between population density and broadband penetration using the above “inhabitants per square kilometer” proxy for the driver among OECD nations. Floyd and Gabel (2003), looking at only the US (and using “people per square mile”) also finds statistically significant positive results in all of his models. De Ridder uses the percent of the population that is urbanized as a proxy for population density and finds a statistically significant correlation as well.

Telecom Density

The existence of legacy infrastructure that can be upgraded at a relatively low-cost for broadband services is expected to be positively correlated with broadband penetration. Wire-line copper infrastructure originally used for telephone and dial-up Internet communications is the most prominent legacy infrastructure for broadband and is usually quantified by the number of telephone lines per capita. Wallsten (2006) and Aron & Burnstein find a positive correlation between telephone lines per capita and broadband penetration. Gruber and Denni find a positive correlation using the *ratio of DSL lines to central offices* as their proxy. This is a more precise measure of the capability for broadband conversion of DSL lines that still reflects the influence of population density and urbanization.

Availability

Availability of broadband is not surprisingly found to be a major factor in penetration rates. Like *telecom density*, this is a measure of the “broadband readiness” of a nation’s infrastructure, however, this metric might include digital cable lines or may refer to coverage (% of population with *access*) of broadband lines as opposed to per capita density. C-F and A-M use this DSL coverage proxy and find statistically significant positive results. Aron and Burnstein’s

analysis of the US market also finds a correlation using the metric of percentage of population living in areas where either DSL or Cable are deployed.[38]

Competitive Factors

In this analysis, market variables at the intersection of supply and demand are categorized as competitive broadband drivers. These include price and levels of competition both within a single technological platform or between technological platforms.

Price

The predicted negative relationship between broadband price and penetration is not played out in empirical analyses, with C-F and A-M finding no correlation and Garcia-Murillo actually finding a positive relationship. The latter study hypothesizes that the relatively early stage of adoption represented by the data set may make for highly elastic price responsiveness. However, De Ridder refines the price variable and considers average national price per megabit received and does find a statistically significant and negative relationship between price and penetration.

Competition

Higher levels of *Competition* are expected to be correlated with lower prices and higher broadband penetration rates. However, the type of competition, inter-platform vs intra-platform, is also important. Within the framework employed for this anslysis, intra- vs inter-platform competition is categorized as a policy factor and that typology will be explored in-depth in the subsequent section. But among the competitive factors, this analysis also seeks to determine if competition writ-large has an expected positive impact on penetration. Increased competition among broadband providers should predictably drive down price and drive up adoption, however, Schumpeterian theory and network effects suggest that a

[38] For the US market, data granularity only reflects whether broadband is available at all, at the zip code level, and does not consider ubiquity. In general, accurate measures for availability (or broadband coverage) are lacking or problematic. The best cross-national data point for OECD countries (available in OECD, *Communications Outlook 2007*) measures only DSL coverage and is based on a variety of metrics across nations, including "the number of lines that have been upgraded, the population covered or the households which could subscribe."

more concentrated market may be better suited to innovation, may incentivize deployment and enhance availability, and thus be positively correlated with penetration.[39] Floyd and Gabel conclude from regression analysis with deployment as the dependent variable that large firms in monopoly or near monopoly markets are in fact more likely to deploy and that "Schumpeter was right."

Further analyses of competition as an independent variable use the proxy of overall broadband market-share monopolized by the national service incumbent. Using this metric, neither De Ridder nor Bauer (2003) find a statistically significant correlation between competition and penetration. Ferreruela and Munoz share this non-result and do not find evidence when using total number of operators of fixed infrastructure in a nation as a proxy either.[40] Garcia-Murillo does find a positive correlation using this metric, but with a smaller dataset. Polykalos (2006) also finds a correlation between competition and penetration when using the incumbent share in the DSL market only as a proxy in a stylized model that utilizes only 14 countries in Europe.

Speed

None of the literature reviewed here explicitly considers the advertised speed of broadband services among the dependent variables impacting penetration. Wallsten (2006) does construct a model with speed as a dependent variable and finds it to be correlated with population density, though he notes the myriad challenges to obtaining reliable and robust metrics that reflect download and upload speeds as experienced by consumers. Garcia-Murillo's and De Ridder's models also build-in speed an independent variable, where price is measured as the log of the *average advertised price per bit per second* of data received. The model in this analysis utilizes this more refined and comprehensive proxy as well.

Policy Factors

[39] See Shumpeter, Joseph (1942).

[40] It should be noted that Cava-Ferreruela and Munoz' proxy may be measuring either intra-platform or inter-platform competition depending on the market.

As drivers in promoting broadband penetration, the policy factors can be viewed as being twice removed from the dependent variable. That is, the broadband policies examined here are designed to stimulate drivers in one of the other sectors.

Unbundling

Although unbundling describes a complex, multi-stage process that is highly differentiated across regulatory districts, scholars have managed to employ proxies for unbundling requirements in econometric studies. De Ridder finds positive results using the number of years that unbundling policy has been in effect in a nation as a proxy for this government policy. Distaso et. al. also find a statistically significant correlation when using the price that access providers pay for unbundled lines as a proxy. Garcia-Murillo examines the impact of unbundling as a dummy variable and finds significant results, but only for middle-income nations in a study that included 100 countries. C-F & A-M use the LLU dummy as well as the impact of the total percentage of DSL lines that are unbundled, but do not find statistically significant results. Floyd and Gabel's study of the US market finds insignificant results for unbundling as well but note the observed ability of incumbents to resist LLU regulations and that the impact of LLU policies on both incumbent behavior and penetration rates varies greatly from market to market.

Wallsten (2006) adds some granularity to the empirical analysis of unbundling by distinguishing between LLU (strictly copper wire access by entrant), Bitstream access (includes access to facilities), and sub-loop unbundling (line access between the facility and the customer), the latter of which Wallsten and Umino (2004) consider to be the most "far reaching" from a regulatory standpoint. Wallsten finds mixed results but statistically significant positive correlation between LLU and penetration and a statistically significant negative correlation between sub-loop unbundling and penetration in some models.

Results of Wallsten's econometric analysis reaffirm a point that will be addressed throughout this study, that policies to enhance broadband competition are complex, highly dependent on local institutions and politics, and difficult to

quantify for inclusion in regression or other empirical analysis. Umino's study of OECD unbundling policies supports this perspective as well and adds to it by highlighting the roles that regulatory arbitration, unbundling sequencing, and pricing metrics all play in the implementation of unbundling policies and the achievement of the objectives these policies are designed to meet. Also, LLU policy is often framed as an alternative policy tool to *inter-platform competition*[41], but many researchers also note the importance of utilizing and sequencing policies that promote both inter and intra-platform competition.[42]

Inter-Platform Competition

In the policy makers eyes, strictly enforced unbundling risks dis-incentivizing deployment by providers who anticipate having to lease new infrastructure to entrants at a low rate. Thus, the contemporary gains in intra-platform competition that unbundling might deliver may be part of a trade-off for slow build-out of infrastructure in the long term. Inter-Platform competition is viewed by many as a way to avoid this tradeoff where distinct technological platforms compete, a wider variety of services and innovations are possible, and providers are incentivized to build-out their own technological infrastructure and compete directly for subscribers. Denni and Gruber (2005) use a modified Herfindahl-Hirschman Index (for technological concentration as opposed to firm) as a proxy for the degree of inter-platform competition and find it to be conducive to positive long-term broadband penetration and to broadband coverage extension. The regression results are favorable for inter-platform over intra-platform competition as well, which has a short-term impact only. Aron and Burnstein's 2003 empirical study of comparative broadband penetration within 46 US states also finds a positive correlation with facilities-based competition when using the percentage of households that have access to both DSL and Cable broadband technologies as a proxy. C-F and A-M, use a dummy variable for the "few OECD countries that have two or more competing providers using different infrastructures on a widespread basis" based on data from 2002 (footnote 6, p455). Meanwhile, Polykalas' study, focused exclusively on Europe, notes that in certain markets, intra-platform competition appears to be a more significant driver of broadband

[41] See, for example, Denni and Gruber.
[42] See Polykalas and De Ridder.

penetration and that facilities-based competition can be a problematic variable due to the likelihood that the incumbent telecom may also own a significant share of the Cable market in some countries.

Distaso finds similar trends over a 4 year time period in Europe in which competition within the DSL segment increased in every nation with the exception of Belgium, Denmark, Finland and Italy and competition between DSL and Cable (also referred to as inter-platform competition) improved in every nation other than Denmark, Spain, Finland, and France. Distaso's time-series study of 14 European nations ultimately finds stronger competition between technological platforms to be a significant driver of broadband diffusion and one that plays a stronger role when compared to that of platform competition within the DSL segment alone. Distaso's model for broadband competition also reveals positive synergies between inter-platform competition and LLU policies.

Rights of Way

The only other distinct broadband policy that scholars have attempted to quantify for econometric analysis is rights of way. Distaso's is the lone research that considers this policy measure by including a dichotomous variable for the centralization of authority over rights of way (which is anticipated to ease market entrance and be positively correlated with penetration) and a dichotomous variable when entrants experience delays in obtaining rights of way (anticipated to be negatively correlated with penetration). The author fails to find statistically significant results for either variable.

Again, determining a meaningful metric for rights of way policy is challenging. Distaso's data-set is restricted to 14 European countries and it is unclear how accurate and comprehensive the rights of way metrics are for each nation. The increased centralization of telecommunications rules and authority in many of the EU member countries does ease this challenge. Likewise, authority over rights of way in the United States is increasingly shifting from municipalities to states, but the great diversity of regulation still makes cross-country analysis an extreme challenge.

Discussion of Econometric Results in the Literature

Given the challenges in data acquisition and the complex and context-dependent nature of broadband deployment, adoption, and policy, it is not surprising that econometric studies of the technology often conflict. Consequently, regression results on many independent variables remain mixed, but there are some emergent trends in the literature and even convergence on some of the factors driving broadband penetration. The most obvious trends are found in the supply factors, where there is some convergence in the literature regarding the positive correlation between population density and the existence of legacy infrastructure and broadband penetration. These trends include the correlations between penetration and population density, the presence of existing infrastructure.

