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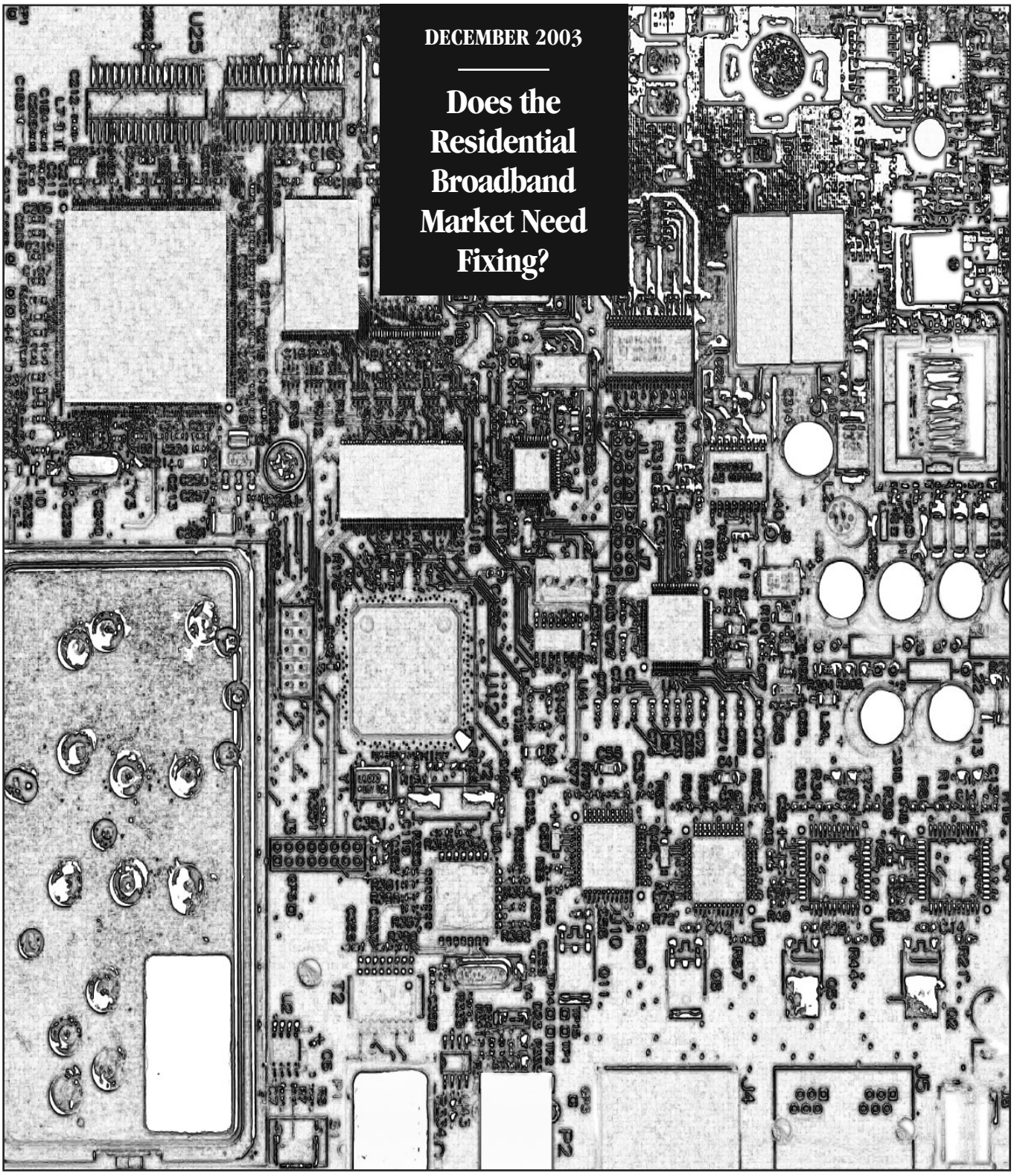
PAPER



DECEMBER 2003

Does the Residential Broadband Market Need Fixing?

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The Congress of the United States ■ Congressional Budget Office

Note

Numbers in the tables and text may not add up to totals because of rounding.

The cover photo of a cable modem circuit is courtesy of CableLabs.

Preface

As the Internet becomes more widely used by consumers, more households want a fast connection to it (usually called broadband) at home. Although that use of high-speed Internet access has grown as fast as the use of any recent consumer good has, many observers argue that the broadband market is not functioning properly, either for reasons internal to it or because of government regulation. This Congressional Budget Office (CBO) paper—prepared at the request of the Senate Budget Committee—reviews the recent trends in the market for residential fast Internet access to determine whether there are impediments to the market's growth. In keeping with CBO's mandate to provide objective, impartial analysis, this report makes no recommendations.

Philip Webre of CBO's Microeconomic and Financial Studies Division prepared the paper under the supervision of Roger Hitchner and David Moore. The paper benefited from the comments of Steven Wildman, Andrew Odylzko, Harold Furchtgott-Roth, Gerald Faulhaber, John Berresford, and Coleman Bazelon. Within CBO, Tom Woodward, Mark Lasky, and Kathy Gramp contributed helpful suggestions.

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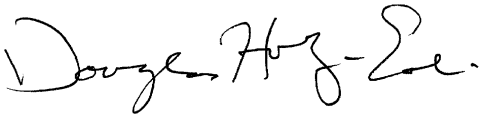

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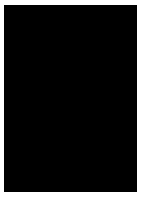
December 2003



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Summary

Households and small businesses have adopted high-speed Internet access, also known as broadband, at a rapid rate over the past three years. Data published by the Federal Communications Commission (FCC) show that as of December 2002, 17.4 million households and small businesses subscribed to high-speed lines for Internet access, up from only 1.8 million in December 1999 (*see Summary Table 1*). A regional view of the data also indicates rapid growth. In 1999, more than 40 percent of the zip codes in the United States did not have even a single subscriber to a broadband service, according to the FCC. At the end of 2002, only 12 percent of zip codes had no such subscribers (*see Summary Figure 1*). Indeed, broadband's rapid rate of growth is rivaled only by that of the most successful of recently introduced consumer electronics products, such as cellular telephones.

Yet some observers maintain that the market is expanding too slowly. They contend that flaws in the market's structure impede even more rapid growth and the benefits it would bring to the economy, and they argue that the federal government should intervene—by providing financial incentives—to encourage such growth. Advocates of federal action have thus introduced two dozen bills to accelerate the deployment of high-speed Internet access—in many cases, by means that would increase federal spending or decrease revenues. This Congressional Budget Office (CBO) report analyzes the development of the residential broadband market (a category that covers both households and small businesses) to assess whether structural features or regulatory obstacles (or both) impede its further rapid growth.

The local networks that supply telephone and cable television services also provide most of the high-speed access to the Internet that is purchased by small businesses and households. Among markets nationwide, the combined share of broadband service provided by local telephone and cable companies averages more than 90 percent. That feature of the supply side of the residential market for high-speed Internet access raises the possibility that the two dominant firms in each individual market might be able to keep prices above the cost of providing service. If that occurred, too few people might subscribe to a broadband service at too high a price relative to the prices that would prevail in a more competitive market—a situation known as a market failure. Many advocates of federal intervention maintain that that is what has happened. Claims of a failure on the demand side of the market are more diverse and in general are less important for the market's operation.

CBO's analysis concludes, however, that nothing in the performance of the residential broadband market suggests that federal subsidies for it will produce large economic gains. That finding is relevant in addressing claims about broadband's future contribution to the economy and the support that some advocates of federal intervention draw from those claims. Specifically, if the market is functioning adequately, economic gains from interventions to increase the number of subscribers are likely to be offset by losses in other markets, leaving the economy as a whole worse off.

Summary Table 1.

High-Speed Internet Access Lines in Residences and Small Businesses

(Thousands)

	Dec. 1999	June 2000	Dec. 2000	June 2001	Dec. 2001	June 2002	Dec. 2002
Asymmetric Digital Subscriber Lines[a]	292	772	1,595	2,491	3,616	4,395	5,529
Other Wired Technologies	47	112	176	138	140	224	213
Cable Modem Services	1,402	2,215	3,295	4,999	7,051	9,157	11,343
Fiber-Optic Cable	1	*	2	3	4	6	15
Satellite and Other Wireless Technologies	50	64	102	182	195	202	257
Total	**1,792**	**3,164**	**5,170**	**7,812**	**11,005**	**13,984**	**17,357**

Source: Congressional Budget Office based on Federal Communications Commission, *High-Speed Services for Internet Access: Status as of December 31, 2002* (June 2003), Table 3.

Note: * = rounds to zero.

a. With asymmetric lines, the speeds at which customers can receive data are by design much greater than the speeds at which they can send information.

Economic efficiency (allocating resources to the uses that will most enhance society's well-being) is not the only reason that federal policymakers might decide to subsidize telecommunications services. Concerns about equity and regional economic development may also enter into their considerations. However, those issues are beyond the scope of this analysis, which addresses only the question of economic efficiency.

Overview of the Residential Broadband Market

Small businesses and households can connect to the Internet through broadband or dial-up connections.[1] Broadband access to the Internet is distinguished from dial-up access provided by a conventional telephone line on two dimensions: speed and availability. Broadband access allows subscribers to connect (with either outgoing or incoming transmissions—usually incoming) at a speed of at least 200,000 bits of information per second. By contrast, dial-up services typically operate at less than 56,000 bits per second. Broadband's performance also exceeds that of dial-up access in that, typically, it is always "on" (dedicated and immediately available).

As noted earlier, local telephone and cable television companies currently dominate the residential broadband market. In December 2002, high-speed Internet access through a cable modem accounted for 65 percent of all broadband subscriptions carried by households and small businesses, and digital subscriber line (DSL) service accounted for 32 percent. Telephone companies deliver DSL service through their existing wired telephone networks using a special modem, which transmits the computer signals at frequencies above the range of human hearing and thus does not interfere with voice telephone service. Cable television companies deliver their broadband service by using an unused channel on their cable network and a special modem.

