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APPENDIX A
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Broadband Regulation in the United States: An Empirical Assessment[1]

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Abstract

Proposals for "network neutrality" rules (NN) would regulate how broadband network operators structure and price their services, limiting their ability to bundle products or to charge Internet content providers for differentiated services. Such rules are advanced on the theory that the "end-to-end" architecture of the Internet demands non-discriminatory end-user access to all applications and content. Yet the engineering and economic bases of the claim are in dispute, and no marketplace evidence is offered that NN regulations would improve consumer welfare.

An empirical test of the economic effects of broadband regulation is possible, however. Historically, "open access" rules have been imposed to address the concerns targeted by NN, and NN is now advanced to replace access rules that have been eliminated.

Although proponents of NN suggest that mandates that broadband access providers share their networks with other Internet Service Providers would allegedly stimulate broadband competition, protect subscribers' access to web applications, and spur innovation in online content, marketplace evidence suggests that broadband regulation negatively impacts consumer welfare. As observed across multiple policy episodes, "open access" rules have been associated with *reduced* broadband subscribership.

- Prior to 2003, unregulated cable modem service attracted nearly twice as many subscribers as regulated DSL.
- Following relaxation of DSL network line sharing rules in Feb. 2003, DSL subscriber growth sharply increased from trend.
- Following the further deregulation of DSL in Aug. 2005, DSL exhibited another statistically significant rise in subscriber growth.
- Advanced fiber-to-the-home networks evidence notably higher growth following explicit elimination of access mandates in 2003-04.

The data suggest that DSL subscribership was a stunning 65% higher, as of 4Q2006, than the level predicted by the trend established prior to deregulation in 1Q2003. DSL subscriber gains – *about 9.9 million households above trend* – pushed overall broadband growth significantly higher following deregulation. This spike in broadband penetration is conservatively estimated to be associated with annualized consumer surplus gains of $2.1 billion. Other social benefits accrue from the stimulative effect of rising broadband penetration throughout the economy; standard models estimate $5 billion in additional GDP, 2003-2006, given the increase in subscribership. Deregulation also is associated with an incremental $800 million in annual capital spending and the creation of nearly 8,000 additional jobs. The direction and magnitude of such empirical outcomes are inconsistent with the conjecture that broadband regulation via NN rules promotes consumer welfare or aids development of the Internet.

I. THE NET NEUTRALITY DEBATE

Some forms of network neutrality (NN) regulation would restrict the ability of broadband Internet service providers (ISPs) – such as cable TV operators delivering cable modem service and telephone carriers supplying DSL or fiber connections – to contract with Internet content and application providers.[2] In particular, under some proposals, ISPs would be prohibited from agreeing to supply faster speeds or enhanced quality of service to users of websites that pay the ISP for superior service. In other permutations, NN regulation would also prevent ISPs from offering their own differentiated product offerings. Such rules would be designed to prevent broadband providers from discriminating against unaffiliated content providers or equipment manufacturers.[3]

Proponents of NN regulation argue that the Internet has emerged as a useful institution due to basic rules governing the way its component parts interact. Engineering principles distinguish between three distinct layers of network communication:

1. the physical layer consisting of the facilities used to carry information;
2. the logical layer consisting of the protocols used to direct information and facilitate interconnection; and
3. the content layer consisting of the information transmitted to end users.[4]

These layers are economic complements. Increasing the quality of physical infrastructure tends to raise the value of content, stimulating investment by content producers who see a greater market opportunity. Likewise, more attractive content increases demand for physical infrastructure used to gain access to such products.

The argument for NN regulation posits that these network layers must be kept separate to ensure that this positive reinforcement process continues. The Internet has developed, and generated economic value, due to an "end to end" (e2e) architecture ensuring that any end user can freely communicate with any other. If physical layer networks integrate into content, the argument continues, complementary inputs could be less accessible to competing content suppliers, diminishing incentives for innovation at the network's edge. As Lawrence Lessig and Robert McChesney write:

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[2] Robert Hahn and Scott Wallsten, *The Economics of Net Neutrality*, 3 ECONOMISTS' VOICE 6 (June 2006); http://www.bepress.com/ev/vol3/iss6/art8/. See also, Keeping the Internet Neutral?: Christopher S. Yoo and Timothy Wu Debate, Vanderbilt Public Law Research Paper No. 06-27 (December 28, 2006); http://ssrn.com/abstract=953989

[3] It is not clear precisely what rules are needed to enforce NN, nor what ISP activities would be prohibited by the rules now being considered by policymakers. See Jon Peha, *Technology and the Benefits and Risks of Network Neutrality Requirements*, presentation to the Federal Trade Commission "Broadband Connectivity Competition Policy Hearing" (Feb. 13, 2007); http://www.ftc.gov/opp/workshops/broadband/presentations/peha.pdf, Slide 3.

[4] See Lawrence Lessig, *The Internet Under Siege*, 127 FOREIGN POLICY (Nov./Dec. 2001), p. 56. See also J. H. Saltzer, D. P. Reed, and D. D. Clark, *End-to-end Arguments in System Design*, 2 ACM TRANSACTIONS ON COMPUTER SYSTEMS 4, p. 278 (Nov. 1984). Some treatments separate content and applications into separate layers. Joseph Farrell and Philip J. Weiser, *Modularity, Vertical Integration, and Open Access Policies: Towards of Convergence of Antitrust and Regulation in the Internet Age*, 17 HARVARD JOURNAL OF LAW & TECHNOLOGY 1 (Fall 2003), p. 90.

> Net neutrality means simply that all like Internet content must be treated alike and move at the same speed over the network. The owners of the Internet's wires cannot discriminate. This is the simple but brilliant "end-to-end" design of the Internet that has made it such a powerful force for economic and social good: All of the intelligence and control is held by producers and users, not the networks that connect them. [5]

From an engineering standpoint, however, the characterization is inaccurate. A design principle does not constitute an architectural blueprint. Rather, the Internet structurally evolves, accommodating mixed models for providing functionality to networks and end users. Growth in the physical and content layers has relied on investments and coordination provided by enterprises building networks and content owners customizing their own modes of functionality.

In fact, network control has often been asserted across layers. Thus, for example, neither ARPANET nor NSFNet[6] allowed commercial enterprises to interconnect, reserving capacity and network functionality for purposes agency decision-makers selectively considered worthy of funding. Similarly, while local area networks (LANs) have been critical to Internet development, the enterprises that build such LANs widely exclude non-employees, erect firewalls, and impose extensive rules governing user access to content.

To better compete for customers, Internet service providers have often meshed physical transport with content, using their position to block spam, viruses, or other malware. In the 1990s, America Online created proprietary online content in order to stimulate demand for computer network access, using a "walled garden" to help build the nation's largest ISP.[7] Yahoo!, while a leading content portal, currently partners with AT&T to provide broadband Internet connections. AT&T pays Yahoo! for each subscriber generated; these payments constitute a significant fraction of Yahoo! revenue.[8] Caching services such as supplied by Akamai[9] allow applications to be delivered more quickly in exchange for fees paid by content suppliers. Other websites build (or lease) their own transport facilities, enjoying exclusive access — and speedier delivery of information to customers – denied to content rivals. Google Search is a prominent

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[5] Lawrence Lessig and Robert W. McChesney, *No Tolls on the Internet*, WASHINGTON POST (June 8, 2006); http://www.washingtonpost.com/wp-dyn/content/article/2006/06/07/AR2006060702108.html.

[6] ARPANET (Advanced Research Projects Agency Network) and NSFNet (National Science Foundation Network) were early communications systems using packet switching, precursors to today's "network of networks." They were funded by the U.S. Department of Defense and the National Science Foundation, respectively.

[7] Kara Swisher, AOL.com (New York : Random House, 1998).

[8] *AT&T-Yahoo Partnership*, NY TIMES (Sep. 25, 1998); http://query.nytimes.com/gst/fullpage.html?res=9802E2D81739F936A1575AC0A96E958260. See also Ritsuko Ando and Eric Auchard, *UPDATE 2-AT&T, Yahoo partnership at risk – WSJ*, REUTERS (Mar. 9, 2007); http://www.reuters.com/ article/idUSN0920641720070309

[9] Akamai Technologies Inc., *Akamai Content Distribution Infrastructure Adopted in PLAYSTATION(R)Network*, BUSINESS WIRE (Dec. 19, 2006); http://www.allbusiness.com/technology/technology-services/4020520-1.html .

example.[10] The argument that e2e categorically delineates the functionality of network components is simply incorrect.

Neither does the e2e characterization withstand scrutiny from an economic perspective. The Internet is far from "neutral," but is governed by unregulated owners who construct their own websites or transport facilities (or both) and then contract for interconnection with those built by others. From the fees paid to backbone providers to carry traffic, to the "user agreements" routinely a part of Internet access subscriptions, terms of trade are negotiated between parties. They are constrained not by regulation (or e2e) but by market forces. In this context, imposing any particular architecture on the Internet is a violation, not an advancement, of the principles on which the "network of networks" has evolved. This may account for the lack of enthusiasm the NN regulatory proposal has garnered from Internet champions[11] such as David Farber,[12] Ed Felten,[13] and Robert Kahn.[14]

II. U.S. REGULATORY REGIMES IN BROADBAND

1. Natural Experiments Testing the Effects of "Open Access"

Beyond theoretical arguments over engineering design and economic structure, the regulatory questions at issue beg for empirical evidence as to the effect of broadband network regulation. Over the past decade, rules were imposed on telephone company-delivered digital subscriber line (DSL) services, and then largely removed. It is therefore possible to compare the before-and-after effects of these broadband regulations, and to compare the performance of DSL services to that of cable modem (CM) services, which have been consistently unregulated since their inception.