In the demand sector, there are some positive signs that the addressable market, measured in dial-up subscribers who are likely to switch to broadband, is positively correlated with broadband penetration as well. Although Wallsten (2006) supplies evidence that dial-up may be competing in some markets, it is reasonable to predict that the accelerated evolution of services delivered over the Internet in recent years to include video, voice and other high-bandwidth services place more of a premium on broadband connectivity. This premium may attract consumers who had little use for a narrow band Internet but value the new services that only broadband can sufficiently deliver. Econometric analysis of other demand factors like income, education and age shows mixed results in the OECD while household computer ownership remains predictably positively correlated with penetration in models that include it.

Results regarding the impact of competitive factors remain mixed as well. Better refined data on broadband prices like that utilized by De Ridder may improve the analysis and results for this variable. Also, the question of whether competition or monopoly incentives spur broadband deployment may be better tested through case-study analysis that can consider sequencing and policy.

Policy makers should seek more qualitative data on the impact of policy factors. Regression analysis shows that both unbundling and inter-platform competition

strategies are impactful in many models, but mixed conclusions over which is the preferred approach signal a need for case-study and context based analysis of the local market before a policy choice (which may include both policies in sequence) is made.

A case-study based analysis will be undertaken in Chapters 5 for this express purpose, but first, econometric models that build on the research reviewed above will be presented in order to further test the most recent data on broadband in the OECD countries.

Chapter 4. Regression Model and Analysis

The econometric analysis undertaken in this section seeks to build on the results of the reviewed literature and sharpen the picture of cross-country analysis of broadband drivers for policy makers.

Data Sources

Data was obtained from the following sources:[43]

- The OECD Broadband Portal[44]
- The OECD Source online database
- The OECD Communications Outlook, 2007
- The OECD Communications Outlook, 2005
- The ITU's Online Database[45]
- The World Bank's *World Development Indicators Database*
- The ECTA's *Broadband Scorecard*, 3rd quarter 2007[46]

Included Variables and Discussion of Data

A wide range of data points and proxies for variables were considered, analyzed and filtered based on correlation matrix results and other reasoning. The discussion below is designed to shed light on the filtering process and to justify the inclusion of some of the variables and proxies in the final models, which will be presented in further detail in the subsequent section.

Dependent Variable

The dependent variable (PENETRATION) is available via the OECD Broadband Portal where it is defined as "broadband subscribers per 100 inhabitants, June 2007" and includes only residential household subscriber data. This data does

[43] Additionally, education data was obtained from OECD (2005), "Education at a Glance"; *years of unbundling* was calculated based on data from Umino (2004); computer ownership data for Australia from Australian Bureau of Statistics; computer ownership data for US from Government Accountability Office (2006).
[44] OECD Statistics (2007), *OECD Broadband Portal.* Available at: http://www.oecd.org/sti/ict/broadband
[45] International Telecommunications Union (2007), *Digital Opportunity Index*. Available at : http://www.itu.int/ITU-D/ict/doi/index.html
[46] European Competitive Telecommunications Association (2007), "ECTA Broadband Scorecard, End of September 2007," Last accessed on April 17, 2008. Available at: http://www.ectaportal.com/en/upload/File/Broadband%20Scorecards/Q307/BB_Sc_Q307_prv2.pdf

not include business-services subscribers or Internet cafes. There are observations for all the OECD countries (30).

Independent Variables

The independent variables included in the final regression models are defined below and discussion of the choice of these variables and the filtering process is included where relevant:[47]

Demand Factors

- ADDRESSABLE: Total Internet subscribers as a percent of the population, 2006. One of the metrics utilized by previous research as a proxy for the size of the addressable market is *Dial-up Share*. The most recent OECD data available on share of total Internet penetration attributed to dial-up is from 2005, but total penetration data according to the ITU's 2006 figures proved a better proxy for *addressable market*. This is the same metric used by De Ridder for his 2005 data set. As per the discussion in the literature review section, there is good reason to be skeptical about the sustained value in using proxies for latent broadband demand based on the number of dial-up subscribers in econometric models for penetration. However, dial-up switching may still be an important factor in certain nations. The variable is included in two of the models and the lagged variable is utilized to capture the impact.
- AGE: Percent of population over 40, 2005. A number of different proxies were considered and tested to serve as the AGE variable that is included in the final models. As discussed in the previous section, there is data to show that broadband adoption is much lower in the over 40 age cohort, so the percentage of the population over 40 years of age was determined to be the best proxy. It should be noted that De Ridder uses a different metric and none of the other models surveyed in the literature review utilize the age variable.
- COMPUTER: Households with access to a home computer, as a percentage of all households, 2006. Only 26 observations could be

[47] See Appendix 2 and 3 for Summary Statistics and Correlation Matrix

obtained for household computer ownership and it is only used in two of the models as a result.

- CONTENT: Total Internet hosts based on country-level domain, per capita, 2006.
- EDU: The share of the population aged 25 to 64 that has received tertiary education, 2005. This is an identical data point to the proxy utilized by De Ridder.
- GDP: GDP per capita, based on US dollar purchasing power parity, 2006.

One demand factor not considered in the final models is *Communications Spending*. A proxy of the relative propensity for household communications spending (detailed in Figure 7) was considered and tested as a demand factor but was determined to be too highly correlated with penetration and some of the independent variables that probably contributed to the OECD's calculation of communications spending. The inclusion of such a variable that does not interfere with model estimations should be considered for future research.

Supply Factors

- COVERAGE: Percentage of DSL coverage, 2005.[48] The best available proxy for broadband availability was DSL coverage, despite the inconsistent measurements for this variable already discussed in Chapter 2, footnote 38.
- INVEST: Investment in public telecommunications networks as a percentage of GDP per capita (USD PPP), 2005. The OECD provides robust tracking of firm-level investment in public telecommunications networks across the region and this variable is predicted to have a positive impact on deployment, quality of service, and penetration, though it is not included in previous econometric studies. Data on telecommunications investment by national governments was also sought but a reliable metric across countries could not be obtained.

[48] According to OECD (2007): "*DSL coverage is measured in various ways across the OECD. The percentages given above may represent the number of lines that have been upgraded, the population covered or the households which could subscrib*e.

- TELEDENSITY: Main telephone lines per 100 inhabitants, 2006. This traditional metric of telecom density proved the most effective measure of existing legacy infrastructure, though the OECD's measure of "total communication access paths" for a country was also considered.
- URBAN: Percentage of total population living in urban area. The following data points were also tested as proxies for population factors that might impact supply: the country's total landmass; the percentage of landmass used by the cumulative 50% of the population; and the number of inhabitants per square kilometer. Urbanicity – the percentage of total population living in urban areas, based on 2006 data from the World bank – proved to be the best proxy. This metric is also used by Wallsten, Bauer and De Ridder.

Competitive Factors

- LNPRICEBIT: Log of the average advertised broadband monthly price per advertised megabit per second received per (USD, PPP), 2007.

Data on average broadband download speed, available through the OECD Broadband Portal, was tested but ultimately not utilized as an independent variable because it is reflected in the *price per bit* variable. These variables are highly correlated as a result.

OECD data on percentage of "access line market share of new entrants…defined as direct access provision using own network" was also considered as a metric for *intra-platform competition*, but only 20 observations could be obtained and it was not included in the final models as a result.

Policy Factors

- INTERCOMP: A Herfindahl-Hirschman Index for inter-platform competition is utilized, whereby percentage shares of total penetration for each technology (DSL, Cable, Fiber, or Other) are squared and summed.[49] The reciprocal value is then used and multiplied by 100 to create an index that

[49] Data by country, by technological platform for 2007, available at OECD Broadband Portal.

theoretically ranges from zero (all subscribers are served by a single technological platform) to 75 (each of the four possible platforms serves 25% of broadband subscribers).[50]

- YRSUNBUND: Total years that local loop unbundling has been available. A number of proxies for *unbundling* were considered, including the monthly price charged by incumbents for local loop access, the percentage of DSL lines unbundled, and a dummy variable for unbundling. However, the former metrics were relatively lacking in terms of number of observations and *years unbundled* proved to be a slightly better measure than the dichotomous dummy.

Model Specification and Estimated Results

The variables specified above form the most reliable and comprehensive models for cross-national broadband penetration in the OECD, given the available data. A positive correlation with penetration is anticipated for all of the variables, with the exception of LNPRICEBIT and AGE. To test these hypotheses, standard OLS regression models were run according to the following specifications:[51]

Model 1

$$PEN_i = \beta_0 + \beta_1 LNPRICEBIT_i + \beta_2 ADDRESSABLE_i + \beta_3 AGE_i + \beta_4 COMPUTER_i + \beta_5 CONTENT_i + \beta_6 EDU_i + \beta_7 GDP_i + \beta_8 COVERAGE_i + \beta_9 INVEST_i + \beta_{10} TELEDENSITY_i + \beta_{11} URBAN_i + \beta_{12} INTERCOMP_i + \beta_{13} YRSUNBUND_i + u_i$$

Model 2

$$PEN_i = \beta_0 + \beta_1 LNPRICEBIT_i + \beta_2 ADDRESSABLE_i + \beta_3 AGE_i + \beta_4 CONTENT_i + \beta_5 EDU_i + \beta_6 GDP_i + \beta_7 COVERAGE_i + \beta_8 INVEST_i + \beta_9 TELEDENSITY_i + \beta_{10} URBAN_i + \beta_{11} INTERCOMP_i + \beta_{12} YRSUNBUND_i + u_i$$

Model 3

$$PEN_i = \beta_0 + \beta_1 LNPRICEBIT_i + \beta_2 AGE_i + \beta_3 CONTENT_i + \beta_4 EDU_i + \beta_5 GDP_i + \beta_6 COVERAGE_i + \beta_7 TELEDENSITY_i + \beta_8 URBAN_i + \beta_9 INTERCOMP_i + \beta_{10} YRSUNBUND_i + \beta_{11} INVEST_i + u_i$$

[50] For full table, see Appendix 4: OECD Inter-Platform Broadband Competition

Model 4

$$PEN_i = \beta_0 + \beta_1 LNPRICEBIT_i + \beta_2 AGE_i + \beta_3 TELEDENSITY_i + \beta_4 URBAN_i + \beta_5 INTERCOMP_i + \beta_6 CONTENT_i + \beta_7 INVEST + u_i$$

The constant β_0 is the model's Y-intercept and u_i is the error-term. Model 1 tests all of the selected independent variables listed above. Model 2 omits COMPUTER, which is the only variable with less than 30 observations. Model 3 omits ADDRESSABLE and COVERAGE as well. ADDRESSABLE is omitted because of the skepticism in the literature over the utility of measures of dial-up users as a proxy for latent demand, as discussed above in the *Data* section and in Chapter 3. Using Model 2 as the unrestricted model for F-test comparison, we fail to reject the null that ADDRESSABLE and COVERAGE are both equal to zero. Model 4 includes only the variables found to be significant in the previous models as well as those found to be most consistently significant in the literature; EDU, GDP, and YRSUNBUND are omitted in addition to the variables not included in Model 2 and Model 3. An F-test using Model 2 as the unrestricted regression fails to reject the null that ADDRESSABLE, COVERAGE, EDU, GDP, and YRSUNBUND are all equal to zero.