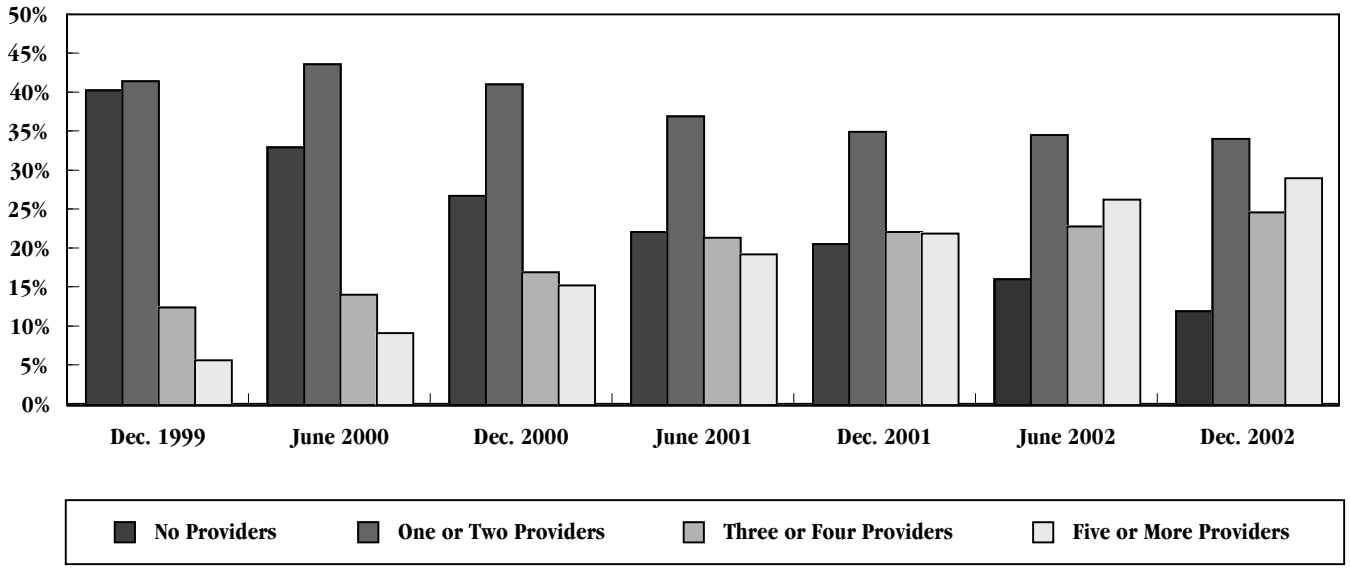
The Supply Side: Competition Now and in the Future

Currently, the major cable and telephone companies maintain their large share of the broadband market at the expense of the growth of their competitors' share (mainly satellite companies and competitive providers that use the telephone companies' wired networks; *see*

1. The markets for Internet access that serve big corporations and institutions are substantially larger and better developed than the residential market, in part because those organizations, whether business, not-for profit, or governmental, came to value high-speed Internet access both as users and providers of information more rapidly than did residential consumers. This report does not address those larger markets.

Summary Figure 1.

Percentage of Zip Codes Nationwide with High-Speed Internet Access Subscribers, by Number of Providers



Source: Congressional Budget Office using data from Federal Communications Commission, *High-Speed Services for Internet Access* (various years).

Note: The data are for lines that provide high-speed Internet access to residences and small businesses.

Summary Figure 2). Both the incumbent local telephone company and the local cable franchise deliver their broadband service over extensive and costly wired networks that were originally designed and built for a different purpose. Those networks create a particular structure of costs. Delivering any service is expensive to begin with because the network has to be built. But once it is in place, service can be delivered at a relatively lower cost. That combination of high startup and low operating costs makes it particularly difficult for would-be competitors to enter the market. As a consequence, some observers are concerned that telephone and cable companies will continue to increase their share of the market and keep prices above the level they would reach if the market was competitive. In that circumstance, too few people would buy broadband services and those who did would pay too much for them.

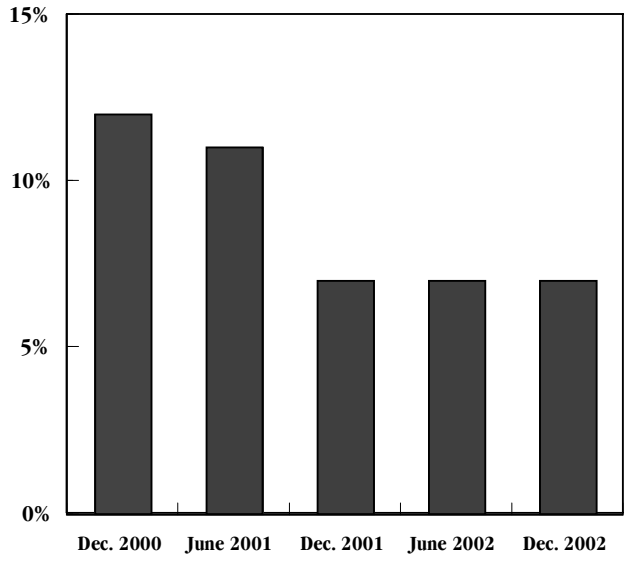
Two developments could prevent that outcome. First, new competitors could enter the market. Second, competition in the larger telecommunications markets could force the telephone and cable companies to behave competitively in the broadband market, even without a larger number of competitors in that market.

New Entrants into the Residential Broadband Market

New competitors could enter the residential broadband market by using either wired or wireless technologies to connect their customers to the Internet. Much of the existing competition in the market comes from firms that use wired technologies. Until 2003, the FCC required incumbent local telephone companies to lease frequencies on their telephone lines to competitive companies that wanted to provide DSL service. In February 2003, the commission announced the start of a three-year transition to gradually eliminate those leasing requirements. The final outcome of that transition is as yet unknown because the FCC's decision is being challenged in the courts and the

Summary Figure 2.

Market Share of Competitive High-Speed Internet Access Providers



Source: Congressional Budget Office based on Federal Communications Commission, *High-Speed Services for Internet Access* (various years).

Note: Competitive providers (for example, satellite Internet suppliers) are providers other than the local cable and telephone companies.

commission had planned in any event to revisit its decision in three years. However, even before the regulatory change, some competitive DSL providers went bankrupt because of the slowdown in investment in telecommunications equipment beginning in 2001. The remaining competitive DSL firms face uncertain prospects, and their share of the market is quite small.

The most prominent technological alternatives in the category of wired high-speed Internet access are new fiber-optic cable networks and the use of existing electric power lines. Despite widespread interest in fiber optics, the latest estimates by the FCC suggest that only 15,000 households and small businesses use it to connect directly to the Internet, and few analysts anticipate rapid deployment of fiber networks in the near future. Moreover, the most likely agents of fiber deployment are telephone companies, which means that such a development would add capacity to the market but not a new competitor. Power lines that transmit electricity are already connected to most residences and small businesses and thus appear to offer a potential broadband connection. In April 2003, the FCC began a major study of that form of broadband communications. However, whether the use of power lines to provide high-speed Internet access is technically viable is unclear. Also uncertain is how the cost of that alternative compares with that of cable modem or DSL service.

Wireless technologies do not at present offer much competition to the local telephone and cable companies in the broadband market; in 2002, they accounted for less than 2 percent of residential broadband connections (*see Summary Table 1*). The FCC continues to make additional portions of the electromagnetic spectrum available for use, and private firms regularly announce new initiatives that use wireless data technology. To date, however, wireless broadband alternatives—including the use of satellite systems—serve only niche markets and limited geographic areas. The latest wireless broadband technologies are designed to overcome many of the problems that constrained earlier wireless systems, but the industry's history of past high expectations and subsequent limited success or even failure suggests that a wait-and-see attitude might be appropriate.

One popular new wireless technology, Wi-Fi, is successful within its rather narrow domain. Designed for connecting local computer networks to large numbers of users without the need to run costly wires, Wi-Fi has since been adopted by consumers (largely as a way of sharing their single DSL or cable modem connection among multiple home computers) and by institutions with large existing facilities, such as universities or hotels (as a way of providing broadband at low cost to peripatetic users). However, few firms have figured out how to profit directly from providing Wi-Fi service (although manufacturers of Wi-Fi hardware are profiting from its popularity). Furthermore, a Wi-Fi base station ultimately requires its own wired or wireless link to connect to the Internet.

Competition in Related Markets

Limited prospects for growth and competitive threats in their core business markets could spur local tele-

Summary Table 2.

Investment by Regional Bell Operating Companies

(Billions of dollars)

	1996	1997	1998	1999	2000	2001
Investment						
Structures and equipment	19.7	20.0	20.2	27.5	35.7	32.4
Research and development	0.2	0.2	0.1	0	n.a.	n.a.
Total	**19.9**	**20.2**	**20.3**	**27.5**	**35.7**	**32.4**
Memorandum:						
Operating Revenues	78.7	80.4	86.0	90.4	109.2	108.7
Total Investment as a Percentage of Operating Revenues	25.3	25.1	23.6	30.4	32.7	29.9

Source: Congressional Budget Office using data from Federal Communications Commission, *Statistics of Communications Common Carriers* (various years).

Note: n.a. = not available.

phone and cable companies to compete more vigorously in the broadband market. As of December 2002, competitive providers in the telephone service market—which in many cases include the same cable television companies that compete with the phone companies in the broadband market—accounted for 10 percent of all residential telephone lines and 13 percent of all telephone lines nationwide. New competitors have also entered the core markets of cable television providers. From June 1998 to June 2002, the number of households that received multichannel video programming from a satellite service doubled, rising from 9.2 million to 18.7 million (or 18 percent of all households with televisions). By contrast, subscriptions to cable video service increased by only 5 percent during that period. To defend their core markets, both local telephone and cable television companies have begun to lower their prices for customers who are willing to buy a bundle of services—for example, telephone, cable television, and broadband access—from the same provider.

Supply and the Performance of the Market

Available indicators of the broadband market's performance are mixed. Price competition is not vigorous, at least not by the standard currently set in the market for cellular telephone service. (Like the broadband market today, it was at one time limited to only two providers but now has four to six competitors in every major market in the country.) Systematic data on broadband prices are sparse; however, existing information suggests that although DSL service providers have dropped their prices slightly (once rebates and other special offers are taken into account), cable providers have raised theirs to match the initially higher DSL rates. Recently, some of the largest DSL providers, including Verizon and SBC, lowered their prices to levels substantially below those of several of their major cable competitors. That move has not yet drawn widespread response from the cable companies.