Proponents of NN rules see regulation as necessary to address a broadband CM/DSL duopoly offering insufficient competitive pressure to protect consumer interests.[15] Whatever the merits of that claim,[16] or the efficacy of addressing market

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[10] John Batelle, The Search (New York: Penguin; 2005), pp. 144, 246; Robert X. Cringely, *Google-Mart: Sam Walton Taught Google More About How to Dominate the Internet Than Microsoft Ever Did*, THE PULPIT WEEKLY COLUMN at PBS (Nov. 17, 2005); http://www.pbs.org/cringely/pulpit/2005/pulpit_20051117000873.html.

[11] "Bob Kahn, the Internet Protocol's co-inventor, says the term net neutrality is a regulatory slogan, which he opposes: 'If the goal is to encourage people to build new capabilities, then the party that takes the lead in building that new capability, is probably only going to have it on their net to start with and its probably not going to be on anybody else's net.'" Wikipedia; http://en.wikipedia.org/wiki/ Network_neutrality (visited 4.5.07).

[12] David Farber and Michael Katz, *Hold Off On Net Neutrality*, WASHINGTON POST (Jan. 19, 2007), p. A19; http://www.washingtonpost.com/wp-dyn/content/article/2007/01/18/AR2007011801508.html.

[13] Ed Felten, *Nuts and Bolts of Network Neutrality*, Princeton University manuscript (July 6, 2006).

[14] Andrew Orlowski, *Father of the Internet Warns Against Network Neutrality*, THE REGISTER (Jan. 18, 2007); http://www.theregister.co.uk/2007/01/18/kahn_net_neutrality_warning/.

[15] Vinton G. Cerf, *Prepared Statement*, U.S. Senate Committee on Commerce, Science and Transportation Hearing on "Network Neutrality" (Feb. 7, 2006); http://commerce.senate.gov/pdf/cerf-020706.pdf.

power via regulation as opposed to antitrust enforcement,[17] residential broadband markets offer a test bed for the effectiveness of open access rules that incorporates any potential market power. In fact, to the degree that existing broadband providers inefficiently restrict consumers' choices, regulatory constraints would more easily improve outcomes. The asserted competitiveness of "open" networks will provide a sharply contrasting alternative to the asserted anti-competitive alternatives.

The empirical investigation pursued in this paper, then, incorporates the effects of whatever market power is exercised by broadband operators. Note also that regulatory constraints on DSL providers were imposed through mid-2005. Since industry concentration in residential broadband has generally declined over time,[18] the results observed in this study reflect outcomes when market power was presumably equal to or greater than that evident currently.[19]

Note too that the results of the natural experiments in "open access" regulation actually reveal the appropriate information for judging NN regulation. That is to say, market power is necessary to justify the imposition of access rules on broadband providers, but is clearly insufficient. Beyond a showing of market power, it must be established that regulation – accounting for its costs, including incentive effects altering network investments – increases efficiency.[20] That is an issue informed by observing marketplace outcomes across different regulatory regimes, not by defining levels of market concentration.

2. Three Historical Regimes for DSL

(A) Unregulated Cable v. Regulated DSL (pre-2003)

Three identifiable regulatory regimes have governed DSL; these policy episodes define the context of the empirical analysis comparing DSL v. CM outcomes. Policies governing fiber-to-the-premises (FTTP) networks, analyzed separately, have also changed over time.

Cable TV operators began offering cable modem services in 1995,[21] and did so without any obligation to share their network infrastructure with other firms. Attempts to

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[16] For a critical view, see J. Gregory Sidak, *A Consumer-Welfare Approach to Network Neutrality Regulation of the Internet*, 2 Journal of Competition Law & Economics 3 (Sept. 2006), p. 349.

[17] Alfred Kahn, *Prepared Statement*, Federal Trade Commission Broadband Connectivity Competition Policy Hearing (Feb. 13, 2007); http://www.ftc.gov/opp/workshops/broadband/presentations/kahn.pdf.

[18] *See, e.g.*, Federal Communications Commission, Industry Analysis and Technology Division, Wireline Competition Bureau, *High Speed Services for Internet Access: Status as of June 30, 2006*, (Jan. 2007), Tables 1, 2.

[19] Whatever the weaknesses of the market share approach to defining or measuring market power, it is the basis for the stated claim that last mile broadband access in the United States is a duopoly, and thereby lacks the competitiveness to achieve efficient outcomes.

[20] See, e.g., Charles Wolf, Jr. Markets or Governments: Choosing Among Imperfect Alternatives (MIT Press, 1989).

[21] Gregory L. Rosston, *The Evolution of High-Speed Internet Access 1995-2001*, SIEPR POLICY PAPER NO. 05-019 (Aug. 2006), p. 6.

require cable operators to provide "open access" to independent ISPs were unsuccessful.[22] A 1999 FCC report concluded that access regulation would risk deterring investment in the rapidly evolving market.[23] The FCC later concluded that cable modem service should be classified as an interstate information service, and therefore be exempt from common-carrier or open access obligations at both the federal and state/local level. The U.S. Supreme Court upheld the FCC's determination in June 2005.[24]

In contrast to unregulated CM services, telephone company DSL services have historically been subject to various regulatory obligations. When DSL was first offered in the 1990s, incumbent local exchange carriers (ILECs) faced three major types of open access rules, allowing rival firms to provide high speed access to end users via the carrier's facilities. First, under the *Computer III* regime, telephone companies were required to provide the broadband transmission component of DSL services on a common-carrier basis.[25] Second, under the Commission's unbundling rules, telephone companies were mandated to provide the copper loops used to provide DSL service on an unbundled basis.[26] This has enabled competitive local exchange carriers (CLECs or dCLECs, for those entrants specializing in data services) to place their switches in a telephone company's central office and to connect that equipment to an unbundled loop supplying DSL services to end users. Third, the FCC's so-called line sharing rules required telephone companies to lease just the high-frequency portion of the loop ("HFPL") used to provide DSL services.[27] Federal and state regulations then set the price for the HFPL far below the price for an unbundled loop as a whole, substantially reducing dCLEC costs.[28]

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[22] The AOL/Time Warner merger, consummated in early 2000, imposed unique third party access obligations. The provisions required the merged firm to offer AOL Broadband only after permitting two independent ISPs to utilize Time Warner Cable infrastructure. The rules did not regulate wholesale prices, nor did they regulate Time Warner's Road Runner broadband ISP.

[23] Federal Communications Commission Cable Services Bureau, *Broadband Today,* A Staff Report to William E. Kennard, Chairman, FCC (Oct. 1999); http://www.fcc.gov/Bureaus/Cable/Reports/broadbandtoday.pdf.

[24] *National Cable & Telecommunications Assn. v. Brand X Internet Services*, 545 U. S. 967 (2005).

[25] Federal Communications Commission, *In the Matter of Appropriate Framework for Broadband Access to the Internet over Wireline Facilities, Report and Order and Notice of Proposed Rulemaking*, CC Docket No. 02-33, pp. 19-20 (Sep. 23, 2005).

[26] 47 C.F.R. § 51.319(a)(1).

[27] Federal Communications Commission, *In the Matters of Deployment of Wireline Services Offering Advanced Telecommunications Capability and Implementation of Local Competition Provisions of the Telecommunications Act of 1996, Third Report and Order*, CC Docket No. 98-147 (Dec. 9, 1999); http://www.fcc.gov/Bureaus/Common_Carrier/Orders/1999/fcc99355.txt.

[28] 47 C.F.R. § 51.319(a)(1)(i).

(B) Cable Unregulated/DSL Partially Deregulated

In February 2003, the FCC eliminated DSL line sharing rules.[29] As a result, dCLECs would have to pay for the entire local loop in order to supply DSL service to customers over the incumbent carrier's lines, or strike a commercial agreement with the carrier to share a loop. The rationale for the reform was that, with lessened network sharing obligations, telephone carriers would invest more heavily in bringing broadband services to residential customers.[30]

FCC member (now Chairman) Kevin Martin voted for the measure, noting "that competition--not regulation--is the best method of delivering the benefits of choice, innovation and affordability to consumers."[31] The policy switch was criticized by others, however, as a measure that would unleash market power and retard broadband deployment. "For consumers, it's a bleak day, according to the Consumer Federation of America. There are about 40 million DSL subscribers now in the United States, and today's decision will likely choke off any future growth, one consumer group said."[32]

Hence, a natural experiment was created, which, by examining subscriber growth data, we observe the results of below.

(C) Unregulated Cable/Unregulated DSL

In August 2005, the FCC eliminated the *Computer III* rules with respect to DSL services. This removed the remaining open access regulations when Internet connections are bundled with transport. With the Commission determining that DSL fell under Title I of the Communications Act, broadband Internet access became treated as an "information service" exempt from common-carrier regulation.[33] This put DSL services on regulatory parity with cable modem service. The rationale, as with the line-sharing deregulation, was that reducing network sharing mandates would improve operator incentives to deploy, upgrade, and market broadband access. Once again, proponents of regulation

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[29] FCC, *FCC Adopts News Rules for Network Unbundling Obligations Of Incumbent Local Phone Carriers* (Feb. 20, 2003); http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-231344A1.pdf.