Table 3: Regression Results

	Regression Models [Adjusted R-Squared]			
Observations:	*26*	*30*	*30*	*30*
Dependent Variable = **PEN**	**Model 1 [.9304]**	**Model 2 [.8821]**	**Model 3 [.8893]**	**Model 4 [.8758]**
Competitive Factors				
LNPRICEBIT	-5.103103 (1.430714)*	-3.789777 (1.628907)*	-4.328846 (1.162067)*	-3.485321 (1.095718)*
Demand Factors				
ADDRESSABLE	.0026062 (.1165038)	.1263415 (.1392763)		
AGE	-.1938108 (.1322696)	-.2727324 (.1531312)**	-.2905834 (.1436726)**	-.261618 (.1416121)**
COMPUTER	.0919029 (.0726645)			
CONTENT	.2616254 (.0649309)*	.282818 (.0773902)*	.3304063 (.0474161)*	.3221602 (.0440746)*
EDU	.2267384 (.1037117)*	.1480858 (.1163685)	.1724072 (.1080053)	
GDP	-.0000671 (.0000553)	-.0000654 (.000066)	-.000068 (.0000635)	
Supply Factors				
COVERAGE	.0048292 (.042257)	-.0101985 (.0429851)		
INVEST	-8.392003 (4.674072)**	-9.883045 (5.992069)	-11.75834 (5.383333)*	-7.202135 (4.684657)
TELEDENSITY	.1089369 (.0976249)	.2409743 (.0918349)*	.2882059 (.0734606)*	.3357786 (.062378)*
URBAN	.1141283 (.0691061)	.1062986 (.0764364)	.1139224 (.0651786)**	.1116276 (.0669998)
Policy Factors				
INTERCOMP	.0892433 (.0365437)*	.1017222 (.0422441)*	.1080561 (.0338589)*	.1414168 (.030607)*
YRSUNBUND	.3911366 (.328928)	.163505 (.2952862)	.0804197 (.2709822)	
CONSTANT	12.38917 (10.66907)	13.96681 (11.55471)	15.23941 (10.1723)	8.909518 (10.12041)

Estimated Coefficients
(Estimated Standard Error)

**Statistically Significant at 95%*
***Statistically Significant at 90%*

Discussion of Findings

The statistically significant negative impact of consumer price per megabit received (LNPRICEBIT) on penetration is salient and builds on the results from De Ridder's analysis. CONTENT is the only statistically significant demand variable across all the models that consider it, but the coefficient is relatively small considering the measure is of Internet hosts per capita and total number of hosts among OECD nations are now extremely high. INTERCOMP (inter-platform competition) is statistically significant with a .05 alpha across all the models as well and will be discussed in detail below.

Looking at the demand factors, the *age* variable is statistically significant at the 90% confidence interval in all the models that don't include the computer variable. The lower observations (26) for COMPUTER probably contributes to the lack of statistical significance for AGE in Model 1. Meanwhile, the *education* variable is only statistically significant when COMPUTER is included. This is because of the observable data points that are introduced into the model without COMPUTER, for which there is no data for Canada, Japan, Switzerland, and Turkey. Switzerland, which is just above the mean in terms of education, is ranked third in terms of broadband penetration, while Canada and Japan rank high in terms of education (Canada is 1st) but considerably lower in terms of penetration (10th and 16th respectively). The coefficient for EDU is lower and the standard error higher in the three models that include these nations as a result.

GDP is consistently insignificant in the models that consider it, which is not entirely surprising given the theories established through previous research that GDP only impacts broadband penetration up until a certain threshold, after which its impact is negative. If this is the case, then wealthy OECD nations are likely beyond the GDP threshold.[52]

Among the supply factors, the *telecommunications investment* shows mixed results and, surprisingly, has a negative sign when statistically significant in models 1 and 3. Although lagged data (from 2005) was used for the INVEST

[52] *Log GDP* was also tested but had only a marginal impact on the coefficient and was still statistically insignificant.

variable, these contradictory result could still be an issue of timing on the return on investment. While this study does not explore research on telecommunications investments and returns, it is possible that the coefficient on INVEST could change over time as network upgrades, infrastructure build-out, and a reactive marketplace come to fruition.

The lack of statistically significant results for the URBAN variable in all three of the models is also surprising because other studies in the literature review found relatively consistent positive results. One reason for the lack of results in my models could be due to the inclusion of the TELEDENSITY variable, which is highly correlated with *urabanicity* and may be capturing most of the impact that high population density would have on deployment of broadband supply. TELEDENSITY, like the AGE variable, is statistically significant in all the models that do not include COMPUTER and benefit from the higher level of observations.

Among the policy factors, inter-platform competition proved to have a statistically significant impact on penetration in all of the models, while the *unbundling* proxy (YRSUNBUND) did not at all. In light of previously mixed results between these two variables in the econometric literature, the rise of fiber as a significant inter-platform competitor should be highlighted. The introduction of this new broadband technology is impacting the competitive marketplace and contributing to increased broadband penetration. As costs are reduced for the deployment of a variety of broadband technologies, enhanced *inter-platform competition* that drives higher penetration rates may be a more significant driver. However, unbundling clearly remains an important policy tool and the subsequent case-study analysis will help shed light on how unbundling initiatives might be optimized when properly sequenced with enhanced inter-platform competition in certain markets.

Policy makers should also take note of the results for the price metric, which were consistent in nearly all the regressions I tested: the price-elastic market of early adopters may be close to saturation and future broadband penetration may

depend on price to a much greater extent. Policy makers will be challenged to be attune to unique market factors that may or may not require open infrastructure policies like unbundling and/or 3rd pipe incentives for inter-platform deployment that will induce competition and drive down prices. However, lower prices may also mean reduced incentives for entrants and the results of these models show that 3rd pipe policies and strategic investments in innovation of broadband technologies may be more promising tools for sustaining growth in penetration rates.

At this point, it will be useful to examine how policy makers have responded to these unique challenges of the broadband market place through case-study analysis on the regional and national levels.

Chapter 5. Case-Study Analysis of Broadband Drivers

Given the complex and interdependent nature of all of the factors impacting global broadband penetration rates, particularly the policy factors, there's a great deal to be learned from national case-study analysis that attempts to understand the correlations between and the impacts of broadband market factors in the national context. The case-studies reviewed below focus on the these factors as well as the policies and strategies that compose NIIIs. The studies add value to this analysis by contextualizing the implementation of the policies already reviewed and offer a chance to examine outcomes on the national and sometimes regional levels.

East Asia

Fransman et. al. (2006) present one of the most recent and extensive case-study collections that explores the various national institutional and political factors that can impact broadband penetration. The book focuses on the puzzle of how nations like Japan, Korea, and many in Europe have surged in broadband penetration in the last 4 – 8 years, while nations like the US and UK seem to lag by the OECD metrics. Empirical results point to a number of explanatory factors for the broadband divide among OECD nations and Fransman et. al. take up the cause of examining whether a stronger regulatory regime and successful unbundling of the local DSL loop in nations that lead the broadband standing is responsible.

The role of the regulator does appear to be a factor in Japan, though the utilization of unbundling policy was probably only one of many policy and political factors. Fransman and Ida note that at first, the unique political-institutional game between the incumbent (NTT) and the regulator in Japan contributed to significant broadband build-out that was not necessarily induced by discrete policy tools. NTT has since been restrained to a greater degree by the regulator and Ida notes the harsh and asymmetric regulation and unbundling NTT has been subject to. Kushida and Oh (2006) tend to agree with Fransman and Ida that political circumstances and disruptive competition spurred in part by the