Data specifically on the broadband investments of the two dominant firms are not available, but the high overall rates of spending by telephone and cable providers along with the rapid increase in the geographic availability of broadband suggest that both types of firms are investing in new broadband capacity. Indeed, between 1996 and 2001, the four largest local telephone companies (companies that were part of the old Bell system) increased their spending on new structures and equipment by 64 percent (*see Summary Table 2*). Cable companies also raised their investment spending substantially, increasing it by 68 percent over five years. Investments of that magnitude indicate that, thus far, the negative consequences of the market's domination by the local telephone and cable companies have been limited.

Some observers contend that both the regulations that have required telephone companies (but not cable companies) to open their networks to broadband competitors and uncertainty about whether those regulations will be in effect in the future have discouraged even higher levels of investment. The FCC's recent decision to suspend the requirement that telephone companies share their wired networks with competitive broadband providers, although subject to litigation and state regulatory interpretation, may reduce whatever restraint that rule might have had on telephone companies' investment in the broadband market. Nevertheless, evidence of a rapid rise in investment by the telephone companies during the period in which those regulations were in effect suggests that the deterrent to such spending that the regulations provided has been limited.

The Demand Side: Public Goods and Constraints on Content

The claims of problems on the demand side of the broadband market derive from underlying arguments about public goods and constraints on the content that is available for downloading over the Internet. Public goods are those goods that once they have been provided can be consumed by an additional person at no cost and for which it is inefficient to exclude any one consumer from receiving them. (National defense is the most frequently cited example of a public good.) Economists generally believe that private markets will supply too small an amount of a public good if they are left to their own workings.

Communications networks have attributes of a public good because an additional subscriber to a network provides a benefit to the existing subscribers—an additional person to communicate with—that is available to all of the network's members at little or no additional cost. Because a would-be subscriber fails to account for that "network effect" in calculating the benefits of subscribing, too few people will subscribe compared with the number that will maximize economic well-being. In the case of high-speed access to the Internet, however, the availability of traditional dial-up access through telephone lines, a slower but still relatively effective alternative, substantially reduces the extent of losses in economic well-being that might be attributable to network effects.

The observation that broadband access is an input that can be used to produce certain public services is the basis for the claim of a second potential failure on the demand side of the market. Services such as public health or education have some of the characteristics of a public good, and government policies promote their availability in a variety of ways, including subsidization of high-speed Internet access at so-called public portals (for example, libraries). However, the use of high-speed Internet access to disseminate those services does not suggest a market failure in that delivery mechanism, nor does it suggest that subsidies to households and small businesses are necessarily the most efficient way to provide more public goods. Existing subsidies for Internet access are also intended to address concerns about lack of access in low-income areas.

A third demand-side issue is the claim that constraints on the entertainment-oriented content that is available over the Internet (for example, restrictions on the number of their products that movie and music producers make available) represent a failure in the market. That claim is not relevant because questions about efficiency and the regulation of entertainment products lie outside of the market for high-speed Internet access. For example, the desirability of a broadband connection might be increased if restrictions arising from copyright protections could be ignored, but the lessening of those protections might have negative consequences as well—for the development of new content and the efficiency of the markets that produce it.

Conclusions

Although the residential broadband market is not characterized by a large number of competitive providers, the forces of supply and demand seem to be working to offer an increasing number of households and small businesses a choice of high-speed Internet

service from among a range of providers. The number of subscribers is growing dramatically; in short, the market is booming. Some of the problems that remain, such as uneven availability, are a function of the market's relative youth and immaturity and are not necessarily permanent features. The current domination of many markets by only two broadband providers, however, could turn out to be more long-lived.

Does the Residential Broadband Market Need Fixing?

Introduction

Households and small businesses are rapidly adopting high-speed, or broadband, access to the Internet. Nevertheless, some policymakers and analysts believe that this process has not proceeded as rapidly as its potential contribution to the economy merits. They advocate federal intervention in the development of the broadband market, including subsidies, to spur additional users.[1]

Broadband access to the Internet is a premium service: its extra speed relative to the dial-up access (through local telephone lines) that was initially available allows households and small businesses to connect to Internet sites more rapidly and download files more quickly, be they music, data, or software. The "always-on" feature of most broadband services provides an instantaneous response, similar to that achieved by depressing the power button on a television's remote control. If the service is functioning properly, it is always available for e-mail or browsing the Internet. In short, consumers of broadband receive a better service for which they pay a higher price.

Why has the availability of broadband access for households and small businesses become a policy issue? In a market economy, the best outcome for most products and services comes from allowing markets to work without specific constraint or encouragement, and policymakers usually leave the market to determine a product's or service's ultimate success. In the case of high-speed Internet access, policymakers might choose to stand aside and let the market determine which firms and technologies win or lose and which consumers decide to take up or forgo broadband service. Ample precedent exists in recent years for that kind of laissez-faire stance. For example, the Federal Communications Commission (FCC) has not actively promoted cellular telephone service, other than by making more licenses available for portions of the electromagnetic spectrum. The technology has largely succeeded on its own. Yet in the recent past, the Congress has considered roughly two dozen bills that propose to subsidize the adoption of high-speed Internet access in the country as a whole or in particular geographic areas.

Advocates of federal intervention argue that the broadband market for households and small businesses deviates so far from the norms of a competitive market that it requires government action. In cases in which a market's performance appears to fall short of the best possible outcome (often called a "market failure"), the federal government has sometimes intervened to improve the market's functioning. According to advocates of intervention, conditions on both the supply and demand sides of the broadband market prevent prices from signaling producers and consumers to buy and sell both the quantity and quality of broadband services that make the most efficient use of society's scarce resources. That inefficiency, they contend, results in slower growth than there might have been in the absence of those supply and demand constraints.

1. Advocates of federal action also argue that the market has not grown in as geographically balanced a manner as the potential benefits might suggest.

Although economists recognize that a market's imperfections can keep it from allocating resources efficiently, they have become increasingly hesitant to recommend intervention. Most markets exhibit some imperfections in either supply or demand, but the majority of them manage to function to the satisfaction of most participants and of society as a whole. Moreover, efforts to solve perceived problems through government action can create problems of their own. In some instances, policies may exacerbate existing difficulties or create new ones. Regulations and subsidies often distort the choices of consumers and producers in ways that encourage behaviors that are as socially undesirable as the original market failure they were designed to cure. In many cases, policies that were intended to address temporary problems become permanent and persist long after the original problems have been eliminated. Thus, the economist's lexicon includes "government or regulatory failure" as well as "market failure."

This Congressional Budget Office (CBO) report addresses two questions about the broadband market. First, is there evidence to suggest that the conditions of supply and demand in the market keep it from working well enough to provide the bulk of the social benefits that should come with its full development? And second, are any imperfections of sufficient magnitude to justify federal intervention, with all the costs that such involvement might entail?

Telecommunications policy is often made for reasons other than market failure. Promoting the development of rural areas and ensuring equality of opportunity are often cited as reasons for policies that are pursued independently of whether the overall market is working well or not. This report does not address those issues.

It also does not address high-speed Internet access for large institutions—for example, corporations, not-for-profit organizations such as universities, and government agencies. Their use of broadband is substantially greater and better developed than use in the residential market because they saw the value of high-speed Internet access early on for providing information and services to their clients and making the public aware of their products. Such institutions also needed high-speed access because of the number of individual users (employees, students, or staff) each of them represents.

Overview of the Residential Broadband Market

Broadband access to the Internet is distinguished from dial-up (or narrowband) access on two dimensions: speed and availability. In its reports on broadband, the FCC defines a service as high speed if it can transmit at least 200,000 bits per second (bps) in either direction (outgoing or incoming).[2] For browsing the Internet, that speed may be sufficient, if occasionally frustrating for users accustomed to faster connections. By contrast, the fastest dial-up services connect at a speed of 56,000 bps, but the actual service is usually much slower because of imperfections on the line. This report follows the FCC's convention in defining high-speed Internet access, or broadband, as 200,000 bps in either direction.[3]

Broadband offers superior performance relative to dial-up access because of another feature: typically, it is always "on" since the connection is dedicated. The user does not have to go through the procedure common in dial-up access of connecting to the Internet service provider and launching the appropriate software application. As a result, the computer may be used more spontaneously rather than as a tool with a setup period. Although the time needed to dial up and log on to a narrowband service may not be large in an absolute sense, it seems to affect the way the computer is used and the way its utility is perceived by the consumer.

2. A bit (or binary digit) is a zero or a one in computer language. The FCC recognizes an additional category of advanced broadband service, which can transmit at least 200,000 bits per second in both directions. Because residential consumers (in contrast to large institutional customers) do not typically use high-speed capacity for outgoing transmissions, CBO focused its analysis on "high-speed" service.

3. By contrast, institutional connections often run at about 1.5 million bps in each direction.

This report follows popular usage and treats broadband and dial-up Internet access as largely separate markets. Some analysts argue that the distinction between the two is not sufficient to characterize them in that way, and the majority of observers agree that the two are to some extent linked because the existence of dial-up access limits the prices that providers can charge for broadband. The working assumption of this analysis, however, is that the dial-up and broadband markets are moving apart and a growing number of consumers view slow access to the Internet as an increasingly unsatisfactory substitute for high-speed connection.

The overall market for Internet access can also be parsed in other ways. For example, in the residential segment of the market, local telephone companies have many fewer customers than the cable companies have. By contrast, cable companies are barely to be found as providers of high-speed Internet service to large businesses and other big institutional clients. Much of their service is provided by using the local telephone company's infrastructure, either directly or through contractual arrangements. As a result, if policy decisions designed for one segment of the market were not properly crafted, they could affect segments in which the competitive conditions were very different.

Much of the data collected and published by the FCC on residential broadband lumps two similar groups together—small businesses and households. The consumers in both groups are relatively small buyers, have few technological alternatives, and in general possess limited technological expertise. CBO follows the FCC's convention and for the purposes of this report refers to the two groups collectively as the residential broadband market.

Technologies Used for Residential Broadband Delivery

Currently, the bulk of residential high-speed access to the Internet is provided by cable modem, digital subscriber line (DSL), terrestrial fixed wireless, and satellite technologies.[4] Cable systems are the most widely used means of access; DSL is a distant second, with the others minor players at this point. Satellite and fixed terrestrial broadband have such a small share of the market that most data sources group them in a single wireless category. Other technologies, such as transmitting signals through the electrical wires, have been successful in the laboratory and in some pilot tests but are not yet being offered commercially.