[30] As for the end of line sharing and the FCC policy to establish a deregulatory environment for fiber-to-the-premises networks (discussed in the next sub-section), Robert Crandall has written: "There is a growing perception that regulation has impeded the growth of the ILECs' DSL services… In August 2003, when the FCC announced that it had decided to eliminate line sharing, it also voted to remove the unbundling obligation for investment in next-generation, fiber-optic networks…These decisions… are surely a step in the right direction and may have had at least a temporary effect on ILEC investment…" Robert W. Crandall, Competition and Chaos: U.S. Telecommunications Since the 1996 Telecom Act (Washington, D.C.: Brookings Institution Press; 2005), p. 127.

[31] Ben Charny, *FCC Loosens Broadband Rules*, CNET NEWS.COM (Feb. 20, 2003), http://news.com.com/FCC+loosens+broadband+rules/2100-1033_3-985313.html.

[32] Ibid. The CFA attributed the slowdown in growth to "higher prices and fewer choices for consumers in high-speed services."

[33] Federal Communications Commission (Sep. 23, 2005), op cit.

argued that the FCC's deregulatory steps would have negative consequences for broadband customers and the Internet generally.[34]

3. Regulation and Deregulation of FTTP

Fiber optic lines that directly connect the customer's premises to the Internet provide the largest capacity and fastest data speeds currently available to consumers. Originally, the regulatory policy applicable to FTTP networks was unclear, including whether such networks would be subject to wholesale access obligations. In Feb. 2003, however, the FCC explicitly exempted "greenfield" FTTP systems (constructed in new developments where no older lines were in place) from such access mandates. The Commission also exempted new FTTP lines replacing old copper loops from unbundling, provided that the carrier provided requesting CLECs with access to copper loops that remained in service or offered CLECs voice-grade circuits via fiber lines. These rules were officially published, as part of the Telecommunications Act's Triennial Review, in August 2003.[35]

Further deregulatory clarification occurred the following year. In August 2004, the FCC exempted incumbent phone networks from being obligated to offer unbundled access on fiber lines linking apartment or condo developments. In October, phone company fiber connecting near the customer's premises was removed from unbundling obligations.[36] Hence, in 2003-2004, regulatory actions substantially removed uncertainty about "open access" rules for fiber networks, instituting a regime largely exempting FTTP carriers from network sharing obligations.

III. EMPIRICAL EFFECTS OF "OPEN ACCESS" IN DSL

The premise for "open access" rules is that consumer welfare will increase when CM and DSL network owners are legally unable to limit on-net access to rival services. This not only parallels the theoretical argument for Net Neutrality, it operates as a similar policy intervention, setting regulatory terms for broadband service providers by

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[34] Andrew Jay Schwartzman of the Media Access Project was quoted as saying: "This is a bad day for the Internet. I think it means higher prices and less competition and threatens the growth of the Internet" *FCC Reclassifies DSL as Data Service - Week of 9/20/05*, Northern Light**;** http://www.centerformarketintelligence.com/analystviews/20050920-WeeklyReport.htm (visited April 5, 2007).

[35] Federal Communications Commission, *In the Matter of Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers, Report and Order and Order on Remand and Further Notice of Proposed Rulemaking*, CC Docket No. 01-338 (Aug. 21, 2003); http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-03-36A1.doc.

[36] Josh Long, *Broadband Relief Spurs Bell Investment*, XCHANGE MAGAZINE (Dec. 1, 2004); http://www.xchangemag.com/articles/525/525_4c1window1.html.

mandating user access to vertical services. In either case, common carrier regulation is substituted for market forces.[37]

Hence, open access and NN are portrayed as substitutes, and advocates for the latter base their political argument for regulation on the elimination of the former. For instance, THE NEW REPUBLIC editorialized for NN legislation in June 2006 on the grounds that, during the previous year, the FCC "exempted telecoms that provide Internet connections from [open-access] restrictions, dealing a blow to both entrepreneurship and political discourse."[38] Similarly, Vinton Cerf has backed NN due to deregulation. "Cerf said that he thought things were better before 2005 when broadband providers were controlled by common carriage rules that prevented providers from discriminating in terms of what traffic was carried. 'It protected the Internet,' he said."[39]

The strong similarity of these policy approaches allows empirical evaluation of the argument for NN regulation. With respect to open access rules, it is possible to subject the regulatory hypothesis to marketplace evidence. Do the suggested policies achieve the pro-consumer results intended? Here we conduct such a test by examining data generated by the discrete deregulatory episodes just described.

In particular, we examine how broadband subscribership responds to changes in broadband regulations, testing the implications of "open access" rules on the evidence yielded by subscriber choices. In this Section, we examine three different scenarios, the last two of which overlap.[40] Each prediction derives from the hypothesis that "open access" regulation promotes efficiency. This implies that consumers should prefer such platforms, and purchase services more frequently, compared to rival offerings by proprietary networks. Across three broadband regime switches, the specific implications are as follows:

(1) pre-1Q2003: CM unregulated, DSL regulated with "line sharing"
Prediction: *DSL subscribership will exceed CM subscribership*.
(2) 1Q2003-4Q2006: DSL "line sharing" eliminated 1Q2003
Prediction: *DSL subscriber growth will decline from trend.*
(3) 3Q2005-4Q2006: DSL classified "information service" 3Q2005
Prediction: *DSL subscriber growth will further decline from trend.*

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[37] See Bruce M. Owen, *The Net Neutrality Debate: Twenty Five Years After* United States v. AT&T *and 120 Years After the* Act to Regulate Commerce, Stanford Law and Economics Olin Working Paper No. 336 (Feb. 2007).

[38] The Editors, *Open Net*, THE NEW REPUBLIC (June 19, 2006); http://www.tnr.com/doc.mhtml?i=20060626&s=editorial062606.

[39] Wayne Rash, Net Neutrality Advocates Face Off, eWeek (July 17, 2006); http://www.eweek.com/article2/0,1895,1990357,00.asp.

[40] In the following Section, we examine how FTTP deployment responded to the elimination of fiber unbundling obligations enacted by the FCC between Feb. 2003 and Oct. 2004.

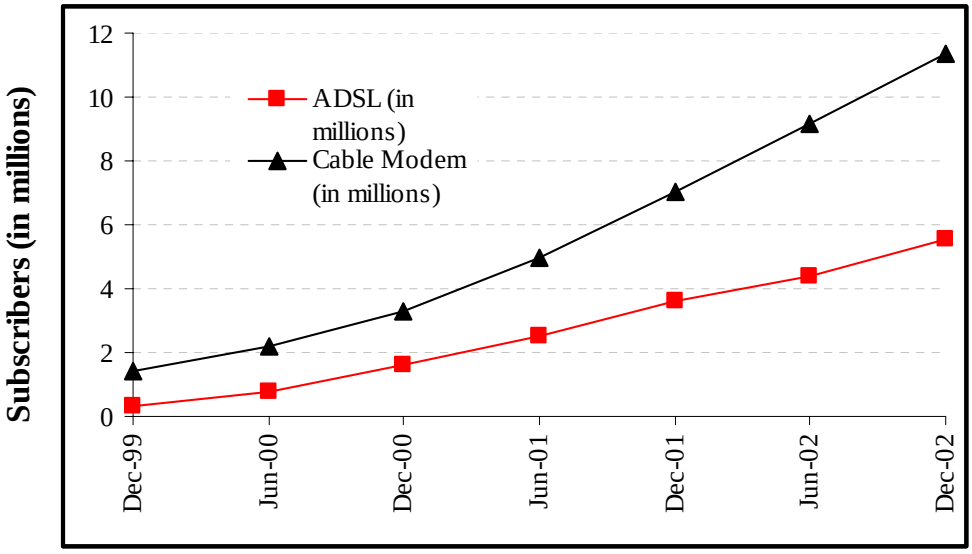
The first of these episodes has been evaluated in previous work, and is only summarized here.[41] The next two episodes are analyzed using econometric tests to gauge how subscriber growth responded to regime shifts that eliminated "open access" rules.

1. Growth of DSL vs. Cable Modem Prior to 1Q 2003

While DSL and cable modem technologies were developed at roughly the same time, unregulated cable companies expanded the availability and penetration of their services much more quickly than regulated telephone companies. By year-end 1999 cable dominated the emerging residential broadband market: residential and small business DSL lines totaled just 0.29 million, while cable modem subscribers numbered 1.40 million. Cable continued its dominance through year-end 2002, when it served 11.34 million, double the number of DSL lines (5.53 million). See Figure 1.

[41] George Bittlingmayer & Thomas W. Hazlett, *Cable "Open Access": The Ideal and the Real*, 26 TELECOMMUNICATIONS POLICY 5 (2002); Thomas W. Hazlett & George Bittlingmayer, *The Political Economy of Cable "Open Access,"* 4 STANFORD TECHNOLOGY LAW REVIEW (2003).

FIG. 1. RESIDENTIAL AND SMALL BUSINESS ADSL AND COAXIAL CABLE LINES IN THE U.S., 1999-2002



Source: FCC, *High Speed Services for Internet Access* (semi-annual report).