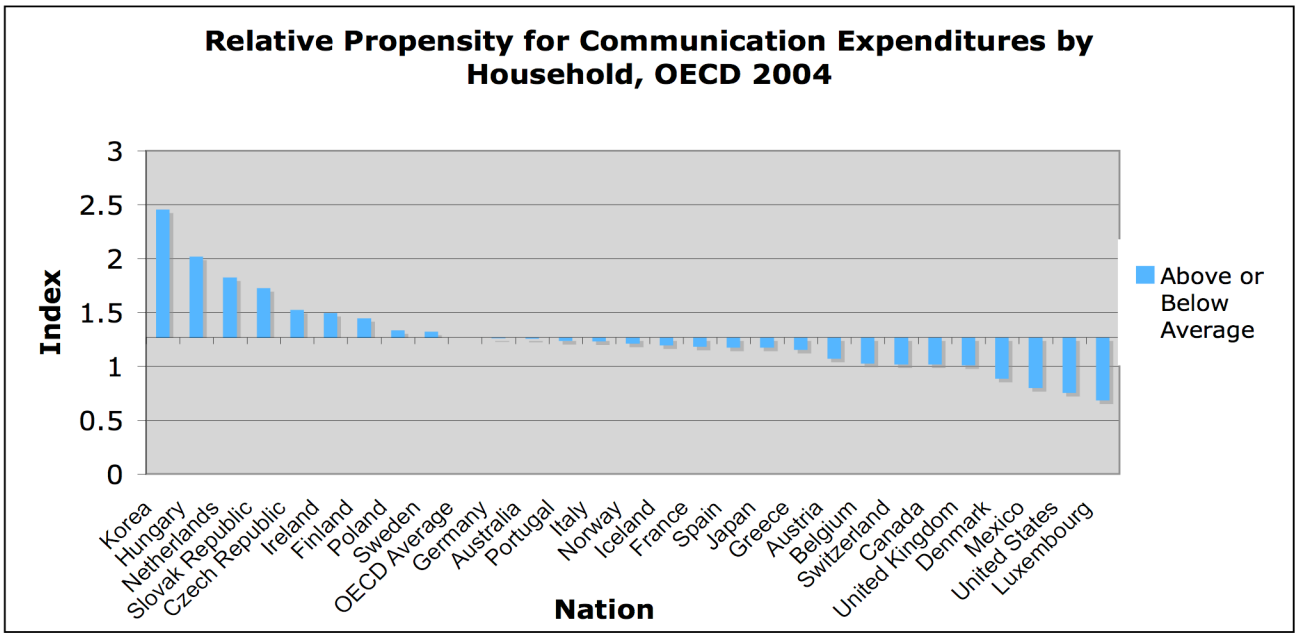
harsh unbundling requirements placed on NTT contributed to broadband's success in Japan. It should be noted that penetration rates in Japan are challenged by a significant rural population and the higher propensity for Japanese households to rely on Internet cafes as opposed to home computer ownership. Still, both intra-modal and facilities-based competition and build-out continue in Japan where 56% of the market is served by DSL, 33% Fiber and 14% Cable, and the price per megabit of service is lower than anywhere in the OECD.

Local loop unbundling in Korea appears to have played less of a role but other government policies and initiatives were critical. The ITU conducted an in-depth case study of Korea in 2003 (see Kelly et. al.) that highlights unique demand factors that drove broadband adoption as well as a vibrant marketplace on the supply-side where firms were consistently pressured to upgrade infrastructure and provide new services. Facilities-based competition flourished in this environment in the late 90s and Korea transitioned from a country with an Internet subscribership of under 1% in 1995 to the leading nation in the OECD broadband rankings in 2002. Chung's 2006 case-study supports these findings and nicely maps the history of the broadband market in Korea and the key role played by disruptive competition. However, both of these case studies note that the vibrant broadband market in Korea owes much to the government's NIII – Chung cites government investment in the Internet backbone to the tune of $747 million beginning in 1995 and Kelly maps a history of comprehensive government initiaitives and public-private partnerships dating back to 1997 expressly focused on stimulating the IT and broadband sectors. Picot and Wernick (2007) support these findings as well and cite Korea's Information Infrastructure Plan, direct government investment in backbone infrastructure, and the lack of restrictions on market entrants to be significant drivers.

Many scholars are quick to point out the unique market and demand advantages that have propelled Korea – a relatively economically disadvantaged nation in the OECD club - to the top of the broadband rankings. Some of the Demand and Market Factors that are particularly high in Korea include a densely populated,

youthful, urban population-base and a large pool of early adopters. Frieden (2005) notes that the entrepreneurial spirit of Koreans on the supply side also drives up penetration rates as producers are eager to meet the high demand. OECD data below supports the view that Korea might be an outlier in terms of broadband Demand Factors, as Koreans have by far the highest propensity to spend on communications technologies compared to other OECD populations:

Figure 7: OECD Communications Spending



Additionally, Korea may have actually benefited from the relatively low penetration rates realized in the dial-up Internet era. Some analysts suggest that nations with high dial-up subscription rates may suffer from a market place where consumers are hesitant to switch to broadband. Meanwhile, in Korea, by the time government investment in infrastructure and private sector Internet services came to full realization, broadband was the mode of choice and many citizens have, in effect, been raised on high-speed Internet.

Europe

Alongside Japan and Korea as broadband leaders are a number of European nations. Scholars find a variety of explanatory factors for European success in

broadband penetration, depending on the nation and sometimes sub-region of focus.

The Scandinavian nations and the Netherlands, for example are noted to have benefited from government ownership and investment in fiber infrastructure. In 2001, the Swedish government invested 5 billion Kroner in rural broadband networks and the Dutch government invested $39 million in Fiber To The Home networks and R & D.[53] OECD 2007 also cites a variety of demand factors in many European nations (like Income and education), the benefit of urbanization (particularly in Denmark and Iceland), but also the success of LLU (in Denmark, Finland, and the Netherlands) as broadband drivers. These governments were also early movers when it came to initiatives to develop the wider ICT sector and effectively stimulate demand for broadband services. The Danish government, has invested in a program to help small businesses realize the benefits of broadband and ICT and the Swedish government has been subsidizing computer ownership since 1997 and now ranks third among OECD nations by this metric.

In Western Europe, there is significant evidence of a correlation between broadband penetration and LLU. J. Scott Marcus (2005) found that approximately 1/4th of the 12 million new broadband lines subscribed to in the EU in a 12 month period from 2003 to 2004 were either fully unbundled, shared access, bitstream access, or simple resale lines. In France, this number was at nearly 45% and broadband penetration nearly doubled for the same period. In Germany, entrants share of Deutche Telecom's DSL market via unbundled lines grew from 5% in 2002 to 13% in 2004.[54] By 2006, new entrants had a majority share of the overall EU broadband market.[55]

[53] Taaffe, Joanne, June 18, 2001, "Dutch, Swedes Vote Subsidies for Broadband-Government Activity," *Communications Week International*.
[54] Cave (2006), p229.
[55] European Commission (2007).

Table 4: Unbundled DSL Lines in Select European Nations[56]

	31/12/2002	31/12/2003	30/12/2004	30/06/2005
Germany	175 000	465 000	870 000	1 500 000
% of DSL lines	5%	10%	13%	18%
Spain	3 000	16 000	114 000	297 000
% of DSL lines	0%	1%	4%	9%
France	3 000	273 000	1 591 000	2 330 000
% of DSL lines	0%	8%	25%	30%
Italy	52 000	240 000	450 000	653 000
% of DSL lines	6%	11%	10%	12%
Netherlands	50 000	232 000	462 000	584 000
% of DSL lines	14%	24%	25%	27%
United Kingdom	2 000	8 000	47 000	69 000
% of DSL lines	0%	0%	1%	1%
Sweden	9 000	30 000	210 000	299 000
% of DSL lines	2%	5%	24%	25%

Case-study analysis highlights a variety of common drivers in both Europe and East Asia. Krafft (2006) notes the impact of disruptive competition in the French DSL market and the importance of a concerted government effort to reform the National Infocommunications System of Innovation in order to “catch-up” in broadband. Likewise, Schejter (2007) highlights the importance of setting definitive goals in crafting an “information society” in Europe, both at the regional and national institutional levels, strategically implementing policy in order to meet the goals, which included expanded broadband penetration and enhanced competition.

Eccentricities in the European market-place are revealed through national case-studies. Direct government investment in an expansive municipal broadband infrastructure and intense competition in the private-sector market for open access is noteworthy in Sweden (Lindmark, 2006). The market in both Italy and Germany is dominated by the telecom incumbent and progress in inter-platform competition is extremely slow (Bullingen, 2006 and Cristiano, 2006). Competition is widely restricted to the DSL platform in France as well, but an aggressive

[56] Le Floch (2006).

regulator is one of the reasons the incumbent hasn't been able to dominate the market like its counterparts in neighboring countries.

The European Union and Commission have also played significant roles in broadband policies on the continent, despite lacking a great deal of the necessary authority and tools. Picot and Wernick (2007) reveal the importance of the Commission in setting objectives, putting direct and indirect pressure on member states, and coordinating policies and build-out efforts. Most importantly though, EU law has a major influence on how member states define and implement unbundling policy, as revealed in Schecter (2007). The author analyzes the legal framework governing telecom in the EU and highlights the importance of the clear and strict definition of the "local loop" by the EU as being distinct from the vagaries of US law. The wider role of the European Union as a regional legal institution dictated that these vital definitions be "made at the highest normative level [while] the analysis for their application is made at the [national] regulator level," (p25). Despite the lack of regulatory authority for the EU or even regulatory harmonization among the member states,[57] the regional institutions and the structural component they provide have still contributed to the broadband Policy Factors.

Global Trends and the International Broadband Competition

The process of policy migration from region to region is another factor highlighted in the case-study literature. Privatization is one common meme, beginning with the break-up of AT&T in the US and privatization in the UK, researchers have uncovered distinct trends in telecom policy that have migrated across the OECD countries. More relevant to this analysis, Kahin (1997) finds that US gains in Internet innovation and the Clinton/Gore administration's rhetoric to create an "information society" to be important catalysts in the development of national information infrastructure initiatives in Japan. The authors then trace the competition in digital advancement to Korea, where gains by both the US and

[57] Fransman (2006) notes that there is a distinct drive towards harmonization of telecom regulation within the EU but that it would be inaccurate to consider any body other than the National Regulatory Agencies to be in possession of a given nations broadband policy tools.

Japan are cited as the impetus for national programs to expand Internet deployment and adoption. Ure (2003) also characterizes aggressive unbundling initiative in Japan as part of a strategy within a regional competition over broadband penetration rates.

Various European nations have adopted and reformed policy tools as a part of these national strategies as well, like local loop unbundling and stimulation of inter-platform competition, based on implementation models in East Asia and the US. Krafft's case-study notes the corrective nature of efforts in France to expand broadband penetration as a direct response to the success of Korea and Japan in this arena. Additionally, the OECD rankings of national broadband performance - though problematized in both the scholarship and the main stream press[58] - have provided and added element of competition for some of the OECD nations. For example, De Ridder notes that recent policy initiatives in New Zealand have been explicitly spurred by poor showings in the rankings.