Cable Modem Systems. Most cable television companies have upgraded their structures, equipment, and wires to provide fast Internet access through one of their unused channels. Such upgrades are usually part of a larger effort that allows the companies to provide more channels of digital video services and, in some cases, telephone service. In many instances, cable operators have installed a "backbone" of fiber-optic cable in their distribution systems to increase their capacity and reduce the need for intermediate electronics, which cost money and introduce distortion. Thus, in a modern "cable" system, only the last few segments of the distribution system still use the coaxial cable that gives the technology its name. At each residence or business, the cable is plugged into the cable modem, just as it might be into an additional television. The computer is attached in its turn to the modem through a computer network cable.

By its very nature, the cable system makes users share its limited capacity. Consequently, as more households log on to the system, each receives a smaller amount of capacity, which leads to congestion and slowdowns at times of peak use. Industry analysts assume that as the demand for data services grows, cable companies will increase the amount of fiber-optic cable in their systems to boost capacity and reduce the bottlenecks. Today, cable modem service is generally faster than DSL

4. For an extended discussion of residential broadband technologies, see Federal Communications Commission, *Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion: Third Report* (February 6, 2002), Appendix B; and National Research Council, *Broadband: Bringing Home the Bits* (Washington, D.C.: National Academy Press, 2002), pp. 120-160.

service, and consumers have generally experienced fewer troubles in getting the service up and running.

The cable companies enjoy an advantage over local telephone companies in the residential broadband market, in part because they were able to agree on a common standard for the required modem early on. Consequently, the necessary complements—equipment and training—were produced in a timely way.

Cable modem services are typically provided by the local cable monopoly franchise, but in a few cities, competing companies have installed a second cable line and are providing both cable video services and fast Internet access.

Digital Subscriber Line Service. All DSL service uses the existing telephone wires and is typically provided by the local telephone company (or incumbent local exchange carrier, as it is often called). However, it can also be provided by a competitive company that rents the local company's lines or equipment, or both.

DSL technology works by splitting into two parts the electromagnetic spectrum available to carry data over the telephone line. Low-frequency waves carry the voice signal, and high-frequency waves, above the range of human hearing, carry the computer data signal. DSL service can be of several types, the most important being asymmetric digital subscriber line (ADSL), which is what most residential customers get when they contract for the service. With ADSL service, the speeds at which customers can receive data are by design much greater than the speeds at which they can send information. Other types of DSL service are usually more expensive and generally provide a higher level of operation. For the most part, this report follows the convention used by most analysts and does not distinguish between the different kinds of service.

DSL technology has several limitations that have prevented local telephone companies from making the service available to a large fraction (possibly as much as a third overall) of the households in their service area. DSL service is distance sensitive—in most instances, customers have to be within 18,000 feet of the central telephone office that serves them. However, technological improvements and the wider use of remote terminals are lessening that restriction. An additional limitation for some local telephone companies is that earlier investments made to improve the quality of voice traffic have proved incompatible with conventional DSL technology.

Terrestrial Fixed Wireless Systems. In a fixed wireless system, the service provider attaches a radio transmitter/receiver to a customer's premises, and that device communicates with the provider's central antenna site. In general, terrestrial fixed wireless services are characterized by the portion of the electromagnetic spectrum over which the services are provided (each portion has different physical characteristics).[5] The services that operate at the lower bands of the spectrum can be provided from as much as 35 miles away from the central antenna hub. By contrast, the services that operate in the upper bands are limited to between two and five miles from the central hub (because the signals can be easily disrupted by precipitation or tree foliage). Other services require that the radio transmitter be in the central antenna's direct line of sight, which means that to serve a large area economically, providers must negotiate line-of-sight access individually with the owners of tall buildings.

Because of their characteristics, the various services have each attracted a different clientele. The lower-band wireless systems have been more widely used for residential service, because they can reach dispersed geographic areas.

Satellite Residential Internet Service. Internet service provided by satellite operates similarly to the video services that such technology provides. A ground station beams up the data signal to the satellite, which then transmits it to the area within its reach. Customers with the requisite equipment can receive and unscramble the signals. However, unlike video signals, which are the same for all subscribers, the Internet sig-

5. This discussion is derived in large part from Federal Communications Commission, *Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services: Sixth Report* (June 20, 2001), Appendix A.

nals are customized for individual residences, which increases their cost.[6] Most satellites orbit the earth at some distance; thus, the data they transmit are delayed slightly because the signal can travel only at the speed of light. However, the delay in sending and receiving signals is not thought to be as troublesome for satellite Internet access as it is for voice transmissions.

Satellite broadband service may be two way or one way. In both of those cases, the customer receives information through the satellite; however, in one-way service, the customer transmits information through a conventional dial-up connection.

Satellite broadband service suffers from many of the same drawbacks that are associated with terrestrial fixed wireless service; for example, the satellite receiving "dish" has to have direct line-of-sight access to the satellite, which for most of the United States means the southern sky. Mountains and even tall buildings can block that access, and bad weather can degrade the signal. However, because it is wireless, satellite service is usually thought to have a comparative advantage over wired technologies in remote areas.

In a number of cases, suppliers of satellite service have entered and then quickly exited the market, making the supply of such service seem uneven.[7] In other cases, satellite firms have continued to support existing subscribers but have not accepted new ones. Such practices leave open the question of how available this service is to the consumer seeking to subscribe to broadband access.

Increased Subscriptions and Revenues

The number of households and small businesses that subscribe to a service providing broadband access to the Internet has grown quite rapidly. According to FCC data, the total number of broadband lines used by households and small businesses increased almost tenfold between December 1999 and December 2002, rising from 1.8 million to 17.4 million.[8] Over the same period, the number of DSL subscriptions rose by a factor of 19, cable modem subscriptions increased eightfold, and the broadband wireless services market quintupled in size (*see Table 1*). By 2002, CBO estimates, 27 percent of all households with computers and 28 percent of all households with Internet access had broadband service.[9]

Cable modem and DSL service dominate both the absolute number of residential high-speed lines and the growth in such subscriptions that has occurred in recent years. In December 1998, the FCC reported that 375,000 households and small businesses had cable or DSL broadband subscriptions.[10] By December 2002, 16.8 million subscribers had high-speed Internet access through one of those two alternatives. Thus, for the two most prominent technologies combined, the number of subscribers rose by a factor of 45 in four years, for an average annual rate of growth of 159 percent. Despite the recent higher growth rate of DSL service, as noted above, cable modem subscriptions still outnumber DSL subscriptions by roughly two to one.

6. Satellite service is likely to remain a niche or premium product in the residential broadband market because of the limited capacity of each transponder (the device that relays the communications signals) and the cost of increasing their numbers. The transponder's limits do not matter as much for broadcasting a single set of programs (video service) as they do for responding to Internet communications and "surfing" by many individual users.

7. See, for example, Patrick Olsen and Gail Mitchell, "DirecTV Broadband to End Internet Service," *Chicago Tribune*, December 17, 2002, p. 8.

8. Federal Communications Commission, *High-Speed Services for Internet Access: Status as of December 31, 2002* (June 2003), Table 3, available at www.fcc.gov/wcb/iatd/comp.html.

9. That calculation ignores small business subscribers because the FCC does not break out those data. See Federal Communications Commission, *High-Speed Services for Internet Access: Status as of December 31, 2002*; and Eric Newburger, *Home Computers and Internet Use in the United States: August 2000*, Current Population Reports, P23-207 (September 2001), p. 1.

10. Federal Communications Commission, *Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion: First 706 Report* (February 2, 1999).

Table 1.

High-Speed Internet Access Lines in Residences and Small Businesses

(Thousands)

	Dec. 1999	June 2000	Dec. 2000	June 2001	Dec. 2001	June 2002	Dec. 2002
Asymmetric Digital Subscriber Lines[a]	292	772	1,595	2,491	3,616	4,395	5,529
Other Wired Technologies	47	112	176	138	140	224	213
Cable Modem Services	1,402	2,215	3,295	4,999	7,051	9,157	11,343
Fiber-Optic Cable	1	*	2	3	4	6	15
Satellite and Other Wireless Technologies	50	64	102	182	195	202	257
Total	**1,792**	**3,164**	**5,170**	**7,812**	**11,005**	**13,984**	**17,357**

Source: Congressional Budget Office based on Federal Communications Commission, *High-Speed Services for Internet Access: Status as of December 31, 2002* (June 2003), Table 3.

Note: * = rounds to zero.

a. With asymmetric lines, the speeds at which customers can receive data are by design much greater than the speeds at which they can send information.

Households are adopting high-speed Internet access as rapidly as they have adopted any telecommunications service in the recent past. For example, cellular telephone service, now available in most regions of the country, took six years to reach 7.5 million subscribers, a feat that the residential broadband market achieved in 3.5 years.[11] That high adoption rate for broadband is all the more remarkable considering that the market for service to households and small businesses started in earnest only in the late 1990s. Before the mid-1990s, the Internet itself was used mainly by academic researchers and technophiles. Clearly, however, neither cell phones nor broadband Internet access is as widely adopted as television or landline telephone service is and thus not as central to the typical consumer's participation in economic and civic life.

The rapid increase in subscriptions for residential broadband access has led to a rapid rise in companies' revenues. CBO estimates that in 2000, subscription charges for broadband, leaving aside installation fees and promotional discounts, were about $1.5 billion. By 2002, that stream of revenues had grown to between $7 billion and $8 billion (depending on estimates of prices).[12] That increase was due to both the rise in the number of subscriptions that was discussed above and higher prices for cable modem service (discussed later). By comparison, the FCC estimates that in 2002, subscribers and advertisers paid $43.8 billion to the cable industry—in addition to their fees for high-speed Internet and cable telephone service.[13] Local telephone companies earned even more; in 2001, the most recent year for which the FCC has published data, households and businesses paid those companies about $116.5 billion.[14]

Because cable and local telephone businesses are "mature," their sales of subscriptions for high-speed Internet access to households and small businesses represent a substantial fraction of their annual growth. Between

11. Gerald R. Faulhaber, "Broadband Deployment: Is Policy in the Way?" 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, 2003), p. 226.

12. The annual average prices for cable modem and DSL service come from ARS, Inc., a market research firm in La Jolla, California (www.ars1.com).

13. Federal Communications Commission, *Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming: Ninth Annual Report* (December 31, 2002), Table 4.

14. Federal Communications Commission, *Statistics of Communications Common Carriers, 2001* (September 12, 2002), p. 170.

Table 2.