These data do not prove that lack of regulation caused cable's dominance, but they are inconsistent (absent further information) with the hypothesis that open access promotes broadband deployment. Moreover, Wall Street analysts have concluded that regulatory factors did play an important causative role in the relatively quick deployment of cable modem services. According to Blake Bath of Lehman Brothers:

> The reason that the cable companies really stepped up their investment in 1997 and beyond was they were not regulated, they weren't forced to open up their networks. There were multiple revenue streams that they could address. They could price the services however they wanted.[42]

Such commentary helps evaluate the link between regulatory events and market outcomes. Investor behavior itself provides further evidence of the link between "unregulation" and cable's growth. In a study of 29 events which, between Jan. 1998 and Oct. 2000, significantly impacted the possibility of "open access" mandates for cable modem services, Bittlingmayer & Hazlett (2003) found that events advancing open access rules[43] produced negative returns for cable modem providers, but *no positive returns* for the overall Internet Index.[44] On the contrary, events defined as setbacks for

[42] Quoted in Adam Thierer, *Broadband and the Markets: Perspectives from the Investment Community*, Cato Institute Policy Forum (July 24, 2001), p. 15; http://www.cato.org/events/transcripts/010724et.pdf.

[43] There were 8 open access "victories," which included a ruling by a Portland judge against AT&T, the vote by Broward and Pittsburgh in favor of open access, the FCC avowal to scrutinize the AOL Time Warner merger, and rumors of regulatory action." Table 7 in Bittlingmayer & Hazlett (2003).

[44] Returns were calculated for 1-day and 3-day periods surrounding open access event announcements. Reported returns are abnormal, Nasdaq-adjusted.

open access,[45] produced high abnormal returns (returns adjusted for contemporaneous movements in the overall market) for cable modem providers such as Excite@Home, *and positive returns* for the Internet Index, a portfolio containing a large number of firms selling Internet-related services. See Table 1. These results suggest that investors did not expect open access to stimulate innovation and growth.

TABLE 1. ABNORMAL % RETURNS FOR INTERNET STOCK INDEX AND EXCITE@HOME AROUND OPEN ACCESS EVENTS, JAN. 1998-OCT. 2000[46]

	Internet Index		Excite@Home	
	1-day	3-day	1-day	3-day
Setbacks for Open Access (n=21)				
Mean	1.1	1.7	7.6	8.1
Median	0.7	2.4	8.0	8.2
Cumulative	24.6	41.6	364.2	408.6
Victories for Open Access (n=8)				
Mean	-0.1	-0.1	-4.9	-6.4
Median	0.3	0.0	-4.0	-6.6
Cumulative	-1.0	-1.0	-33.2	-41.0

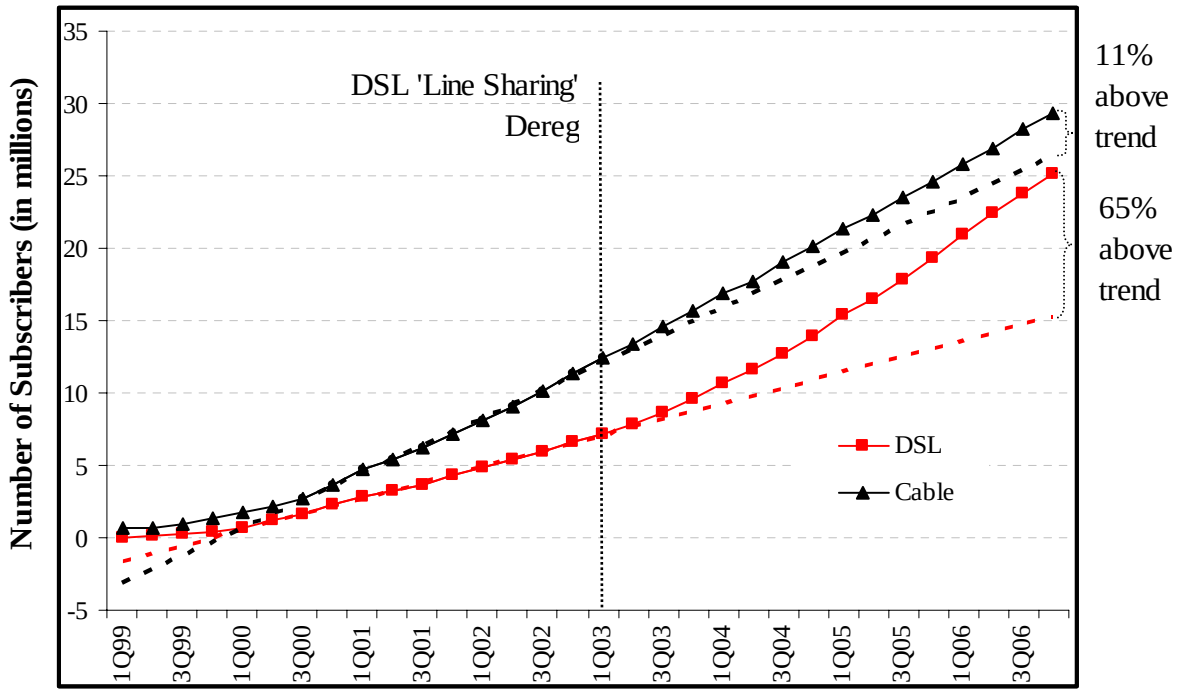
2. DSL Growth Before 1Q2003 vs. DSL Growth After 1Q2003

DSL subscribership experienced a sharp increase in trend soon after the FCC's decision to end line-sharing. During this period, DSL subscribership rose from 6.61 million (year-end 2002) to 25.14 million (4Q 2006). At the same time, cable modem subscriber growth continued at a fairly constant pace, suggesting the increasing DSL growth pattern was due to factors specific to DSL rather than the broadband market generally. See Figure 2. By the fourth quarter of 2006, the *CM-DSL* gap shrank from 5.30 million (27% of the broadband subscribers), the level it reached in the first quarter of 2003, to 4.20 million (just 8% of broadband subscribers). Looking only at CM and DSL, the CM share of broadband was 64% in 1Q2003, with DSL at 36%. By 4Q2006, CM share had fallen to 54%, with DSL rising to 46%.

[45] There were 21 "setback" events. "These include announcements of mergers and favorable developments for a variety of mergers, including AT&T's purchase of cable operators TCI and MediaOne. Also included are various rumored deals that never took place, notably linkups of AOL and Excite@Home, and AT&T and Time Warner. Finally, this group of events also includes legal and political setbacks such as a Miami city council ruling in favor of the cable companies and the June 22, 2000 appeals court ruling that struck down Portland, Oregon's local access requirements." Table 6 in Bittlingmayer & Hazlett (2003).

[46] Results as reported in George Bittlingmayer and Thomas W. Hazlett, *Financial Effects of Broadband Regulation*, Chapter 11 in Robert Crandall and James Alleman, eds., BROADBAND: SHOULD WE REGULATE HIGH-SPEED INTERNET ACCESS? (Washington, D.C.: AEI-Brookings Joint Center for Regulatory Studies, 2002), p. 259.

FIG. 2: DSL & CABLE MODEM SUBSCRIBERS IN THE U.S., 1Q1999-4Q2006



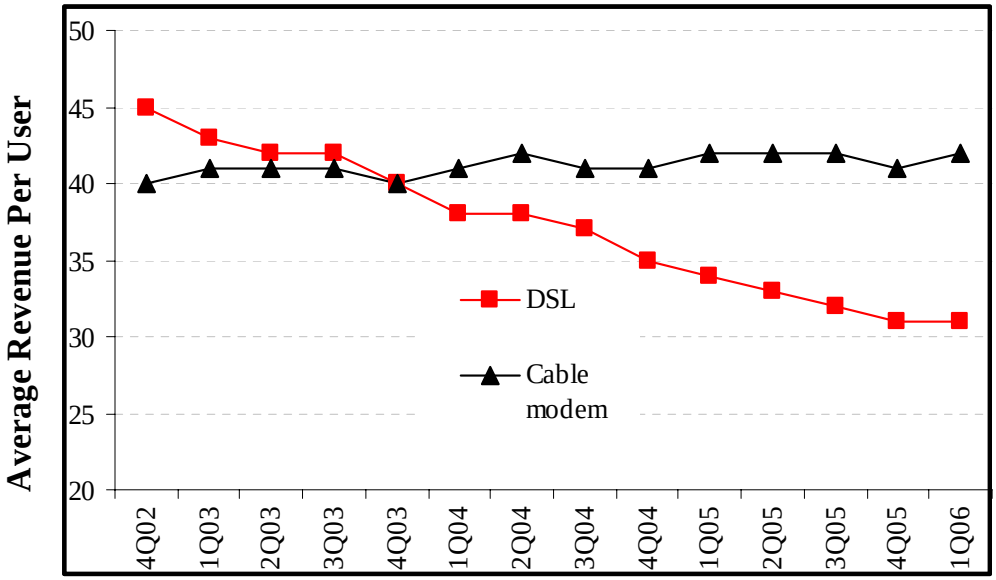
Sources: Legg Mason and Kagan.
Notes: Legg Mason U.S. DSL and cable modem data cover the period from 1Q99 through 1Q06; Kagan provides U.S. broadband data from 1Q05 through 4Q06. To merge the data from these two different sources, Kagan figures from 2Q06 through 4Q06 were normalized with the mean of the multipliers (Legg Mason/Kagan) calculated over the five overlapping data points. The linear time trend was estimated using the data from 3Q2000 through 1Q2003.

By the fourth quarter of 2006, DSL penetration dramatically exceeded the pre-deregulation trend. The level of DSL subscribers in 4Q2006 was 65% higher than projected, linearly extrapolating DSL subscribership observed in the 3Q2000 to 1Q2003 period. Meanwhile, CM subscribers exceeded the same projected trend by 11%.