Discussion of Broadband Policy Strategies in East Asia and Europe

When broadband markets and policies designed to enhance them are examined from the ground-up, through case study analysis, some important lessons emerge, particularly in the context of the regression results from previous studies as well as the models in this analysis. In East Asia, for example, intense competition to enhance value-added services and broadband speeds have contributed to both lower prices and higher levels of broadband penetration. Lower prices, in Korea in particular, are also driven by unusually high demand, but these factors had to overcome a notable income deficit (compared to most other OECD nations). If price and speed are becoming more significant factors contributing to broadband penetration, then the case of Korea, where these factors have always played a greater role, should be instructive for policy makers.

[58] Within the scholarship reviewed here, Wallsten (2007) is the most outspoken critic of the rankings and FCC Commissioner Roger McDowell summed-up skepticism over the rankings from the US perspective in his 2007 article "Broadband Baloney."

Circumstances in Korea (and Japan to a lesser degree) required a comprehensive broadband strategy from policy makers that combined investment in infrastructure and key partnerships with the private sector. Korea's NIII permeated multiple levels of government; IT skills were effectively integrated into national education curriculums; "broadband certification" was required for building permits at an early stage; and buy-in from major research institutes was facilitated. The East Asia cases - and some of the Scandinavian nations - also reveal that there is a role for policy makers in stimulating demand for broadband. For example Japan is the "oldest" population in the OECD and the Ministry of International Affairs and Communications has developed a comprehensive "E-Japan Strategy" with a focus on consumer protection measures, online security, e-mail spam reduction and integration of E-services into government as demand-side initiatives that are responsive to this demographic.

Supply-side policies have also been crucial in Japan, and the timing of unbundling particularly so. One outcome of the political game between NTT and the government over efforts to break-up the telecom behemoth throughout the early 90s was the massive build-out of infrastructure by the incumbent in an effort to enhance its reputation and justify its monopoly status. By 1998, after the pseudo break-up of NTT into three sub-entities under a single holding company was complete, the regulator was finally in position to enforce open infrastructure policies. There was plenty of infrastructure to open up and entrepreneurs were able to enter the market at a reduced rate.

An infrastructure glut that is opened up to entrants appears to be part of the story in nations like Sweden, Norway, and Denmark as well, though here it was a combination of the incumbent's build-out and direct investment by the government in backbone infrastructure and beyond – particularly in Sweden, where government initiatives to meet USOs contributed a great deal to build-out beyond Stockholm. Strategic investments in the IT business sector and R & D are another contributor in the Scandinavian nations.

Significant growth in broadband penetration rates in West Europe have been much more recent. Demand factors are not as prominent in this region and incumbent build-out has been slow in comparison to the Scandinavian nations and Japan. In Italy, for example, the politically influential incumbent Telecom Italia, free of any unbundling requirements, has dominated the DSL market (which itself composes 97% of Italy's broadband market). Inter-platform competition is struggling to emerge in Italy and penetration rates remain low.

Recent progress in other West European nations appears to be due, in part, to unbundling policies that are beginning to induce competition in the DSL sector (the role of regional institutions in supporting and coordinating the implementation of these policies is also noteworthy). Germany, which had been a traditional laggard, saw the second highest growth in the OECD from 2006-2007, most of which was in the DSL sector where the line leasing and resale market is now vibrant. In France, the DSL incumbent was able to resist unbundling and dominate the market while inter-platform entrants consistently failed to compete. In 2002 the regulator introduced aggressive unbundling policies and competition in the DSL sector flourished. Now the incumbent strategy is focused on fiber build-out, a booming sector in its own right where early movers and some cross-over providers from the newly competitive DSL sector will pose competition. France has moved from 17th in the broadband rankings and well below the OECD penetration average to 13th and well above from 2003 to 2007.

Chapter 6. Discussion of Findings and Recommendations for US Broadband Policy

The empirical research undertaken in the last few chapters sought to identify the key broadband drivers and the most effective policy tools for enhancing them. Returning to the segmented model of the broadband market factors, findings from the empirical research will now be distilled and contextualized for the U.S. case. Each section of this chapter will begin by returning to one of the research questions posed in the Introduction.

Contemporary Drivers of Broadband

(What are the key market factors driving broadband penetration among the leading nations?)

Demand Factors

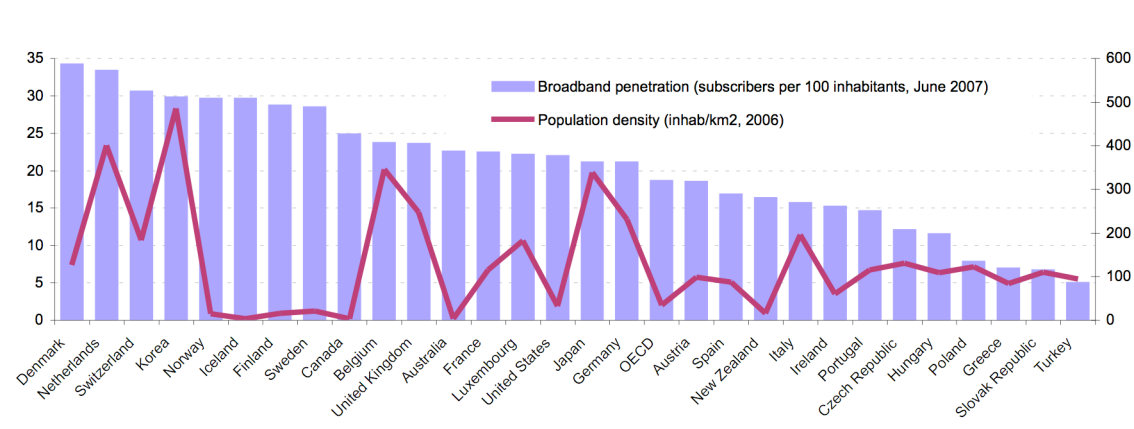
A key finding regarding demand drivers is that certain factors are less prominent than predicted, like income, age, and education. As the global broadband market matures and broadband becomes critical infrastructure for all citizens, certain aspects of demand demography are becoming less of barrier to high penetration levels. The consumer's path to broadband is also changing, with less evidence that dial-up is a necessary step towards broadband and value-added services making leap-frogging more likely. However, the econometric models in this paper highlight the fact that locally relevant content remains a key demand driver. Also, the issue of computer ownership and other consumer ICT hardware ownership factors will remain an important factor and policy makers should take notice of these variables as two of the few demand factors that policy can more easily influence (as opposed to age or income, for example) and can easily integrate into a NIII through demand-side programming to stimulate the production of local content and ICT adoption.

Supply

The emergent convergence in the literature regarding the importance of certain supply factors like population density and teledensity (the latter is enhanced by econometric findings in this paper) should signal to policy makers the acute

challenge they face in incentivizing infrastructure build-out to rural areas. But many nations are meeting this challenge by refining USOs and developing new build-out incentives and partnerships to meet the demands of evolving telecommunications technologies. It's worth noting that half of the top-ten nations in the chart below have population densities below the OECD average and that the Netherlands and Switzerland have succeeded as well despite low levels of urbanicity:

Figure 8: Broadband Penetration and Population Densities



Competitive

Price and speed are key emergent drivers of broadband penetration in the OECD. This is in part due to the technological advancements of broadband itself, which can deliver value-added services above previous speed thresholds. Also, customized pricing plans in markets where a variety of speeds and/or bandwidth allocations are available could be behind this trend. This should signal to policy makers the importance of having competitive markets that both drive down prices and incentivize innovations in services and infrastructure.

Key Broadband Policy Factors

(What are the available policy tools that have been proven to positively stimulate the drivers of broadband deployment and adoption?)

The econometric research has shown mixed results when it comes to unbundling and inter-platform competition, which are often framed as opposing policies in the literature. The econometric results of this study show that the impact of inter-

platform competition may be strengthening as a result of the emergence of fiber technology. However, the case-study analysis reveals that unbundling proves impactful for nations that can rely on a glut of legacy infrastructure developed by either the incumber (in the case of Japan and Germany) or the government (in the case of Sweden and Denmark), but timing and enforcement are crucial. Meanwhile, nations that choose a 3rd pipe strategy (like Korea) must develop comprehensive initiatives as part of the NIII to support investment and enhance demand drivers. But there is also a vital inter-play between open infrastructure and 3rd pipe strategies: as unbundling achieves its objectives, 3rd pipe entrants will also emerge and responsive policy making that fosters inter-platform competition as well will need to be initiated. This was the sequence of events in Japan where inter-platform competition is now plentiful. France appears to be on the cusp of these benefits as well but the regulator will be challenged to refine open infrastructure policies in order to sustain competition within and between new platforms.[59]

The case studies reveal that there is a significant role for government in broadband policy and strategy beyond just unbundling. An effective NIII is a concerted effort on the part of policy makers that includes the buy-in of many institutions, private sector firms, and the public at large. Emerging empirical research on the positive impact of broadband on economic competitiveness reveals that enhancement and expansion of this critical infrastructure are valuable policy objectives.

A Critical Look at the US NIII

(Is there room for improvement in the US when it comes to broadband and broadband policy in the US?)

In light of the findings cited above, it is worth returning to the current broadband strategies that compose the US NIII and considering their efficacy.

[59] As Fiber build-outs by multiple firms commence in France, the regulator is under pressure by entrants to sustain strict unbundling policies in the fiber sector that would be comparable to its aggressive enforcement on the DSL incumbent, France Telecom. Meanwhile, France Telecom will also be a significant player in Fiber and is demanding that these regulations apply to entrants as well in the emergent Fiber platform.

Another Look at US Broadband Strategies

Policy makers in the US currently favor deregulation and forbearance on open infrastructure regulation all in the interest of incentivizing extended build-out of existing infrastructure as well as inter-platform competitive entrants. The rhetoric in the US speaks to a policy that favors the 3rd pipe strategy and is based on a logic that posits that forbearance on open infrastructure policies will induce development of 3rd pipes by private sector providers that will then deploy new infrastructure without fear of open infrastructure regulation cutting into profits on new platforms or extensions of legacy platforms.

While there is some evidence that the recent change in course in the US away from an open infrastructure strategy may prove successful – many cite the budding FTTH initiative by Verizon Communications, for example – there is also well-founded criticism of the current strategies and many signs that they are not succeeding. The US is falling behind according to many of the OECD's broadband metrics, particularly in terms of price, speed and fiber build-out.