Percentage of Zip Codes Nationwide with High-Speed Internet Access Subscribers, by Number of Providers

Number of Providers	Dec. 1999	June 2000	Dec. 2000	June 2001	Dec. 2001	June 2002	Dec. 2002
None	40.3	33.0	26.8	22.2	20.6	16.1	12.0
One	26.0	25.9	22.7	20.3	19.3	18.4	17.3
Two	15.5	17.8	18.4	16.7	15.7	16.2	16.8
Three	8.2	9.2	10.9	13.2	13.1	13.3	14.4
Four	4.3	4.9	6.1	8.2	9.1	9.6	10.3
Five or More	5.7	9.2	15.3	19.3	22.0	26.3	29.1

Source: Congressional Budget Office using data from the Federal Communications Commission.

1998 and 2001, cable and local telephone companies' total revenues (including those for broadband services) rose by an average of roughly $6.6 billion per year;[15] between 2000 and 2002, the broadband market grew by roughly $3 billion per year. Thus, CBO estimates that the growth of broadband subscriptions accounted for 45 percent of the cable and local telephone companies' increase in total revenues.[16]

Geographic Dispersion of Subscriptions

Subscriptions for residential broadband service have become much more widely dispersed geographically over the past few years, according to surveys by the FCC. At the end of 1999, 40 percent of zip codes nationwide had no broadband subscribers (*see Table 2*).[17] By December 2002, that figure was substantially smaller: only 12 percent of zip codes had no broadband subscribers. Much of that broader geographic reach is the result of suppliers' increasing the number of regions in which they make their service available. Thus, over the same period, the percentage of zip codes in which five or more providers of broadband service had subscribers rose from 6 percent to 29 percent. Consequently, not only is broadband more widely available than it was a few years ago but it is also available from a larger number of sources.

The FCC's zip code data have potential shortcomings, both on the upside and the downside. Most notably, it would seem that the data were understated because once satellite providers entered the residential broadband market, service was available to virtually any subscriber who wanted it throughout most of the lower 48 states. However, high prices and other factors have substantially limited satellite subscriptions.

Furthermore, the fraction of the population that has high-speed Internet access available could be larger than the FCC's count indicates because the zip codes that have seen increases in service have generally been those with the most people. In the most populous 50 percent of zip codes, 99.5 percent or more of their residents have access to high-speed Internet service.[18] Overall, only 2 percent of U.S. residents live in zip codes that have no broadband subscribers, which indicates that many of the problems of supply that were

15. According to the Semiannual Wireless Industry Survey conducted by the Cellular Telecommunications & Internet Association, revenues from cellular telephone service represented another $39.8 billion at the end of 2002 and grew at an annual average rate of $6.4 billion between 1998 and 2002. However, cell phone revenues do not increase the revenues attributable to the companies' wired networks and so are not included here.

16. Revenues were $1.5 billion in 2000 and between $7 billion and $8 billion in 2002, therefore increasing by roughly $6 billion in 2001 and 2002, or about $3 billion per year.

17. Federal Communications Commission, *Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion: Third Report.*

18. Federal Communications Commission, *High-Speed Services for Internet Access: Status as of June 30, 2002* (December 2002), Table 11, available at www.fcc.gov/wcb/iatd/comp.html.

more common two or three years ago have been resolved.

Yet to some extent, the FCC's zip code data may overstate how available broadband services are to residential consumers. For instance, a provider may offer service and hence have subscribers in only one part of a zip code. Although the FCC might count that entire zip code as having a provider, residents in some portions of it would not have access to broadband service or would have fewer providers than the FCC's data indicated. DSL providers in particular have reported substantial problems in increasing that technology's availability. Verizon, for instance, indicated that as of spring 2003, it could not provide DSL service to roughly 40 percent of the households in the areas it serves; that figure rises to 50 percent in some markets.[19] DSL providers had planned to have 95 percent of their structures and equipment upgraded and able to provide broadband by 2003. However, some industry observers suggest that only about two-thirds of their infrastructure is ready.[20] By contrast, cable companies have upgraded 90 percent of their infrastructure.

Finally, the FCC's data on broadband subscribers do not distinguish between households and small businesses. Providers may have programs aimed at the more developed business segment of the market, leaving residential consumers without options that are targeted toward them.

The Supply Side: Competition Now and in the Future

As noted earlier, most residential broadband markets are dominated by two large providers: a telephone company and a cable company. The FCC has reported that as of December 2002, there were only one or two providers with broadband subscribers in 34 percent of zip codes in the United States.[21] In other markets, a number of smaller firms—that in most cases use the local telephone company's infrastructure—provide some competition to the main residential broadband companies. Those competitive providers held a significant share of the overall residential broadband market in the last half of the 1990s but have declined in importance during the past two years. In December 2000, such companies (mainly satellite firms and competitive broadband providers that use wired networks) accounted for 11.5 percent of all high-speed connections to residences and small businesses.[22] By December 2002, their share had fallen to 7.0 percent (*see Figure 1*).

In general, analysts argue, markets with a small number of competitors will perform inefficiently relative to more competitive markets in which a larger number of firms establish the prices for services. In a market with only two providers, known as a duopoly, the two dominant competitors, recognizing that price competition ultimately would leave them worse off, might succeed in keeping prices above the level that a market with a large number of competitive firms would reach. In that case, those producers' gains would be society's losses: fewer consumers would have broadband than the number that would subscribe to a service in a more competitive market, and they would pay more for it.

Because the broadband market is still developing, it is premature to say that the currently dominant companies have established a duopoly. As noted earlier, many consumers consider dial-up access to the Internet an acceptable substitute for broadband, which limits the pricing power of the dominant firms. Yet a policy concern remains because for some other consumers, dial-up access is seen as a poor substitute for broadband. Thus, if local telephone and cable companies were able to secure their position and exercise

19. Peter Howe, "Verizon Battling on Broadband," *Boston Globe*, May 15, 2003, p. A1.

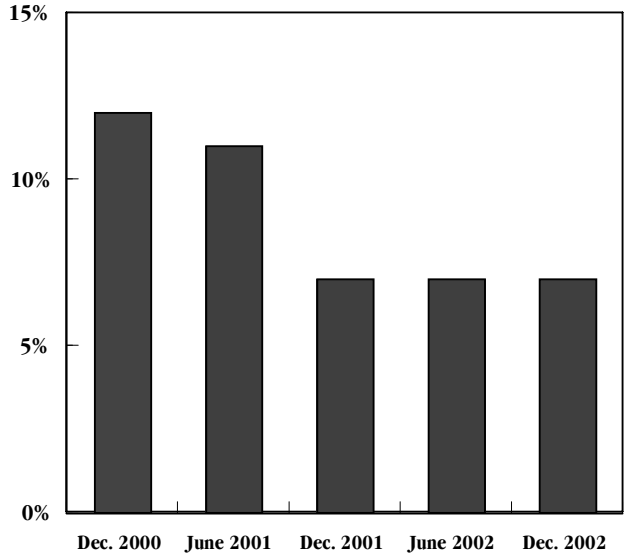
20. Lara Warner, Bryan Kraft, and Julia Belladonna, *The Broadband Battle 2003: A Crossroads for High-Speed Data* (New York: Credit Suisse/First Boston Equity Research, April 3, 2003), p. 8.

21. Federal Communications Commission, *High-Speed Services for Internet Access: Status as of December 31, 2002.*

22. Based on Federal Communications Commission, *High-Speed Services for Internet Access* (various years).

Figure 1.

Market Share of Competitive High-Speed Internet Access Providers



Source: Congressional Budget Office based on Federal Communications Commission, *High-Speed Services for Internet Access* (various years).

Note: Competitive providers (for example, satellite Internet suppliers) are those other than the local cable and telephone companies.

market power in providing high-speed Internet access, they might be able to maintain prices above those that would apply in a competitive market.

Even if the share of the two dominant firms in most local markets is large and growing, a key policy question is whether the current conditions on the supply side of the market (discussed in the subsections below) are likely to persist. If they are not, the case for federal intervention is weakened, particularly in the context of the ongoing deregulation of the telecommunications sector as a whole. In the near term, two factors might reduce the power of the dominant suppliers—or at least the potentially negative effects of their large share of the market. First, actual and potential new entrants to the market could limit the current major producers' ability to keep prices high. Second, competitive pressures in the "home," or core business, markets of the cable television and telephone companies that provide high-speed Internet service might cause them to compete more vigorously in the residential broadband market.

High Fixed Costs: A Barrier to New Market Entrants

Neither of the dominant providers of high-speed Internet access entered the market as a new firm bringing a new service to consumers. Instead, both the cable television and local telephone companies that share the market for high-speed access offer broadband service as extensions of the television and telephone services that account for the bulk of their revenues and that require the extensive wired network that each controls. That last factor—that history and current technology dictate that a wired network is at present the most economical means of delivering broadband to households and small businesses—is the most basic condition on the supply side of the residential market.

The costs of the cable television and telephone networks used to deliver broadband differ in amount but are similar in that they are characterized by high levels of fixed and "sunk" (generally, irreversible) costs. Those kinds of costs make it likely that the average cost of broadband service will decline as new subscribers join the network.[23] The cost of upgrading a preexisting cable or telephone network to provide high-speed Internet access is substantial; however, once the upgrade has been made, providing service to additional subscribers requires relatively modest investments in the network's infrastructure (although such investments are larger for DSL providers than for cable systems). Furthermore, once service to the new subscribers is in place, the cost of continuing it is low.

23. For an analysis of the costs of local telephone service, see F. Gasmi and others, *Cost Proxy Models and Telecommunications Policy: A New Empirical Approach to Regulation* (Cambridge, Mass.: MIT Press, 2001), Chapter 5. For a discussion of the relationship between the local telephone companies' cost structure and barriers to entry into the market for local telephone service, see Federal Communications Commission, *Report and Order and Order on Remand and Further Notice of Proposed Rulemaking* (adopted, February 20, 2003; released, August 21, 2003), paragraphs 73-91.

For would-be competitors, that cost structure impedes their entry into the market. They would have to make substantial initial investments simply to start providing service. At the same time, the incumbent companies would have the option of resisting such competitors by reducing their prices. In addition, the investments that a new entrant would have to make—mostly the so-called last-mile connections to residences and businesses—would be in large part irreversible because they would be "illiquid" (the new entrant would find it difficult to sell the investments if it decided to leave the market). That factor makes those investments particularly risky and thus presents a further obstacle to would-be entrants.