Rather than raising prices to reflect increased market power, as predicted by some, telephone carriers instituted serious retail rate reductions for DSL service. According to Bernstein Research, these price cuts were initiated by SBC in May 2003, with other telcos quickly following.[47] Cable TV operators, while leaving nominal prices relatively stable for cable modem service, responded by aggressively increasing data speeds.[48] A price series showing estimated U.S. average monthly retail rates for DSL and CM service (see Figure 3) is consistent with this explanation.

[47] Bernstein Research, *Broadband Update: Seasonality Remains a Question But Growth Continues Unabated; The Fight Turns to Net Additions* (July 7, 2006).
[48] Ibid.

FIG. 3: MEAN MONTHLY RATES FOR DSL & CM SERVICE, 4Q2002-1Q2006



Source: Bernstein Research, *Broadband Update: Seasonality Remains a Question But Growth Continues Unabated; The Fight Turns to Net Additions* (July 2006).

An econometric test is performed to determine whether the observed growth spurt in DSL subscribership following "line sharing" deregulation is statistically significant. As described in the Appendix, the regime shift in 1Q2003 is appraised by comparing subsequent DSL subscriber growth to previous DSL growth, while controlling for concurrent CM subscriber growth. In a further investigation, Canadian CM and DSL subscriber growth levels are used as additional control variables.[49] Both approaches help account for changes in the broadband market that, perhaps unrelated to the DSL regulatory reform, impact subscriber growth.

The data suggest that DSL growth did not decline with U.S. deregulation, but rose substantially (see regression results in Appendix). The impressive post-deregulation increase in output, as measured in subscribership, is not accounted for by general factors in the broadband market visible either in U.S. cable modem subscriber growth, as seen in Figure 2, or by Canadian DSL and cable modem subscription increases.

3. DSL Growth Before 3Q2005 vs. DSL Growth After 3Q2005

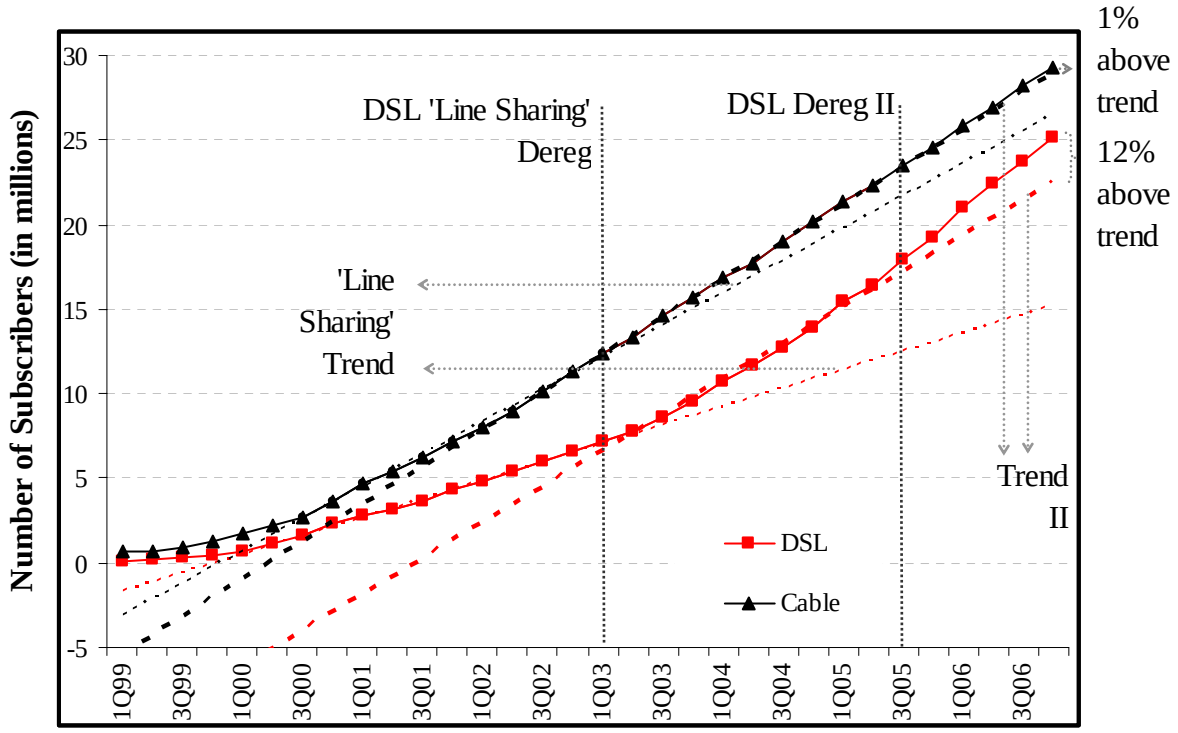
In August 2005, DSL was further deregulated when the Internet access service was declared by the FCC to be an information service under Title I, not subject to

[49] Legg Mason Canadian broadband subscribership data extend from 4Q99 to 1Q05. Kagan provides Canadian broadband data from 2Q05 through 4Q06. Since there are no overlapping periods between these two different data sources, a dummy variable is used in the regression to control for the effects of the change in data source.

common carriage regulation. Figure 4 extends Figure 2, projecting broadband subscriber trends as of 2Q2005 and showing actual levels recorded through 4Q2006.

In Figure 2, a linear time trend ("Trend I") was estimated using actual subscriber data through the first quarter of 2003.[50] A second linear time trend is, as shown in Figure 4, calculated using observed subscriber levels during the intermediate period, 1Q2003 through 2Q2005. This second trend ("Trend II") is then projected through the fourth quarter of 2006, where our data end. According to this simple method, the increase in DSL households that occurs following the Aug. 2005 DSL deregulation amounts to about 12% of total 4Q2006 subscribers. In other words, DSL subscribership again increases from trend in the period following the 2005 deregulation. Despite the short time for post-reform effects to develop (just six quarters, 3Q2005 to 4Q2006, inclusive), there are about 2.63 million *additional* households subscribing to DSL by the end of 2006 than if the trend prior to deregulation (obtaining 1Q2003 to 2Q2005) had continued. CM growth, in contrast, is just one percent above the Trend II prediction at year-end 2006.

FIG. 4: DSL & CM SUBSCRIBERS IN THE U.S., 1Q1999-4Q2006



Notes: The linear 'line sharing' time trend is estimated using data from 3Q2000 to 1Q2003. The linear Trend II is estimated from data between 1Q2003 and 2Q2005. See Fig. 3 for sources and data notes.

[50] This estimation used ordinary least squares, as do subsequent time trend projections.

As with the previous (1Q2003) deregulation episode, an econometric model was estimated to test whether DSL subscriber growth changes in the period following reform. The model and the statistical results are described in the Appendix. The estimated regression reveals that the incremental gain in subscriber growth following the 3Q2005 deregulation is positive and of a statistically significant magnitude. The data suggest that the U.S. broadband market grows, relative to trend, following deregulation. Incremental gains in subscriber additions are observed after both the 2003 deregulation (end of line sharing) and the 2005 deregulation (information services classification). These gains are not explained by general broadband market trends, as concurrent CM subscriber growth is again included as an explanatory variable.[51]

IV. EMPIRICAL EFFECTS OF "OPEN ACCESS" IN FTTP

As described in Section II, the regulatory status of FTTP was originally unclear, and investors did not know if such networks would be subject to unbundling rules.[52] The FCC then explicitly eliminated FTTP's network sharing obligations in a series of rulings between Feb. 2003 and Oct. 2004.

Capital markets, equipment suppliers, and telecommunications carriers considered the policy key to clearing the way for large FTTP deployments. The Telecommunications Industry Association (TIA), a trade association representing equipment and infrastructure manufacturing firms, identified the 2003 FCC action eliminating open access rules as essential for FTTP development:

> For more than four years, TIA has been urging the commission to move to this type of framework that rewards the necessary investment in new and advanced technologies that will make broadband services available more widely and will make the supporting networks more robust."[53]

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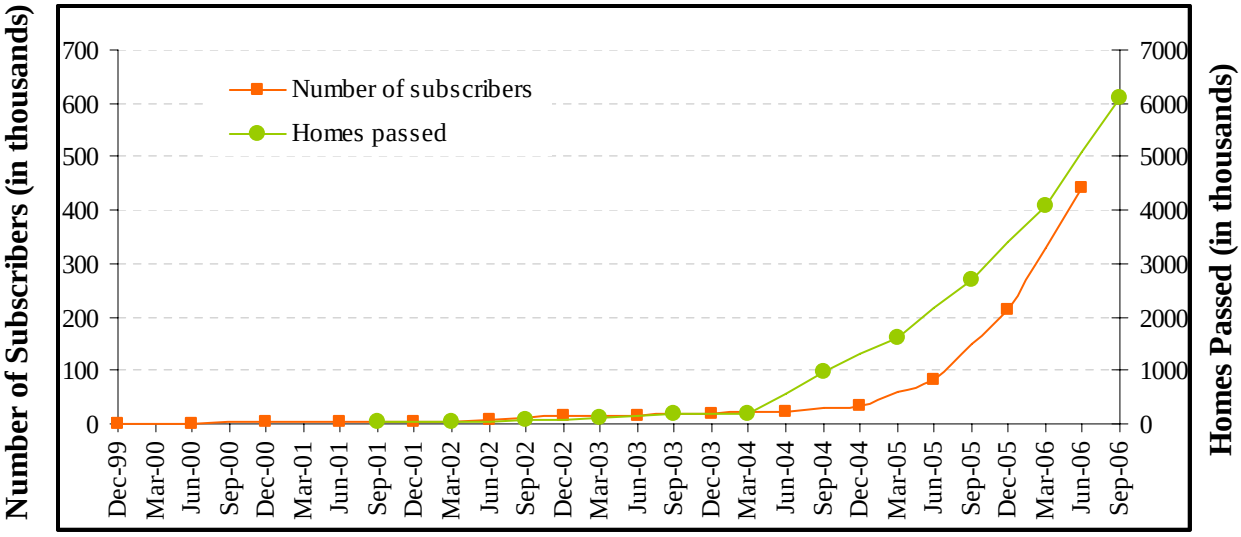
[51] Canadian broadband subscriber data are not included in this analysis of the 2005 deregulation since there exist no overlapping Canadian observations (in the Legg Mason and Kagan series) to smooth the distinct sources. Using a dummy variable to adjust for the use of different data sources is problematic here, given that the new (Kagan) data series begins 2Q2005, just one quarter before the deregulation dummy switches on, confusing effects of the independent variables. Nonetheless, a regression using this method finds that U.S. DSL subscriber growth post-deregulation (in 3Q2005) is higher than previous trend, with statistical significance for the dummy coefficient at the 94% confidence level.