Criticism in the scholarship and even in the main stream media often cite regulatory backpedaling on unbundling requirements from the '96 Act as a source of some of the failings in US broadband performance. The glaring lack of competitive markets in the DSL sector is likely an outcome of both this policy shift and the recent consolidation of national DSL providers. However, the 3rd pipe strategy has arguably been successful, given the US' high ranking (5th in the OECD) in terms of inter-platform competition.[60]

Despite this success, analysts like Bauer (2005) are justifiably concerned over whether competition and innovation in the inter-platform marketplace will be sufficient to drive down prices and boost speeds in the US compared to those of East Asia and Europe. Disruptive competition, spurred in large part by aggressive unbundling requirements placed on NTT, played a major role in driving down prices and advancing penetration rates in Japan. France has embraced this model as well and signs of disruptive competition there are

[60] See Appendix 4: OECD Inter-Platform Broadband Competition.

beginning to emerge. Disruptive competition again is cited as a major driver in Korea as well. But here, a 3rd pipe strategy is what induced competition, but one that was notably integrated in a comprehensive, driven, and ultimately impactful NIII.

While the debate over *open infrastructure* vs. *3rd pipe* continues, there has been greater convergence in the criticism of the US national broadband strategy, programs within the rural expansion strategy, and the larger NIII. First and foremost, criticisms regarding the FCC's data collection methodology and metrics have been widespread. The commission responded in March 2008 with significant rule changes that included increasing the speed that defines basic broadband (to a 768 kbps minimum); the requirement that providers report broadband services on a more granular, tier-based system; increasing data collection frequency; and the requirement that providers report service at the census track level (as opposed to the less granular zip code level).[61]

Within its current *rural expansion strategy* the two main programs to fund broadband expansion into rural and low-income areas, the USDA's broadband loans program and the Universal Service Fund administered by the FCC, have been highly criticized. The USDA program, as of 2005 had approved $872 Million in loans to rural broadband providers but has been widely criticized for both its lack of funds distributed and misallocations of funds that were distributed.[62] The Congressional Research Committee (November 9, 2007) estimates the program's rate of loan awards to be as low as 5% and a series of reforms for the program are currently under review (see Federal Register, 2005). In regard to the USF, S. Derek Turner's (2006) empirical research on rural broadband deficits finds evidence that reforms of the Fund directed at broadband services could also greatly improve the impact on rural populations and in November 2007 the Federal-State Joint Board on Universal Service recommended a series of reforms that would redirect USF moneys to broadband.[63]

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[61] See Federal Communications Commission, 19 March, 2008, "FCC Expands, Improves Broadband Data Collection," last accessed on April 20, 2008. Available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-280909A1.pdf

[62] See USDA (2005) and Reardon, Marguerite. May 31, 2006. "USDA Sued Over Broadband Loan Program." *CnetNew.com.* Last accessed on April 19, 2008. Available at: http://www.news.com/USDA-sued-over-broadband-loan-program/2100-1034_3-6078762.html

[63] Available at: http://www.fcc.gov/wcb/tapd/universal_service/JointBoard/welcome.html

Finally, a common criticism of the overall US broadband strategy is that it's lacking or even absent.[64] However, the survey of current efforts in the US to this point clearly shows that this is not the case: US policy makers have carved out policies that embrace a 3rd pipe strategy, that are staunchly deregulatory and free market, that have set and nearly achieved the goal of universal broadband service, and that seek to facilitate continued innovation in the ICT sector through tax based incentives and R & D investments.

The sentiment that the US "lacks a national broadband strategy" actually speaks to the absence of an effective NIII and a failure on the part of elected officials and policy makers to articulate explicit and meaningful values in and objectives for improving national information infrastructure and access to it.

Towards an Effective NIII

(How can policies that have proved successful in other nations be adapted and applied to the US context?)

The case-study literature reviewed in this analysis consistently points to the important role national governments can play in coordinating broadband strategies and developing policies responsive to a complex marketplace, communicating values and objectives to the public that support those strategies and policies, and facilitating partnerships and buy-in from a range of stakeholders as part of a truly national initiative. An effective NIII starts with good data and motivated public officials that share the value of enhancing and expanding critical infrastructure in order to improve global competitiveness. In East Asia, and increasingly in Europe, we have seen governments develop comprehensive initiatives that have overcome a number of factors that might have held these nations back in terms of broadband performance. These NIIIs were driven in part by a sense of competition and a desire to innovate - in the policy realm as well as

[64] See Baller and Lide (2007), who also cite Commissioner Copps in their criticism of the "absence of a national broadband strategy."

the technological realm - in order to keep pace with other world leaders. An effective NIII will first require a sense of urgency and a desire to innovate.

Returning to the NIII *Broadband Strategies Framework*, the following policy recommendations are proposed for each of the broadband strategy segments:

National Broadband Strategy

The face of the NIII, the national broadband strategy involves public messaging, coordination of policies and actors, monitoring of progress, and investment in demand-side initiatives to facilitate innovation and adoption. Based on results of this study, the following recommendations are proposed as reforms to the current national broadband strategy:

- Follow-through on recent improvements to FCC broadband data acquisition and metrics with aggressive monitoring and decisive reporting on the part of the NTIA.

- Data-driven objectives that broadly seek to improve broadband penetration rates, prices, and quality of service should be developed and articulated to the public.

- Partnerships with the private sector and civil society should be sought out and demand-side initiatives that improve ICT skill-sets and adoption rates should be developed.

- Integration of NIII into multiple levels of government, policy making, and policy initiatives should be facilitated.

Open Infrastructure Strategy

The econometric literature and cases reviewed in this study show that unbundling policies can induce competition and contribute to expanded broadband penetration, however, expanded and enhanced broadband clearly does not require unbundling. Successful open infrastructure policies are

strategically applied and sequenced appropriately. Additionally, as the Europe case studies show, institutional structure and authority is an issue that can't be ignored.

- A careful examination of the deregulation of broadband infrastructure should be undertaken and empirical analysis of whether open infrastructure policies in the U.S. should be instated or reinstated should be part of this effort. With the emergence of fiber broadband technology as a service option in the U.S. and often to a greater extent in other OECD nations, the question of whether or not unbundling fiber infrastructure will enhance competition without restricting build-out should be addressed immediately.

- Open infrastructure policies should be reevaluated at the national level. If unbundling is to ever be utilized as an effective policy tool in the US, the FCC must work to define clear terms for it and local institutions must be granted the power of enforcement.

- Open infrastructure rules recently applied to wireless spectrum should be monitored, enforced, and gauged for efficacy.

3rd Pipe Strategy

Current policies in this sector have met some success and will likely be enhanced by a more driven and comprehensive NIII, as was the case in Korea. Successful 3rd pipe strategies depend on innovation, but policy makers should be careful that US global competitiveness does not risk being completely *dependent* on innovation. A responsible and responsive 3rd pipe strategy requires the following reforms:

- Direct R & D investment (or policies that incentivize it indirectly) should be based on sound research that is free from political and corporate interests.

- Policies and initiatives to free up wireless spectrum for broadband communications should continue to be pursued, but the process needs to be better streamlined, expedited, and freed from political and corporate interests.

- Rights of way should continue to be eased. “One-stop state franchising” for rights of way permits that include significant requirements for low-income and rural build-out and allowances for public interest broadcasting are a promising policy mechanism in this regard, but one that still requires monitoring.

Rural Expansion Strategy

The objective of rural expansion policies should be filling the gaps in access between rich and poor, urban and rural. Demand for broadband services beyond urban centers is proving significant but progress by private sector firms to undertake expensive build-outs to these areas has been slow in the US. In light of this market failure, the following reforms of the current rural expansion strategy are proposed:

- Universal Service Obligations should be refined for the broadband age and a satisfactory portion of the USF should be explicitly directed to broadband communications.

- The USDA rural broadband loan and grant programs needs to be better supported by expert analysis, on-the-ground monitoring, and clearly defined rules for awards that consider a wider pool of applicants.

- Public private partnerships between local governments, service providers, and civil society organizations that combine public and private moneys for infrastructure investment should be supported and facilitated.

Conclusions and Suggestions for Future Research

The preceding analysis of broadband drivers in the OECD contributes to a growing body of econometric and case-study based research that seeks to identify how policy makers can expand and enhance broadband deployment and adoption in order to improve global competitiveness. Such research can help policy makers better understand the dynamic broadband marketplace and develop effective national information infrastructure initiatives to stimulate growth in a critical infrastructure sector. The results of this study should signal the key areas where policy makers can make a positive contribution to broadband markets: by inducing competition that drives down prices and spurs innovations, by leading and coordinating demand-side initiatives that consider the wider ICT sector, and by investing in policies and initiatives that facilitate the build-out of critical infrastructure. The evidence suggests that the policies that are a part of such initiatives should be part of a larger initiative that is effectively articulated to the citizenry and private sector partners alike, that the policies should be data and context driven, and that policies and the institutions that determine them should be highly responsive to the unique character of local broadband markets.

The experiences of the world's leaders in broadband performance show that such initiatives can make a difference and future research should seek to empirically measure these impacts. One promising case-study in this regard would be Korea, where measures of the impact of the nation's world-class broadband infrastructure on its global competitiveness would greatly add to existing scholarship. Another subject for study is nations where direct government investment in broadband infrastructure has been significant, like Sweden and Iceland. An examination of the open infrastructure policies as they were applied to these networks and the corresponding effect on competition, prices, and social welfare costs would be enlightening. Researchers should also closely monitor the current progress in fiber build-outs around the world. This new platform is already a major player in Japan and case-study research on the contributing factors to this success should be conducted. Meanwhile, deployment of fiber is just taking off in France, a nation that has only recently instigated high levels of competition across broadband technologies. Empirical research on the effect of recent policy reforms in France and other west European nations will prove timely as many others in the OECD will be struggling with how to induce fiber build-outs and continue to compete.