Broadband service is not the principal product of either the cable or the local telephone companies. Rather, in both instances, the service overlays a network that was designed and built to serve other functions—a so-called legacy network. Because so many of the costs of providing broadband service are common to the network's legacy services as well, it is difficult to properly allocate those costs among the services that are provided and the customers that are served. That limitation complicates any analysis of how current costs in the residential broadband market compare with those that would prevail in a competitive market.

Entry by Firms That Use Wired Technologies. Before the dramatic slowdown in investment by telecommunications firms that began, roughly, in 2001, investment in new wired technologies, such as fiber-optic cable, or modification of the wired network used to distribute electricity were seen as competitive alternatives to the cable and telephone networks.[24] To date, the opportunities offered by those alternatives have yet to be realized.

Optical fiber is an important component of every broadband network, regardless of the technology being used to provide the last-mile connections to customers (and are a central component of the Internet itself). Because it can carry much more data than rival mediums can, fiber-optic cable is often considered "future-proof," meaning that it will be a long time before new technologies require higher capacity than it can provide. But in only a few instances is fiber actually used to deliver broadband Internet access over the last mile to residential subscribers. The FCC's latest publication on fiber-optic cable reports that only an estimated 15,000 households and small businesses get broadband services through fiber.[25]

With that small a fraction of today's market, fiber is unlikely to become a significant competitor in most residential markets in the next few years. One reason is that fiber networks require new installation, and the most expensive piece of that work is labor—which is not subject to the kinds of cost reductions that other products in the electronics sector, such as computer chips and computer disk drives, have experienced. Another issue is that fiber systems may pose problems in existing residential settings—such as requiring specialized, expensive telephones with separate power supplies.

Those problems aside, the likeliest candidate to develop and install a fiber network would be the existing local telephone company. Indeed, several companies have already joined together to begin developing common specifications for future fiber systems, a move that could lower their costs (through economies of scale in producing such materials).[26] That kind of investment would not increase the number of competitors in the broadband market; rather, it would increase the local telephone company's broadband capacity.

24. This section of the paper discusses entry by firms that build and use their own facilities. FCC regulations permit competitive firms to provide service by renting the wires and switches ordinarily used by the incumbent companies. That type of market entry is discussed later.

25. Federal Communications Commission, *High-Speed Services for Internet Access: Status as of December 31, 2002*, Table 3.

26. Ben Charny, "Baby Bells to Twist Fiber Together," *CNET News*, May 29, 2003, available at http://news.com.com/2100-1037-1011333.html; and Bruce Hammond, "As Fiber Plans Move Forward, Bells Turn Eyes to Multiple Forms of Video Services," *Telecommunications Report*, November 15, 2003, pp. 1 and 39.

By contrast, most potential broadband customers are currently connected to the wired network that is used to transmit electricity—in addition to any connections they might have to telephone and cable television networks. That third wire is a potential connection to the Internet. Several power companies are running field tests to determine the economic and technical viability of using power lines to transmit broadband signals.[27] And in April 2003, the FCC began a formal study of that form of broadband access.[28]

Since the technology is only in the field-testing phase, it could be years, if ever, before power-line broadband service becomes a major competitor in the residential market. Currently, it is unclear whether the existing power grid can be used to provide broadband and whether the costs of "conditioning" the grid will allow Internet access through power lines to be competitive with cable modem or DSL service.

Entry by Firms That Use Wireless Technologies. The prospects are also uncertain for new broadband market entrants that use wireless technologies; a variety of opinions exist about the economic viability of one technology or another. Recent experience in the markets for cellular telephone and satellite video service has shown, however, that if a technology provides service comparable with that offered by the telephone and cable companies, new firms can enter the market successfully and, as in the case of cell phone service, provoke significant price competition.

The evidence is mixed about whether wireless technologies will increase the number of competitors in the residential broadband market in the near term. The problem is not a lack of public or private efforts. The FCC has made and continues to make portions of the electromagnetic spectrum available for terrestrial fixed wireless Internet access and other types of wireless data transmission, and companies regularly announce broadband initiatives that employ new wireless technologies. But many such initiatives in the past have proved limited in their scope, serving only niche markets and small geographic areas; others have been economic disappointments. The problems firms face in introducing new wireless data technologies are myriad and range from technical to financial.[29] (For instance, some of the technologies require a direct line of sight between the transmitter and the receiver, a factor that increases costs and restricts where such technologies can be used. In other instances, reception can be degraded by bad weather or even leafy trees.) The latest broadband wireless technologies are designed to overcome many of those problems, but the industry's history of high expectations that remain unfulfilled suggests that a wait-and-see attitude might be appropriate.

Broadband service provided by satellite is a prime example of the mixed record of wireless broadband providers. Like those of many wireless technologies, satellite connections are sensitive to location and weather. In addition, satellite companies have entered and left the market in quick succession, leaving customers unsure about the continued availability of service. Nevertheless, broadband service provided through satellite technology remains attractive, especially to customers in remote locations.

Wireless broadband providers who wanted to enter larger urban markets might not find it easy, for several reasons. First, newcomers to the market would start offering services in a few areas or cities at a time, but the wired incumbent (DSL or cable) providers could be expected to respond by reducing their prices, which would add to the already high costs of entry faced by new providers. Second, the existing providers would already have signed up the "easy" customers, the ones

27. In some cases, electric power companies are participating in broadband investments that use conventional technologies. Their power-line poles, easements, and rights-of-way, as well as their access to capital, make them valuable partners in such projects.

28. Federal Communications Commission, *Notice of Inquiry*, Docket 03-104.

29. This discussion is based on a review by Greg Caltabiano of SOMA Networks (a wireless broadband provider) titled "Lessons Learned: Requirements for the Profitable Last Mile" (*Telephony Online*, April 9, 2003), available at http://telephonyonline.com/ar/telecom_lessons_learned_requirements/index.htm.

with the highest level of demand, and a new entrant would have to break into the market without a backlog of demand to cushion the financial requirements of entry and during the initial stage of operations. Third, a new competitor entering the broadband market would differ from either the satellite companies entering the multichannel video (cable) market or the digital cellular telephone companies entering the analog cell phone market. In the latter two instances, the entrant companies had superior technology with which to compete—superior in the sense that they could offer a much wider array of features (more stations from the satellite providers or more options, such as voice mail and caller I.D., from the digital cell phone firms). But in the case of households that have preexisting wired access, wireless technology currently has little by which to distinguish itself, except price.

Notwithstanding such obstacles, firms that offer wireless alternatives have made substantial headway in competing with wired incumbents in both the telephone and multichannel video markets. Wireless telephone service has grown rapidly as a new and distinct telecommunications option. Evidence has been accumulating over the past few years that some customers are substituting wireless for wired telephone service.[30] In the wireless broadband market, wireless firms have made inroads in rural areas where the larger broadband providers are not yet offering service.[31]

Although existing telephone companies are also using wireless technologies to expand their share of the residential broadband market, their entry into the wireless arena does not increase the number of competitors in the market. For example, Verizon alone has several technical trials or commercialization projects under way that use wireless data technologies:

- Technology that is now undergoing a technical trial in Northern Virginia would expand Verizon's geographic DSL capabilities to allow it to serve households and businesses that lie beyond the current distance limitation.[32]

- A service introduced in the Washington-Baltimore and San Diego areas would permit the company to offer mobile broadband services by using its cellular network, upgraded with the so-called third-generation (or 3G) cellular technology.[33] (That service is seen as a premium product and is not aimed at the residential market.)

- A technology introduced in Manhattan would permit Verizon DSL subscribers to use a different wireless technology—so-called Wi-Fi—to access the Internet at broadband speeds simply by being within 300 feet of designated pay telephones.[34] (*Box 1* discusses the Wi-Fi technology.)

Verizon expects that the new services will take some sales away from its wired offerings (just as its cellular telephone service to some extent steals sales from its traditional telephone services). For the most part, however, it anticipates that the new services will complement or expand its current offerings.

30. Matt Richtel, "F.C.C. Backs Phone Number Portability," *New York Times*, November 12, 2003.

31. On November 4, 2003, the FCC held a showcase and workshop for rural wireless Internet service providers to highlight the potential of wireless broadband in rural areas. The workshop presentations and a video are available at www.fcc.gov/osp/rural-wisp.html.

32. Roy Mark, "Trial by Broadband," *ISP Planet*, August 6, 2002, available at www.isp-planet.com/news/2002/vz_020806.html.

33. Ben Charny, "Verizon Spends a Billion Dollars on 3G," *CNET News*, September 3, 2003, available at http://news.com.com/2100-1039-5070870.html. Analog cellular systems represented the first generation; today's digital technology is the second generation; and advanced digital technology offering broadband and other services is referred to as the third generation.

34. Barnaby Feder, "Verizon Sets Up Phone Booths to Give Access to the Internet," *New York Times*, May 14, 2003. The FCC has recently begun regulatory proceedings to increase the radio spectrum available for license-exempt uses, such as Wi-Fi. See Kenneth Carter and others, *Unlicensed and Unshackled: A Joint OSP-OET [Office of Strategic Planning and Policy Analysis-Office of Engineering and Technology] White Paper on Unlicensed Devices and Their Regulatory Issues* (Federal Communications Commission, May 2003).

Box 1.

The Case of Wi-Fi

Wi-Fi is currently the most successful wireless link to the Internet. It was originally designed to allow a computer network, whether in an organization or at home, to connect its computers internally at broadband speeds without needing to have run wires through walls.[1] Wi-Fi serves many of the same purposes for a computer network that a cordless phone serves at home.[2] But just as the cordless phone's base station needs a telephone line through which to connect to the public telephone network, so Wi-Fi base stations need a broadband connection to the Internet (commonly called backhaul) to provide broadband service to their clients. Also like the cordless phone, Wi-Fi devices use low-power transmitters, which limits their range to about 300 feet.

Building on the success of Wi-Fi in corporate- and home-network markets, hotels, airports, and other hospitality industry firms began using the technology to offer fast Internet access to business travelers and others whose only alternative was a slow dial-up mode. The hotel or other business must still have its own broadband access to the Internet to provide the link between the Wi-Fi "hot spot," as the area around a Wi-Fi base station is called, and the Internet. In other instances, community groups have connected downtown areas to provide Wi-Fi Internet access for entire sections of a city by using overlapping hot spots. Similarly, universities and other organizations have blanketed their campuses with Wi-Fi coverage. In every instance, however, the Wi-Fi base stations are linked to the Internet by a second broadband connection, either wired or wireless.