[52] Fiber-to-the-home (FTTH) and fiber-to-the-curb (FTTC) are terms that are also used to describe these advanced, high capacity, high-speed Internet access technologies. *Review of the Section 251 Unbundling Obligations of Incumbent Local Exchange Carriers; Implementation of the Local Competition Provision of the Telecommunications Act of 1996; Deployment of Wireline Services Offering Advanced Telecommunications Capability*, 19 FCC Rcd 20293 (2004) .

[53] TIA President Matthew J. Flanigan, as quoted in *FCC Triennial Review Decision Boosts Incentives to Deploy Next-Generation Networks*, PULSEONLINE (Oct. 2003); http://pulse.tiaonline.org/article.cfm?id=1850.

FIG. 5. U.S. FTTP SUBSCRIBERS. 1999 – 2006



Sources: Subscribers: "High Speed Services for Internet Access" (semi-annual report), FCC; Homes Passed: "FTTH/FTTP Update" (Oct. 2006), RVA LLC Market Research and Consulting.

As seen in Figure 5, FTTP subscribers increased sharply from trend beginning about December 2004 or June 2005. While FTTP technology was operational in Dec. 1999, less than 14,000 households were connected up through Dec. 2002. In the two years, June 2004 to June 2006, however, nearly 420,000 FTTP subscribers were added. The reaction of FTTP homes-passed (HP) was even more dramatic. HP grew from 19,000 in Sept. 2001 to 189,000 in March 2004. By Sept. 2006, however, it stood at about 6.1 million. Technology deployment appears to have substantially accelerated after the FCC explicitly eliminated the unbundling obligations.

The post-deregulation FTTP growth spurt was causally related to the policy switch according to independent analysts and technology suppliers. Gartner Dataquest, an NYSE-listed firm specializing in market research, explicitly adjusted its forecast of fiber optic equipment sales to reflect the 2004 reforms. Specifically, Gartner's Nov. 2004 projection for purchases of physical infrastructure inputs was shifted upwards throughout the 2005-2008 forecast period. The 2005 forecast for fiber network input sales approximately doubled.[54] The firm explained the forecast adjustment thusly:

> *Gartner Dataquest predicts that the FCC ruling providing unbundling relief for fiber-to-the-curb solutions for incumbent local-exchange carriers (ILECs) provides a significant opportunity for vendors during the next three years. This comes from the acceleration of the timetable of network deployment, particularly for vendors that are nonincumbents in*

[54] Bettina Tratz-Ryan, Ron Cowles, Jouni Forsman, *FCC's Unbundling Relief for FTTC Provides Vendor Opportunities*, GARTNER RESEARCH, No. G00124742 (Nov. 4, 2004).

> *the North American fiber market. This ruling lowers the threshold of market entry for advanced broadband access technology.*[55]

The overall growth pattern appears consistent with the Gartner Dataquest view that broadband regulation furthers network deployment. The evidence mirrors the DSL results, where reductions in "open access" mandates have been followed by above-trend increases in broadband subscribers.

V. ESTIMATING SOCIAL GAINS FROM DSL DEREGULATION

Policy driven increases in broadband subscribers positively impact Consumer Surplus, Investment, and Employment. These effects can be estimated using the approach by Crandall, Jackson, and Singer (2003),[56] which employs a two-stage method. First the direct benefits of broadband adoption on consumers gained via high-speed Internet access are calculated. Then, the effects of widespread broadband deployment on the overall U.S. economy, focusing on investment flows, job creation and GDP growth, are estimated. This paper follows that approach by quantifying increases in DSL deployment following deregulation.[57] The implications of DSL regulation are estimated using the DSL growth forecast based on the trend in evidence while line-sharing regulations were in effect (through 1Q2003), and comparable estimates made using actual DSL subscribership through year-end 2006. Hence, the effects of the 2003 and 2005 DSL reforms are aggregated in this assessment of deregulatory broadband policy.

In 2002, 5.71 million U.S. residential consumers[58] paid an average monthly fee of about $39.51 for DSL access, leading to approximately $2.71 billion in annual revenues. Assuming a linear demand schedule for DSL access with price elasticity = -1.5[59] implies that these 2002 consumers gained $0.90 billion in annual surplus (or $158.04 per subscriber), in addition to the $2.71 billion they paid. If the pre-deregulation trend in DSL subscribership had continued through 4Q2006, there would have been 15.25 million

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[55] Ibid.

[56] R. W. Crandall, C. L. Jackson, and H. J. Singer, *The Effect of Ubiquitous Broadband Adoption on Investment, Jobs, and the U.S. Economy, A RESEARCH STUDY CONDUCTED BY CRITERION ECONOMICS, L.L.C. FOR THE NEW MILLENNIUM RESEARCH COUNCIL* (Sept. 2003); http://www.criterioneconomics.com/docs/ubiquitous_broadband_adoption.pdf.

[57] To be conservative, gains associated with increases in FTTP deployment are ignored in this analysis.

[58] This subscriber level represents the average for 2002. Other references to subscriber levels in a particular year are also averages, unless stated otherwise.

[59] Crandall, Jackson, and Singer (2003) consider two linear demand scenarios: one with a price elasticity (at market output) of -1 and the other with elasticity equal to -1.5. Both of these assumptions are for the baseline case in 2001-02. To be on the conservative side, the calculations herein use an elasticity of -1.5 for pre-deregulation demand. (In contrast, assuming an elasticity of -1 yields consumer surplus equal to $7.24 billion, annualized, in 4Q2006. If the pre-deregulation subscriber growth trend had continued, annual consumer surplus would have equaled $4.40 billion, a difference of $2.85 billion.) Crandall, et al. also make computations for a log-linear demand schedule, but reject this approach on the argument that with increasing penetration the price elasticity of demand should fall below -1. Parallel shifts of a log-linear demand schedule, on the contrary, maintain a given price elasticity.

customers generating $5.67 billion in annualized revenues.[60] This would have generated $3.19 billion in consumer surplus per annum (or $209.22 per subscriber).

However, subscribership actually increased to 25.14 million in the fourth quarter of 2006. As a result, consumers gained surplus of $5.26 billion per year (again, $209.22 per subscriber),[61] with $9.34 billion in revenues being generated. Based on these estimates, DSL deregulation is associated with $3.67 billion in revenue gains and $2.07 billion in extra consumer surplus per annum, as of 4Q2006. This omits increases in consumer value generated by competitive responses of cable TV operators, which would add to deregulatory gains. It is widely noted by analysts that cable modem service speeds have been dramatically increased in recent years as DSL offerings have improved.[62]

Crandall, et al. (2003) next estimates[63] the effects of broadband penetration on the number of jobs and U.S. GDP. They first project the number of DSL and cable modem subscribers from 2007 onwards by fitting an S-curve onto 1999-2006 data.[64] Then they estimate DSL and cable modem capital expenditures (capex) for each year using Bear Stearns and Morgan Stanley projections. Bear Stearns forecasts DSL deployment and customer premises equipment expenditures per new customer, as well as maintenance expenditures per existing customer. Lacking the expenditure breakdown per new or existing subscriber, we here divide the total DSL capex by the mean number of subscribers for each year to compute an average annual multiplier. See Table 2 which compares actual economics outcomes with those projected by the DSL growth trend established under "open access" (i.e., prior to the elimination of line-sharing in 1Q2003), like Tables 3-5.

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[60] This assumes a mean monthly DSL subscription price of $30.98, the actual price for year-end 2006 reported in Bear Stearns, *December Broadband Buzz: A Monthly Update on Critical Broadband Issues* (Dec. 29, 2006).

[61] These calculations assume that the linear demand schedule shifts out to the right (higher quantities demanded) while anchored to the original point (on the price axis) where quantity demanded equals zero. Therefore, the increase in consumer surplus is largely generated by buyers with relatively low demand prices. If, instead, higher penetration is assumed to result from a generic increase in consumer demand prices (a parallel shift of the demand schedule upwards), the consumer surplus gains associated with deregulation are far more dramatic: $11.05 billion in annualized consumer surplus is generated as of 4Q2006 assuming elasticity = -1.5. Assuming an elasticity of -1 would further raise CS gains, calculated in this more ambitious way, to $16.57 billion.

[62] Bernstein Research, *Broadband Update: Seasonality Remains a Question But Growth Continues Unabated; The Fight Turns to Net Additions* (July 7, 2006), p.6.

[63] Crandall et al. (2003) also estimates social gains from additional expenditures on computing capacity due to increased broadband diffusion. While these indirect effects are beneficial, they are excluded from the analysis here.