Bibliography

Aron, D.J. and D.E. Burnstein. 2003. "Broadband adoption in the United States: an empirical analysis." Paper presented at the *31st Research Conference on Communication, Information and Internet Policy*, Arlington, VA, September 19-21. Available at SSRN: http://ssrn.com/abstract=386100

Baller, Jim and Casey Lide. 2007. "Eight Bold Steps to a National Broadband Strategy," *FTTH Prism*, Vol. 4, No. 1, January.

Bauer, Johannes. 2005. "Unbundling Policy in the US: Players, Outcomes and Effects." *Communications & Strategies* 57.

Bauer, Johannes. 2006. "Broadband in the United States." From *Global Broadband Battles: Why the US and Europe Lag While Asia Leads*, Martin Fransman, ed. Stanford Business Books: California. pp133-163.

Bauer, Johannes and Jung Hyun Kim and Steven S. Wildman. 2003. "Broadband Uptake in OECD Countries: Policy Lessons and Unexplained Patterns." Paper presented at the *European Regional Conference of the International Telecommunications Society,* Helsinki, Finland, August 23-34, 2003.

Bullingen, Franz. 2006. "Development of the Broadband Market in Germany" From *Global Broadband Battles: Why the US and Europe Lag While Asia Leads*, Martin Fransman, ed. Stanford Business Books: California. pp195-218.

Cava-Ferreruela, Inmaculada and Antonio Alabau-Munoz. 2006. "Broadband Policy Assessment: A Cross-National Empirical Analysis," *Telecommunications Policy* 30: pp445-463.

Cave, Martin. 2006. "Encouraging Infrastructure Competition Via the Ladder of Investment." *Telecommunications Policy* 30, pp223-237.

Chung, Inho. 2006. “Broadband, the Information Society, and National Systems.” From *Global Broadband Battles: Why the US and Europe Lag While Asia Leads*, Martin Fransman, ed. Stanford Business Books: California. pp87-108.

Cristiano Antronelli and Pier Paolo Patrucco, "Broadband in Italy" From *Global Broadband Battles: Why the US and Europe Lag While Asia Leads*, Martin Fransman, ed. Stanford Business Books: California, pp219-239.

Commission of the European Communities. 2007. "European Electronic Communications Regulation and Markets." *Communication From the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 12th Report.* Brussels.

Committee on Broadband Last Mile Technology, Computer Science and Telecommunications Board, National Research Council. 2002. *Broadband: Bringing Home the Bits.* The National Academies Press. HTML Version available at: http://www.nap.edu/html/broadband/index.html

Congressional Research Report. 2007. “Broadband Loan and Grant Programs in the USDA’s Rural Utilities Service,” *Prepared for Members and Committees of Congress*, November 9. Available at:

http://www.nationalaglawcenter.org/assets/crs/RL33816.pdf

Correa, Daniel K. April 2007. "Assessing Broadband in America: OECD and ITIF Broadband Rankings." Policy Review for the *Information Technology and Innovation Foundation*. Available at: http://www.itif.org/files/BroadbandRankings.pdf

Crandall, Robert, William Lehr and Robert Litan. 2007. "The Effects of Broadband Deployment on Output and Employment: A Cross-sectional Analysis of US Data." *The Brookings Institution: Issues in Economic Policy*, Number 6: July. Available at: http://www.brookings.edu/reports/2007/06labor_crandall.aspx

Dhliwayo, Jabulani. 2005. "Developing a Fibre Optic Backbone for Africa." From *Open Access for Africa: Challenges, Recommendations and Examples*, Samuel Danofsky ed. UN ICT Task Force Working Group on the Enabling Environment: New York.

Distaso, Walter and Paolo Lupi and Fabio Manenti. 2006. "Platform Competition and Broadband Uptake: Theory and Empirical Evidence From the EU." *Information Economics and Policy* 18, pp.28-106.

De Ridder, John. 2007. "Catching-Up in Broadband – What Will it Take?" *Working paper on Communication Infrastructure and Services Policy*. OECD: Paris, 25 July.

Federal Communications Commission. 2007. "High-Speed Services for Internet Access: Status as of December 31, 2006," available at: http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-277784A1.pdf

Federal Communications Commission. 2008. "High-Speed Services for Internet Access: Status as of June 30, 2007." *Industry Analysis and Technology Division Wireline Competition Bureau*: Washington, DC.

Federal Register. 2005. "Department of Agriculture, Rural Utilities Service." From *Proposed Rules*. Vol. 70, No. 63: Monday, April 4.

Flamm, Kenneth. 2004. "The Role of Economics, Demographics, and State Policy in Broadband Competition: An Exploratory Study." *Presented at the Telecommunications Policy and Research Conference.* Arlington, Virginia: October 2.

Floyd, Eugene and David Gabel. 2003. "An Econometric Analysis of the Factors that Influence the Deployment of Advanced Telecommunications Services." *MIT Internet and Telecommunications Convergence* Consortium August 31.

Fransman, Martin, ed. 2006. *Global Broadband Battles: Why the US and Europe Lag While Asia Leads*. Stanford Business Books: California.

Frieden, Rob. 2005. "Lessons from Broadband Development in Canada, Japan, Korea and the United States." *Telecommunications Policy* 29, pp.595-613.

Fuhr, Joseph P. and Stephen B. Pociask. 2007. "Broadband Services: Economic and Environmental Benefits." *American Consumer Institute*, policy brief, October 31. Available at:

http://www.internetinnovation.org/Portals/0/Documents/Final_Green_Benefits.pdf

Garcia-Murillo, Martha 2005. “International broadband deployment: The impact of unbundling.” *Communications & Stratégies 57*, 83-105.

Gambling, W. A. 2000. "The Rise and Rise of Optical Fibers*." IEEE Journal on Selected Topics in Quantum Electronics*. Vol. 6, No. 6: Nov./Dec., pp. 1084-1093.

Gillett, Sharon E. and William H. Lehr and Carlos Osorio. 2004. "Local Government Broadband Initiatives." *Telecommunications Policy* 28: 537 - 558.

Google. 2007. *Ex Parte Filing for the Federal Communications Commission: Service Rules for Spectrum Auction.* Available at: http://services.google.com/blog_resources/ex_part_via_efiling.pdf

Government Accountability Office (United States). May 2006. “Telecommunications: Broadband Deployment is Extensive throughout the United States, but it is Difficult to Assess the Extent of Deployment Gaps in Rural Areas.” *Report to Congressional Committees*. GAO-06-426.

Gruber, Harald and Denni, Mario, "The Diffusion of Broadband Telecommunications: The Role of Competition" (September 2005). Available at SSRN: http://ssrn.com/abstract=829504

Ida, Takanori. 2006. "Broadband, Information Society, and National System in Japan." From *Global Broadband Battles: Why the US and Europe Lag While Asia Leads*, Martin Fransman, ed. Stanford Business Books: California, pp65-86.

International Telecommunication Union. 2003. “Birth of Broadband.” *ITU Internet Reports*. Geneva: September.

International Telecommunications Union. 2007. *Digital Opportunity Index*. Available at http://www.itu.int/ITU-D/ict/doi/index.html

International Telecommunication Union and United Nations Conference on Trade and Development (ITU and UNCTAD). 2007. “World Information Society Report 2007.” UNCTAD: June.

International Telecommunications Union Online Statistics: *ICT EYE*. Last accessed on April 17, 2008. Available at: http://www.itu.int/ITU-D/icteye/Default.aspx

Kahin, Brian and Ernest Wilson, eds. 1997. *National Information Infrastructure Initiatives: Vision and Policy Options."* Cambridge, Massachusetts: MIT Press.

Kelly, Tim and Vanessa Gray and Michael Minges. 2003. “Broadband Korea: Internet Case Study.” *International Telecommunication Union*. Geneva: March.

Kushida, Kenji and Seung-Youn OH. 2006. "Understanding South Korea and Japan's Spectacular Broadband Development: Strategic Liberalization of the Telecommunications Sectors." BRIE Working Paper 175. Travers Department of Political Science: Berkeley.

Le Floch, Loic. 2006. "The World Broadband Access Market." *Communications & Strategies*, Issue 61, January: p163-167.

Lehr, William et al. 2005. "Measuring Broadband's Economic Impact" *Broadband Properties,* November. Available at: http://www.broadbandproperties.com/2005issues/dec05issues/Measuring%20Broadband%20Eco%20Impact,%20Lehr,%20Gilett,%20Sirbu.pdf

OECD. 2005. "Education at a Glance, 2005." OECD, Paris.

Organization for Economic Co-operation and Development. 2007. "Broadband and ICT Access and Use By Households and Individuals." *Working Party on the Information Economy.* Paris: Dec 21.

OECD Statistics, 2007. *OECD Broadband Portal.* Available at: http://www.oecd.org/sti/ict/broadband

Pew Internet and American Life. 2007. "Home Broadband Adoption 2007," from *Reports: Technology & Media Use*, July 3. Available at: http://www.pewinternet.org/report_display.asp?r=217

Picot, Arnold and Christian Wernick. 2007. "The Role of Government in Broadband Access." *Telecommunications Policy* 31, pp660-674.

Public Interest Spectrum Coalition. 2007. *Filing For the Federal Communications Commission: Comments Regarding Spectrum Auction.* May 23. Available at: http://www.publicknowledge.org/pdf/pisc-fcc-comments-20070523.pdf

Rockefeller, John. 2007. *Floor Statement: Senate Resolution 191*. May 8. Available at: http://www.baller.com/pdfs/SRes191.pdf

Roller, Lars-Hendrik and Leonard Waverman. 2001. "Telecommunications Infrastructure and Economic Development: A Simultaneous Approach." *The American Economic Review*, Vol. 91, 4, Sep: p.909.

Sacramento Regional Research Institute. 2007. "Economic Effects of Increased Broadband use in California," prepared for *AT&T*, November. Available at: http://www.srri.net/AboutUs/EconEffectsBB_Summary.pdf

Senate Committee on Small Business & Entrepreneurship. *September 26, 2007 Hearing on Improving Internet Access to Help Small Business Compete in the Global Economy, .* Accessed on December 22, 2007. Proceedings available at: http://sbc.senate.gov/20070926.cfm

Senate Resolution 191. May 8, 2007. *Resolution on Next-generation Broadband Networks*. Accessed on December 22, 2007. http://www.benton.org/node/5912

Schejter, A. 2007. "From all my teachers I have grown wise, and from my students more than anyone else:" What Lessons can the U.S. learn from Broadband Policies in Europe? Presented at the 35th TPRC Research Conference on Communication, Information and Internet Policy, Arlington, Va.