The limit of 300 feet on its transmitter's range and the need for a broadband connection for the Wi-Fi base station restrict the technology from delivering broadband access in most residential situations. Manufacturers of electronics equipment are now trying to extend Wi-Fi's success by increasing the distance at which it can be used.[3] In one effort, several manufacturers have banded together to promote a successor, WiMAX, which they argue will be more appropriate for the residential broadband market.[4]

Simultaneously, businesses that offer Wi-Fi service are trying to make it more profitable. The broadband connection from the Wi-Fi hot spot to the Internet may cost a business several hundred dollars a month. Yet Starbucks, which has almost 2,000 hot spots in its coffee shops nationally, reports daily average use of only two customers per spot.[5] Other issues for businesses that must be resolved include congestion and security. Most fundamentally, the business model for the technology remains unclear because generally, the use of Wi-Fi is free. A hotel might provide both Wi-Fi and cable television at no charge to make their rooms more attractive to travelers. Similarly, colleges and university campuses may not charge for Wi-Fi separately from their other computer network services. If Wi-Fi is to spread beyond the confines of universities and hotels, which ultimately subsidize it through the sales of other services, businesses need to find a way to charge for its use.

1. John Markoff, "Led by Intel, True Believers in Wi-Fi Say It Will Endure," *New York Times*, July 14, 2003, p. C1.

2. Because Wi-Fi is governed by many of the same Federal Communications Commission regulations that apply to cordless telephones, it uses the same frequencies in the radio spectrum.

3. Some industry analysts argue that Wi-Fi has been more successful than previous wireless technologies because the manufacturers adhered to openly available, nonproprietary standards and worked to ensure interoperability for the products of different manufacturers. That move helped expand the market, they contend, which in turn allowed economies of scale that further reduced costs and made the equipment even more popular.

4. Information about WiMAX is available at www.wimaxforum.org.

5. See "Bubble Trouble," *The Economist*, June 26, 2003.

Convergence of Communications Technologies and Competition in Related Home Markets

The local telephone and cable television companies that compete in the broadband market also confront one another—but in different roles—in their respective home markets. The cable companies are currently wired entrants in the local telephone market and may play a larger role in the future. And additional investment in the telephone network could allow telephone companies to compete in the multichannel video market.[35] As incumbents, both telephone and cable companies see little chance of substantial growth in sales and profits in their home markets. As entrants into one another's home markets, their prospects are brighter, but the risks are greater and the competitive environment more complicated, comprising decisions about investment (which is often high in cost and irreversible), pricing, and responses to third-party competitors that employ alternative technologies.

With multiple roles and points of competition, the wired incumbents in the local telephone and cable television industries might reap even greater profits if they effectively coordinated their efforts. Yet coordination also poses problems that could spill over into the broadband market and make the companies' current dominance less profitable. As yet, the telling signal of competition—price decreases—has not emerged in either home market (*see Box 2*).

Competition in the Market for Multichannel Video Programming. In the market for the distribution of multichannel video programming, satellite providers—mainly those offering the new smaller-dish technology—increased their share of all households that subscribed to a multichannel video programming service from 9.8 percent in 1997 to 21 percent in 2001.[36] Throughout the 1990s, direct satellite broadcasters that used small-dish receivers increased their subscriber base substantially, from 2.2 million subscribers in 1994 to 19.2 million subscribers in 2002 (*see Figure 2*).

In the late 1990s, the number of both satellite and cable subscriptions had been growing, although satellite subscriptions grew much more rapidly than did cable subscriptions. Then in 2001 and 2002, the growth in cable subscriptions stagnated. Early data for 2002 indicate that growth in subscriptions to satellite services, combined with a weak economy, may have reduced annual growth in the number of cable subscribers to less than half a percentage point.[37] According to the FCC, 98 percent of television households nationwide already have access to cable service, and approximately 65 percent (or 69 million households) subscribe.[38] Consequently, cable companies can count on no new large groups of unserved households to add to their market. For them, broadband offers a new and substantial source of funds, and they have already invested significant sums in trying to tap that source. The FCC reports that in 2002, cable companies collected $5.6 billion, or 11.3 percent of their total revenues, from subscriptions to their broadband, telephone, and interactive television services.[39]

Continuing competitive pressure from the satellite companies may force cable firms to look for additional ways to differentiate themselves. To compete with the satellite companies, cable companies have increasingly

35. Telephone companies have a long history of failed pilot projects in the market for delivery of multichannel video programming. For a survey of those attempts, see "Premier of Video on Demand," *USA Today*, October 12, 1994, available at www.usvo.com/history/usatoday10-94.html.

36. Federal Communications Commission, *Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming: Eighth Annual Report* (January 14, 2002), Table C-1; and *Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming: Ninth Annual Report* (December 31, 2002), Table B-1.

37. Federal Communications Commission, *Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming: Ninth Annual Report*, p. 3.

38. Ibid., Table 1. The FCC reports that substantial criticism and uncertainty surround that estimate and notes that different sources put the share of cable's availability as low as 78 percent (see pp. 9 and 10).

39. Ibid., Table 4.

Box 2.

Trends in Prices for Multichannel Video Programming and Local Telephone Services

A look at competition and prices in the primary markets of the two major broadband providers, or market "incumbents"—cable systems and local telephone companies—reveals no decrease in prices even though their market shares have been eroding as new competitors enter the market. Cable companies have maintained and even increased prices when faced with competition in the video distribution market. As their competitors' share of the market has grown, cable systems have competed by offering more programming rather than by lowering prices. According to the Federal Communications Commission's (FCC's) latest report on cable prices, rates for video programming service rose by 7.3 percent between July 2000 and July 2001.[1] However, the average number of channels carried by cable systems also increased; thus, on a per channel basis, rates rose by 1.5 percent during that period.

That kind of increase is nothing new. The Bureau of Labor Statistics (BLS) reports that between 1993 and 2002, the price of cable service for urban consumers rose at an average annual rate of 4.7 percent. By comparison, the consumer price index (CPI) as a whole (the cost-of-living measure that BLS maintains, which is commonly used to gauge inflation) rose by 2.3 percent per year during the same period. However, the CPI measure for cable service may overstate the price rise because it does not adjust for the increase in the number of channels or for the higher-quality digital service that cable systems now offer.

Similarly, prices for local telephone service over the 1993-2002 period, as measured by the CPI, generally rose with the index as a whole, or by roughly 2.4 percent per year. The FCC reports a lower figure for the average annual price increase for local service—1 percent for the period from 1993 through 2001.[2] Since the FCC and BLS both use the same 95 cities to calculate their averages, methodological differences—in particular, what each agency includes under the umbrella of "local telephone service"—must account for the divergence in results.

Analysts have proposed various explanations for why those incumbents have managed to maintain or even increase their prices when faced with new entrants into the market who have had some success in claiming a share of it. Some observers argue that, notwithstanding the new entrants, the incumbent providers still have substantial market power—that is, they are able to keep prices above the level that would apply if the market was competitive. Other analysts contend that although some markets have seen new entrants and more competitive pressures on incumbents, in most markets there is little range of choice (especially in local telephone service).

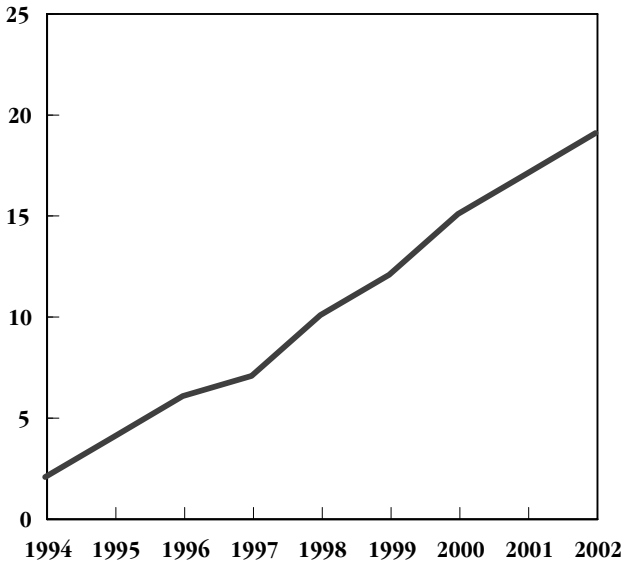
1. Federal Communications Commission, *Report on Cable Industry Prices* (April 4, 2002), Table 1. For a discussion of those prices, see Steven S. Wildman, *Assessing Quality-Adjusted Changes in the Real Price of Basic Cable Service* (East Lansing, Mich.: Quello Center for Telecommunications Management and Law, Michigan State University, September 10, 2003).

2. Calculated from Federal Communications Commission, *Trends in Telephone Service* (May 2002), Table 14.1.

Figure 2.

Households That Subscribe to a Satellite Video Service

(Millions)



Source: Congressional Budget Office using data from Sky Research (an industry research group), available at www.skyreport.com/dth_counts.cfm.

offered services—in particular, voice telephone and broadband—that the satellite firms cannot offer as easily or as cheaply. That competition may force the cable companies into increased competition with the incumbent local telephone companies over a range of services.

By contrast, the competition that incumbent cable television companies face from wired entrants is not great: it exists in only 2 percent of markets.[40] According to industry data, competitive broadband service providers currently serve about 1 million of the approximately 69 million households that subscribe to cable. Of those 1 million households, 460,000 customers subscribe to cable modem services.[41] The competitive broadband providers offer the same range of services that the incumbent cable providers do: multichannel video programming, Internet broadband, and voice telephone. In the wake of the slowdown in telecommunications investment that began in 2001, those competitive cable providers have concentrated on expanding the number of their subscribers within the area that they serve rather than expanding the number of areas in which they offer service.

Although those entrants do not represent a large number of subscribers in total, they can be a source of substantial competition in some local video programming markets. The General Accounting Office found that in markets in which the incumbent cable company faced a competitive cable firm, cable video rates were on average about 15 percent lower than they were in similar markets that had no such competition.[42]

Competition in the Market for Residential Local Telephone Service. Competitive companies thus far have captured only a small fraction of the residential market for local telephone service. In December 1999, competitive local telephone companies provided telephone service to 3.4 million local access lines serving households and small businesses, out of the 143.1 million such lines nationwide.[43] By December 2002, competitive local telephone firms were providing service to 14.4 million of the nation's 141.4 million residential and small-business access lines, or 10.2 percent of the total. Incumbent local telephone companies saw the

40. General Accounting Office, *Issues Related to Competition and Subscriber Rates in the Cable Television Industry*, GAO-04-8 (October 2003), p. 9.