[64] Note that the Morgan Stanley data used for prediction includes actual numbers for the first four and projections for the remaining four years.

TABLE 2. DSL CAPITAL EXPENDITURES

Year	Total DSL Capex[65]	DSL Subs[66]	Capex Multiplier	DSL Subs w/o DSL regulation[67]	Capex w/o DSL reg	DSL Subs w/ line sharing	Capex w/ line sharing
2003	996.00	6.38	156.02	8.27	1289.94	7.91	1233.81
2004	1186.30	8.76	135.40	12.26	1659.75	10.07	1363.92
2005	1279.40	10.96	116.77	17.26	2016.00	12.25	1430.89
2006	***1211.50***	***13.04***	***92.94***	***23.08***	***2144.62***	***14.43***	***1341.48***

Using these multipliers, DSL capex over the 2003-2006 period can be estimated given actual levels of subscribers and the pre-deregulation forecast. By 2006, an average of 23.08 million DSL subscribers are estimated to have generated $2.14 billion in annual capital expenditures. On the other hand, under "line sharing" regulation annual capital expenditures by 2006 would have been equal to $1.34 billion on average. Deregulation, therefore, is associated with an incremental $803 million in annual capital spending.

Such expenditures result in the creation of jobs and raise GDP. Using the mean of the two multipliers calculated by the Bureau of Labor Statistics for telephone/telegraph apparatus and communication equipment,[68] the effects of incremental DSL capex on the number of jobs is estimated as shown in Table 3.

TABLE 3. EFFECTS OF INCREASED DSL CAPEX ON JOBS

Year	Jobs Multiplier	Capex w/o DSL regulation	# of Jobs w/o DSL regulation	Capex w/ line sharing	# of Jobs w/ line sharing
2003	18.11	1289.94	23360.74	1233.81	22344.28
2004	18.11	1659.75	30058.12	1363.92	24700.65
2005	18.11	2016.00	36509.73	1430.89	25913.49
2006	18.11	2144.62	38839.06	1341.48	24294.17
Average			***32191.91***		***24313.15***

Annual capex of $2.14 billion on DSL is predicted to create and sustain, on average, 32,192 jobs in the U.S. At the DSL subscriber level predicted by the pre-deregulation trend, job creation would be estimated to equal 24,313, a difference of 7,879. See Table 3.

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65 Bear Stearns and Crandall, et al. (2003) forecasts.
66 Crandall, et al. (2003) estimates.
67 Estimates from linear extrapolation in this paper, explained above.
68 As provided by Crandall, et al. (2003), these multipliers are 17.2278 and 18.9885, respectively.

TABLE 4. EFFECTS OF INCREASED DSL CAPITAL EXPENDITURE ON GDP

Year	GDP Multiplier	Capex w/o DSL regulation	GDP w/o DSL regulation	Capex w/ line sharing	GDP w/ line sharing
2003	2.82	1289.94	3637.62	1233.81	3479.34
2004	2.82	1659.75	4680.50	1363.92	3846.26
2005	2.82	2016.00	5685.12	1430.89	4035.12
2006	2.82	2144.62	6047.83	1341.48	3782.97
Average			***5012.77***		***3785.92***
Cumulative			***20051.06***		***15143.70***

The increase in DSL capex also expands national income (GDP). Again using the multiplier provided by Crandall, et al. (2003), we find that GDP expanded by an average $5 billion annually over 2003-2006 due to DSL capital spending. Under the "line sharing" trend, however, the average annual GDP increase would have equaled just $3.8 billion. Deregulation, therefore, is associated with an estimated annual GDP increase of $1.23 billion. This translates into an increase of approximately $4.9 billion over the four years since the FCC decision to end line-sharing. See Table 4.

All told, the economic impacts implied by the strong increase in DSL broadband subscribers are very substantial. These estimates, which combine the output-enhancing impacts associated with both the 2003 and 2005 DSL deregulations, are summarized in Table 5.

TABLE 5. SUMMARY OF ECONOMIC PROJECTIONS

	w/o DSL regulation	Trend w/ line sharing	Difference
Welfare Implications of DSL Access			
Annualized Revenue by 4Q06 (bil.)	$9.34	$5.67	***$3.67***
Annual Consumer Surplus by 4Q06 (bil.)	$5.26	$3.19	***$2.07***
Average DSL Capital Expenditures, 2006 (bil.)			
	$2.14	$1.34	***$0.80***
Average Number of Jobs Created and Sustained, 1Q2003-4Q2006			
	32,192	24,313	***7,879***
Cumulative increase in GDP, 1Q03-4Q06 (bil.)			
	$20.05	$15.14	***$4.91***

VI. SUMMARY

Net neutrality regulation rests on the belief that that last-mile broadband providers pose a threat to the free flow of Internet traffic, endangering not only the economic interests of their subscribers, but reducing incentives for content creation that threaten the growth of the Internet itself. Opponents of NN typically respond that such harms are hypothetical, that regulation deters investment, and that government rules should not be imposed before there is stronger evidence of anti-competitive conduct by ISPs with market power.

Too little of this debate has considered, however, the substantial body of evidence already available on the question of broadband regulation. Since the dawn of high-speed Internet access, U.S. policy has actively intervened to promote "open access" in some segments of the market, but not others. Moreover, the rules have changed over time, such that we may evaluate how mandated access to networks – to assure neutrality or openness, as defined by policy makers – have helped spur investment, innovation, and deployment.

The evidence in broadband markets strongly suggests that consumers benefit from deregulation. Cable modem services held nearly a two-to-one market share advantage when DSL carriers were most heavily obligated to provide "open access" to competing ISPs. Once the FCC eliminated a key provision of that access regime, ending "line sharing" in a Feb. 2003 ruling, DSL subscriber growth began increasing dramatically. The surge in growth is not explained by overall changes in the broadband market, as DSL gains are in evidence even when contemporaneous trends in U.S. cable modem subscribers and Canadian broadband subscribers (both DSL and CM) are controlled for. Moreover, when further DSL deregulation was granted by the FCC as of August 2005, growth again increased from trend. These post-deregulation growth responses are both statistically significant, as shown econometrically.

By 4Q2006, DSL subscribership was 65% higher – nearly 10 million households – than it would have been under the trend initially established under "open access" regulation. This extremely robust response by consumers is inconsistent with the view that broadband regulation promotes innovation in applications or investment in infrastructure.

While yet a smaller part of the market, the same basic outcome is also observed in deployments of the most advanced broadband networks. Prior to formal elimination of the mandatory network sharing rules for fiber-to-the-premises networks, achieved in a series of FCC decisions between Feb. 2003 and Oct. 2004, FTTP build-outs were miniscule. While the technology was being deployed in the U.S. in 1999, by June 2004 just 16,000 households subscribed. With deregulation, however, FTTP growth kicked in; by June 2006, over 440,000 households subscribed and, by year-end 2006, more than six million households had the option of doing so. Both carriers and independent market analysts explicitly cite the policy switch as a key driver in the "sudden" emergence of FTTP deployments.

The broadband growth associated with deregulation of DSL is estimated to have produced approximately $2.1 billion in annualized consumer surplus gains for broadband users in 4Q2006. Using standard metrics with conservative assumptions, DSL deregulation is projected to create nearly $1.23 billion in annual GDP gains over 2003-2006 period. These empirical findings suggest that the magnitude of the social gains available from broadband deregulation is large. The implication for the Net Neutrality policy choice is apparent. Regulation offers to reverse policy successes visibly associated with favorable outcomes for the growth of innovative content, high-speed networks, and consumer welfare.

APPENDIX: ECONOMETRIC ANALYSIS OF DSL GROWTH FOLLOWING BROADBAND DEREGULATION

1. 1Q2003 Deregulation – End of "Line Sharing"

To test the hypothesis that "open access" rules for DSL promote efficiency, a simple model is constructed to reveal whether DSL subscriber growth increased following the elimination of a key component of that regulatory regime in the first quarter of 2003. The first model (Model I) predicts aggregate quarterly growth for U.S. DSL operators as a function of a constant, a time trend, concurrent cable modem subscriber growth, and a dummy variable to reflect post-deregulation changes. Quarterly subscriber data, 1Q1999 through 4Q2006, are used.[69] Specifically, Model I is defined as:

$$g_t^{US,DSL} = \beta_0 + \beta_1 g_t^{US,Cable} + \beta_2 t + \beta_3 Switch + \varepsilon_t , \qquad (1)^{70}$$

where the dependent variable is the DSL subscriber growth in quarter *t*, and the independent variable of interest is the *Switch* dummy set to one for periods after and including 1Q2003. Cable modem subscriber growth in period *t* and the time trend are controlled for. The null hypothesis implies that $\beta_3 < 0$, meaning that relaxation of "open access" rules is associated with reduced DSL subscriber growth, all else equal.

TABLE A1. Effects of 1Q2003 "Line Sharing" Deregulation - Model I

$g_t^{US,DSL}$	Coef.	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
$g_t^{US,Cable}$	-0.0960	0.1160	-0.83	0.42	-0.3340	0.1420
t	-0.2779	0.0090	-31.05	0.00	-0.2963	-0.2595
Switch	***0.1248***	***0.0217***	***5.76***	***0.00***	***0.0803***	***0.1693***
Constant	0.8432	0.0286	29.46	0.00	0.7845	0.9019
N=31, R-squared=95.34%						

Results are displayed in Table A1. The estimated *Switch* dummy coefficient, β_3, is positive and statistically significant. This evidence is counter to the null hypothesis (that open access rules increase efficiency), and suggests that DSL growth, in fact, *increased* after deregulation even when controlling for contemporaneous CM growth.