Schumpeter, Joseph. 1942. *Capitalism, socialism and democracy.* 1976 edition.

New York: Harper Torchbooks.

Swanson, Ben and George Gilder. "Estimating the Exaflood: The Impact of Video and Rich Media on the Internet, A "zettabyte" by 2015?" White Paper for the *Discovery Institute*. http://www.discovery.org/scripts/viewDB/filesDB-download.php?command=download&id=1475

Turner, S. Derek. 2006. “Universal Service Reform & Convergence: USF Policy for the 21st Century.” *Presented at the 34th Research Conference on Communication, Information and Internet Policy*. Arlington, VA: September 29 – October1.

Umino, Atsushi. 2004. "Developments in Local Loop Unbundling." Working Party on Telecommunications and Information Services Policies. OECD: Paris.

United States Department of Agriculture. 2005. “Audit Report: Rural Utilities Service Broadband Grant and Loan Programs.” *Office of Inspector General Southwest Region*. Audit Report 09601-4-T3: September.

Ure, John. 2003. “Competition in the Local Loop: Unbundling or Unbungling?” *Info: The Journal of Policy, Regulation and Strategy for Telecommunications*. 5; 5: pg.38.

Wallsten, Scott. 2006. “Broadband and Unbundling Regulations in OECD Countries.” Working paper 06-16 for *AEI-Brookings Joint Center For Regulatory Studies*: June. Available at http://ssrn.com/abstract= 906865

Wallsten, Scott. 2007. "Towards Effective U.S. Broadband Policies." *Progress on Point: Periodic Commentaries on the Policy Debate*. Release 14.7 May 2007: The Progress & Freedom Foundation, Washington, DC.

Glossary

BPL: Broadband over power line
DSL: Digital subscriber line
FCC: Federal Communications Commission
FTTH: Fiber to the home
ICT: Information and Communication Technologies
ITU: International Telecommunications Union
Kbps: Kilobytes per second
LLU: Local loop unbundling
Mbps: Megabytes per second
NIII: National Information Infrastructure Initiative
NTIA: National Telecommunications and Information Administration
NTT: Nippon Telegraph and Telephone
OECD: Organization for Economic Co-operation and Development
Tbps: Terabytes per second
USF: Universal Service Fund
USO: Universal service obligations

Appendix 1: Historical Broadband Penetration Rates in the OECD

	2002-Q2	2003-Q2	2004-Q2	2005-Q2	2006-Q2	2007-Q2
Australia	1.31	2.58	5.19	10.66	16.96	22.66
Austria	4.57	6.48	8.65	12.38	15.66	18.64
Belgium	6.24	10.23	14.18	17.35	19.20	23.82
Canada	10.25	13.14	16.39	18.97	21.89	24.96
Czech Republic	0.12	0.28	0.75	4.12	9.37	12.20
Denmark	6.64	11.05	16.90	21.71	29.25	34.33
Finland	3.49	5.34	10.93	18.66	24.87	28.84
France	1.57	3.97	7.87	12.63	17.57	22.55
Germany	3.20	4.83	6.56	10.24	15.11	21.21
Greece	0.00	0.02	0.23	0.84	2.70	7.07
Hungary	0.43	1.15	2.52	4.68	9.73	11.62
Iceland	5.29	10.82	15.19	21.48	26.51	29.78
Ireland	0.05	0.39	1.61	4.23	8.75	15.35
Italy	1.19	2.80	6.02	9.70	13.08	15.81
Japan	3.93	8.57	12.67	16.40	18.95	21.25
Korea	20.26	22.89	24.18	25.47	26.44	29.90
Luxembourg	0.61	2.27	5.57	11.38	17.20	22.24
Mexico	0.16	0.31	0.74	1.67	2.82	4.59
Netherlands	4.93	9.07	15.43	22.32	28.80	33.47
New Zealand	1.09	2.08	3.48	6.96	11.56	16.50
Norway	2.99	6.15	11.26	18.09	24.41	29.78
Poland	0.15	0.45	1.19	2.19	5.33	7.97
Portugal	1.46	3.62	6.35	9.68	12.71	14.70
Slovak Republic	0.01	0.01	0.62	1.61	4.02	6.83
Spain	2.07	4.18	6.46	9.10	13.31	16.98
Sweden	6.75	9.17	12.26	16.69	22.53	28.59
Switzerland	3.83	9.17	14.55	20.20	26.19	30.73
Turkey	0.02	0.06	0.29	1.20	2.91	5.16
United Kingdom	1.27	3.67	7.36	13.25	19.20	23.73
United States	5.49	7.90	10.86	14.16	17.88	22.08
OECD	3.82	5.93	8.48	11.63	15.11	18.76

Appendix 2: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
PEN	30	20.11133	8.683016	4.59	34.33
ADDRESSABLE	30	24.04467	10.62618	4.36	42.76
AGE	30	46.132	6.362348	24.96	53.4
COMPUTER	26	62.45385	16.92152	20.5	84.8
CONTENT	30	19.20367	16.23394	.51	64.06
COVERAGE	30	85.68667	22.47363	9	100
EDU	30	23.00233	9.356974	9.7	43.99
GDP	30	32071.7	13068.69	8571	77841.45
INTERCOMP	30	37.236	19.88755	0	66.57
INVEST	30	.4106667	.1494342	.16	.78
LNPRICEBIT	30	2.659294	.7572517	1.128171	4.579134
TELEDENSITY	30	46.62567	13.13163	18.33	66.89
URBAN	30	75.148	11.01684	56.32	97.22
YRSUNBUND	30	5.8	3.26317	0	11

Appendix 3: Correlation Matrix

obs=26)

	PEN	ADDRES~E	AGE	COMPUTER	CONTENT	COVERAGE	EDU	GDP	INTERC~P
PEN	1.0000								
ADDRESSABLE	0.8670	1.0000							
AGE	0.2948	0.3033	1.0000						
COMPUTER	0.8824	0.8595	0.3071	1.0000					
CONTENT	0.6921	0.6724	0.2085	0.6134	1.0000				
COVERAGE	0.5093	0.4853	-0.0368	0.4050	0.2820	1.0000			
EDU	0.7109	0.5252	0.0226	0.6186	0.3861	0.1685	1.0000		
GDP	0.5208	0.5413	0.2316	0.5783	0.3668	0.1450	0.3133	1.0000	
INTERCOMP	0.0502	-0.0903	-0.1702	0.0013	-0.1813	0.2560	0.1185	-0.2468	1.0000
INVEST	0.3512	0.2933	-0.0826	0.3712	0.3534	0.1518	0.3870	-0.0644	-0.1120
LNPRICEBIT	-0.3830	-0.3965	-0.4864	-0.3572	0.0610	-0.3423	-0.0251	-0.3409	0.1853
TELEDENSITY	0.6273	0.6214	0.3802	0.6836	0.2562	0.0551	0.5308	0.5381	-0.3876
URBAN	0.5968	0.5771	-0.0740	0.5465	0.3698	0.4428	0.5080	0.3537	-0.0384
YRSUNBUND	0.6360	0.4641	0.5193	0.5242	0.4050	0.1263	0.5613	0.4661	-0.1155

	INVEST	LNPRIC~T	TELEDE~Y	URBAN	YRSUNB~D
INVEST	1.0000				
LNPRICEBIT	-0.1531	1.0000			
TELEDENSITY	0.2903	-0.4471	1.0000		
URBAN	0.3540	-0.0835	0.4774	1.0000	
YRSUNBUND	0.0630	-0.2923	0.6003	0.1147	1.0000

Appendix 4: OECD Inter-Platform Broadband Competition

COUNTRY	Broadband Penetration (2007)	DSL Share	CABLE	FIBER	OTHER	HHI *(reciprocal *100)*
Australia	22.66	0.81	0.15	0.00	0.04	32.26
Austria	18.64	0.61	0.35	0.00	0.03	49.77
Belgium	23.82	0.61	0.39	0.00	0.00	48.08
Canada	24.96	0.48	0.52	0.00	0.00	50.32
Czech Republic	12.20	0.45	0.21	0.02	0.32	65.08
Denmark	34.33	0.62	0.28	0.09	0.01	52.89
Finland	28.84	0.84	0.13	0.00	0.03	26.91
France	22.55	0.95	0.05	0.00	0.00	9.34
Germany	21.21	0.95	0.05	0.00	0.00	9.52
Greece	7.07	1.00	0.00	0.00	0.00	0.00
Hungary	11.62	0.58	0.40	0.00	0.01	49.66
Iceland	29.78	0.97	0.00	0.01	0.02	5.12
Ireland	15.35	0.72	0.11	0.00	0.17	43.57
Italy	15.81	0.97	0.00	0.03	0.00	5.34
Japan	21.25	0.51	0.14	0.36	0.00	59.71
Korea	29.90	0.34	0.35	0.31	0.00	66.57
Luxembourg	22.24	0.89	0.11	0.00	0.00	19.60
Mexico	4.59	0.76	0.21	0.00	0.03	37.20
Netherlands	33.47	0.61	0.38	0.01	0.00	48.56
New Zealand	16.50	0.89	0.07	0.00	0.05	20.97
Norway	29.78	0.76	0.15	0.06	0.02	38.99
Poland	7.97	0.69	0.30	0.00	0.01	43.50
Portugal	14.70	0.62	0.37	0.00	0.01	47.32
Slovak Republic	6.83	0.57	0.12	0.16	0.15	60.94
Spain	16.98	0.78	0.21	0.00	0.01	34.06
Sweden	28.59	0.63	0.19	0.16	0.02	54.14
Switzerland	30.73	0.67	0.30	0.00	0.03	46.14
Turkey	5.16	0.99	0.01	0.00	0.00	2.12
United Kingdom	23.73	0.78	0.22	0.00	0.00	34.67
United States	22.08	0.42	0.52	0.02	0.03	54.73