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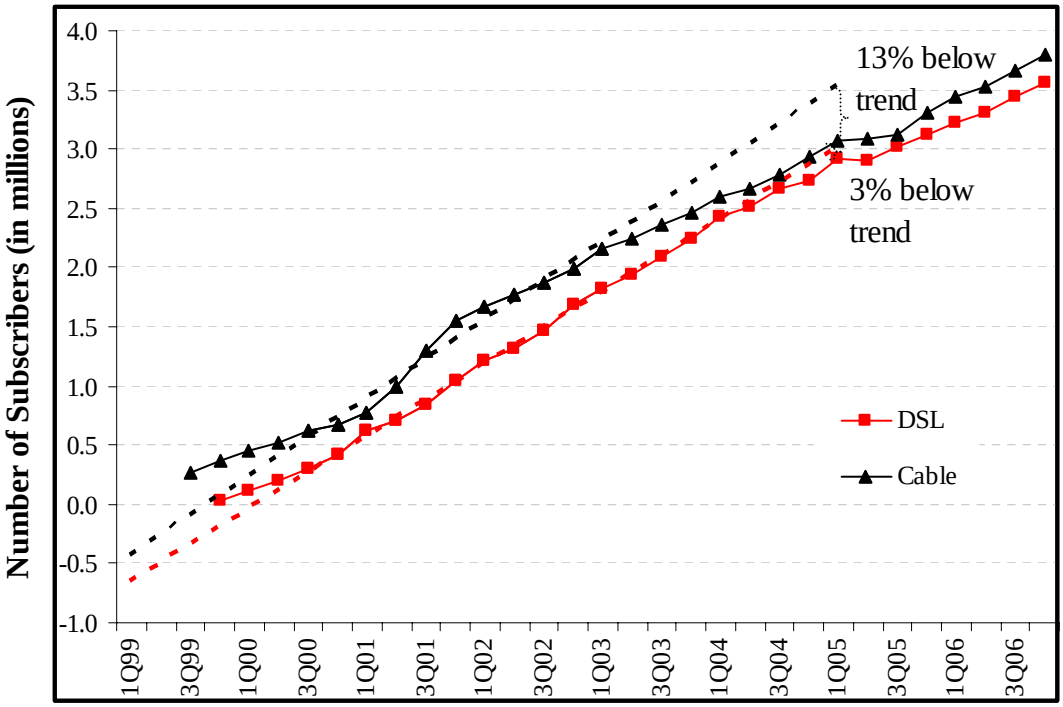
[69] Legg Mason U.S. DSL and cable modem data cover the period from 1Q99 through 1Q06. Kagan provides the U.S. broadband data from 1Q05 through 4Q06. In order to merge the data from two different sources, the Kagan data for 2Q06 and 4Q06 are normalized with multipliers (Legg Mason/Kagan) averaged over the five overlapping data points, 1Q05-1Q06.

[70] Growth is computed by the formula, $g_t^x = \ln(\frac{Subscribers_{t+1}^x}{Subscribers_t^x})$. The time trend is also in log form.

One explanation might be that there were changes in industry economics independent of the "line sharing" deregulation. One source of such change would be technology developments that impacted DSL deployment relative to cable modem service starting about the first quarter of 2003. For that, concurrent market trend evidence from the Canadian broadband market is examined. If factors specific to DSL technology are helping to accelerate DSL deployment, the same trend ought to be apparent in the Canadian broadband race. It is noteworthy that Canada is not only geographically proximate to the U.S., but is structured similarly with respect to broadband, where CM market share exceeds that of DSL.

FIG. A1: DSL & CABLE MODEM SUBSCRIBERS IN CANADA, 3Q1999-4Q2006



Sources: Legg Mason and Kagan.
Notes: The linear time trend is estimated using data from 3Q2000 to 1Q2003. Legg Mason Canadian data cover periods through 1Q05. Since Canadian data from 2Q05 through 4Q06 are provided by a different source (Kagan), trend estimates (based on these data) are extended only through 1Q05. The Kagan dataset does not include cable subscribership for 2Q05. Therefore, the average of 1Q05 and 3Q05 is used as the estimate of 2Q05.

Subscribership statistics from Canada reveal that both DSL and cable modem growth fall below historic trend by the first quarter of 2005.[71] (The time trend is estimated fitting a linear OLS regression to the data from 3Q2000 to 1Q2003, the

[71] Legg Mason data for the Canadian market were only available through 1Q2005. Kagan provided the data from 2Q05 through 4Q06. Canadian cable subscribership in 2Q05 was omitted from the dataset and therefore estimated as the average of 1Q05 and 3Q05.

approach used for the U.S.-only case.) However, the decrease is less for DSL than for cable modem, signaling that industry economics might have turned in favor of DSL in the post-2002 period. We therefore include the Canadian market growth data as control factors when predicting U.S. DSL subscriber growth in Model II, estimated as:

$$g_t^{US,DSL} = \beta_0 + \beta_1 g_t^{US,Cable} + \beta_2 g_t^{Canada,DSL} + \beta_3 g_t^{Canada,Cable} + \beta_4 t + \beta_5 Kagan + \beta_6 Switch + \varepsilon_t \quad (2)$$ [72]

The independent variable of interest is again the *Switch* dummy. However, this model controls for not only same-period cable modem subscriber growth and time trend, but also for concurrent Canadian DSL and Canadian cable modem subscriber growth. The different sources for the Canadian broadband data are also controlled for using a dummy, *Kagan*, set to one for the periods after and including 2Q2005. The data used are from 4Q1999 through 4Q2006. Results are displayed in Table A2.

TABLE A2. EFFECTS OF 1Q2003 "LINE SHARING" DEREGULATION – MODEL II

$g_t^{US,DSL}$	**Coef.**	**Robust Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**	
$g_t^{US,Cable}$	0.0017	0.4388	0.00	1.00	-0.9109	0.9144
$g_t^{Canada,DSL}$	0.0103	0.0465	0.22	0.83	-0.0865	0.1071
$g_t^{Canada,Cable}$	-0.3033	0.1859	-1.63	0.12	-0.6898	0.0833
t	-0.2968	0.1039	-2.86	0.01	-0.5128	-0.0807
Kagan	0.0633	0.0286	2.21	0.04	0.0037	0.1228
Switch	***0.0972***	***0.0293***	***3.32***	***0.00***	***0.0363***	***0.1581***
Constant	0.0017	0.4388	0	1.00	-0.9109	0.9144
N=28, R-squared=91.07%						

The estimated coefficient for the *Switch* dummy is still positive and statistically significant. [73] The results imply, therefore, than post-deregulation DSL growth increases are not explained by industry or technology changes seen in other markets. Even when adjusting for the growth rates of Canadian broadband providers, U.S. DSL subscribership increases by a statistically significant magnitude following the abolition of line sharing.

[72] Growth is computed by the formula, $g_t^x = \ln(\frac{Subscribers_{t+1}^x}{Subscribers_t^x})$. The time trend is also in log form.

[73] After including Canadian broadband growth rates, the R-squared decreases from 95.47% to 90.96%. This may stem from the fact that the number of observations decreases from 30 to 22, as the Canadian data used in Model II are not available for all periods for which quarterly U.S. data have been obtained.

2. 3Q2005 Deregulation – DSL Regulated under Title I

To test whether the observable change in DSL subscriber growth following the Aug. 2005 deregulation is statistically significant, Model I is modified by adding a regime switch dummy to reflect the 3Q2005 policy change. The estimated equation is:

$$g_t^{US,DSL} = \beta_0 + \beta_1 g_t^{US,Cable} + \beta_2 t + \beta_3 Switch_1 + \beta_4 Switch_2 + \varepsilon_t \qquad (3)$$ [74]

As before, the dependent variable is DSL subscriber growth in period *t*. Cable modem subscriber growth and the time trend are controlled for. Now, there are two independent variables of interest. $Switch_1$ dummy is set to one for periods after and including 1Q2003, whereas $Switch_2$ assumes the value of one for periods after and including 3Q2005. The null hypothesis here implies that $\beta_3 < 0$, $\beta_4 < 0$. Results are displayed in Table A3.

TABLE A3. EFFECTS OF 1Q2003 AND 3Q2005 DEREGULATION ON DSL GROWTH

$g_t^{US,DSL}$	Coef.	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
$g_t^{US,Cable}$	-0.0819	0.1180	-0.69	0.49	-0.3243	0.1606
t	-0.2837	0.0070	-40.72	0.00	-0.2980	-0.2693
Switch₁	***0.1133***	***0.0211***	***5.37***	***0.00***	***0.0699***	***0.1567***
Switch₂	***0.0614***	***0.0127***	***4.85***	***0.00***	***0.0354***	***0.0874***
Constant	0.8516	0.0231	36.80	0.00	0.8040	0.8992
N=31, R-squared=96.42%						

Both coefficients of interest are estimated as positive and statistically significant. After including $Switch_2$, R-squared increases from 95.34% to 96.42%, meaning that the explanatory power of the model is slightly higher. Incremental post-deregulation DSL subscriber growth is again, as in the first deregulation, positive – evidence inconsistent with the thesis that "open access" regulation results in greater efficiencies in broadband markets.

[74] Growth is computed by the formula, $g_t^x = \ln(\frac{Subscribers_{t+1}^x}{Subscribers_t^x})$. Time trend is also in log form.