41. John Goodman, *Broadband Service Providers Association: Overview Presentation* (Washington, D.C.: Broadband Service Providers Association, May 2003).

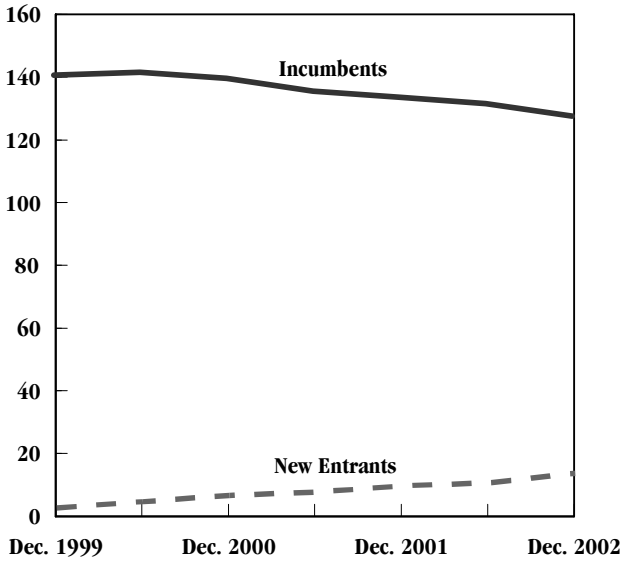
42. General Accounting Office, *Issues Related to Competition*.

43. Federal Communications Commission, *Local Telephone Competition: Status as of December 31, 2002* (June 2003), Tables 1 and 2. The growth of competition in the market for nonresidential access lines is more pronounced. If larger enterprises are included, competitive local telephone companies provided 24.8 million local access lines, or 13.2 percent of all such lines.

Figure 3.

Shares of the Market for Local Telephone Service, by Provider Type

(Millions of local telephone lines)



Source: Congressional Budget Office using data from Federal Communications Commission, *Local Telephone Competition: Status as of December 31, 2002* (June 2003).

number of their subscribers shrink during that period, from 139.8 million to 127.0 million (*see Figure 3*).

As noted earlier, the increasing popularity of cellular telephones also poses challenges to the wired network.[44] According to the industry's trade association, about 5 percent of cell phone subscribers (or approximately 7 million subscribers at the most recent count) have simply ended their conventional telephone subscription. Even for the majority of cell phone users, who do not completely disconnect their landline, the cell phone represents continuing competitive pressure, requiring the local wired telephone companies to upgrade technologies to offer features and convenience. Moreover, the country's 140 million cell phone subscribers install fewer second lines, use fewer pay phones, and otherwise reduce the revenues flowing from the traditional landline network. (*Figure 4* shows the growth in cell phone subscriptions over the past decade.)

At the same time, the current state of competition in the market for wired local telephone service illustrates particularly well the difficulty of overcoming the barriers to market entry that a wired network presents. Only about a quarter of the landlines provided by competitive local telephone companies use facilities that were actually built by those firms; the majority of competitive companies lease some combination of facilities from the incumbent firms.[45] About a third of the lines that competitive telephone firms use are provided by cable companies, and the growth in the cable companies' share of the market in the past several years may signal their future competitive intent (*see Figure 5*).

Local telephone companies are under substantial pressure to find new ways to pay for their high fixed costs. Competitors such as the cable companies and the cell phone service providers have over the past four years reduced the number of lines from which the incumbent local telephone companies derive revenues. Those strains may force the local phone companies into more vigorous competition with the cable companies over residential broadband.

Regulation

In the Telecommunications Act of 1996 (Public Law 104-104), policymakers reduced the barriers to entry

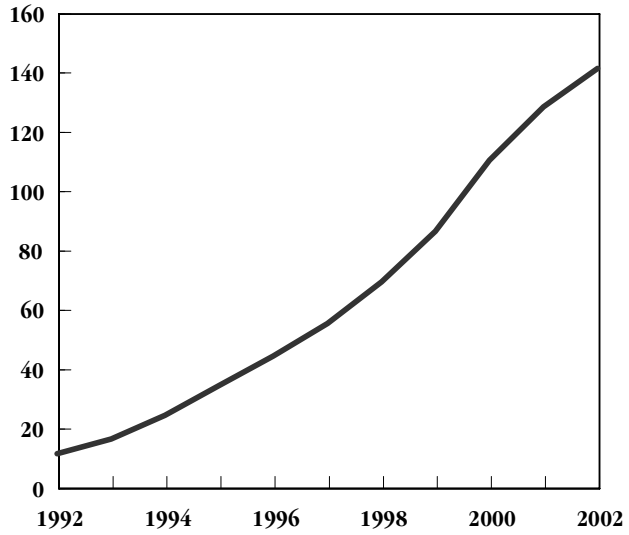
44. Local telephone companies are also cell phone providers and so may be cannibalizing their own sales. Statistics on cell phone subscribers come from the Cellular Telecommunications & Internet Association's Semiannual Wireless Industry Survey, available at www.wow-com.com/industry/stats/surveys/. For a discussion of the cell phone's challenge to wired local telephone service, see Federal Communications Commission, *Eighth Report and Analysis of Competitive Conditions with Respect to Commercial Mobile Services* (June 26, 2003), pp. 49-52.

45. Federal Communications Commission, *Local Telephone Competition: Status as of December 31, 2002*, Table 3. Because the FCC does not break down those data into residential and nonresidential categories, CBO could not calculate the number of residential lines provided by competitive local telephone companies.

Figure 4.

Cellular Telephone Subscribers

(Millions, at year's end)



Source: Congressional Budget Office using data from the Semiannual Wireless Industry Survey of the Cellular Telecommunications & Internet Association, available at www.wow-com.com/industry/stats/surveys/.

into the telephone services market by directing the FCC to establish regulations that allowed potential entrants to rent the incumbent local telephone companies' existing network or its components on very favorable terms. Until recently, the FCC's rental policy also applied to broadband service provided through the telephone lines. That policy has been the object of much criticism and lies at the hub of the current debate about asymmetric regulation.

Industries that rely on networks to deliver their services—electricity and natural gas are examples outside of the telecommunications sector—have typically been regulated. The reason is that at least initially, those networks were associated with such large economies of scale and presented such formidable barriers to other firms that wanted to enter the market that consumers would have faced an unchecked monopolist if regulation had not provided some protection. The cable and local telephone networks that dominate the emerging residential broadband market are no exception. Early in their existence, the two networks were both regulated; currently, the telephone companies are subject to more direct regulation than the cable companies are.

Specifically, the Telecommunications Act of 1996 requires incumbent local telephone companies to rent to their would-be competitors, as a package or as individual items, seven federally designated elements of their system at prices calculated to mimic what a competitive market would have provided to wholesale customers, given the advancing technology found in this industry. The competitors are free to pick and choose which of those elements they need for their business and to rent them at those relatively low prices. Cable providers of broadband access face no such requirement to rent their facilities to competitors. (*Box 3* discusses how regulation has affected investment by local telephone companies.)

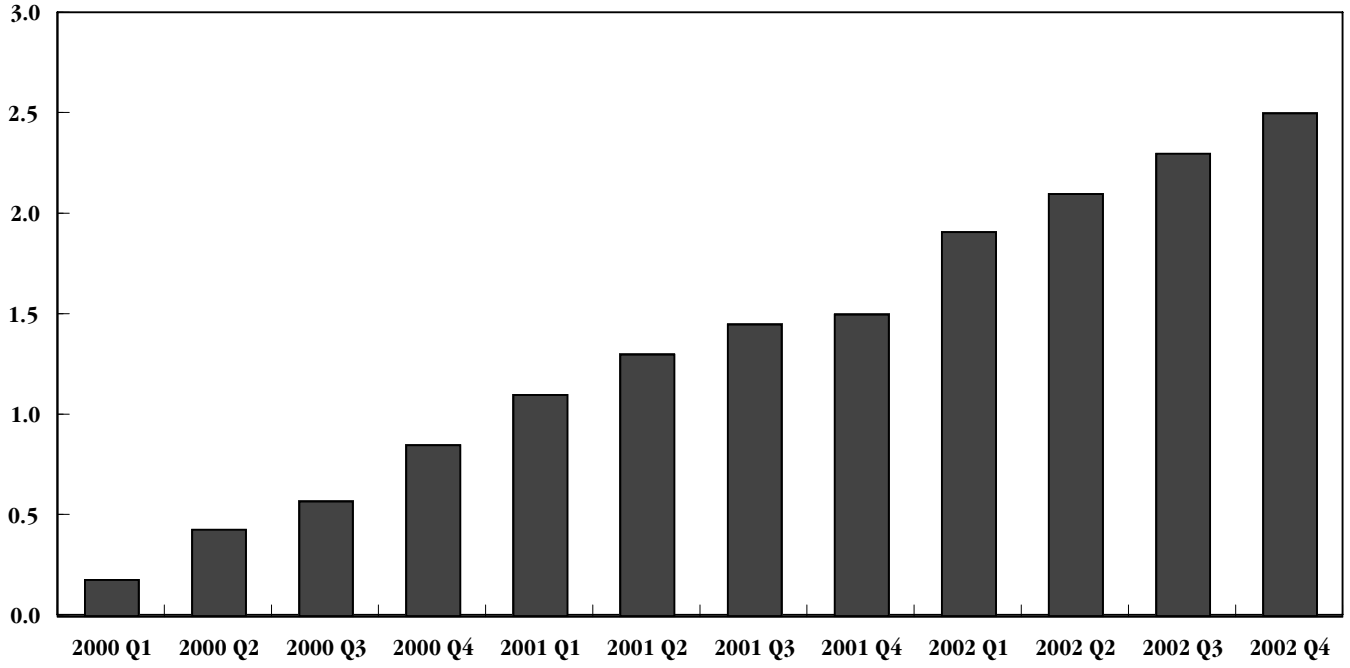
In addition to the provisions noted above, regulators imposed specific line-sharing requirements on local telephone companies with regard to residential broadband service. Specifically, the local telephone companies have been obliged to allow competitive DSL firms to rent the high-frequency portion of the incumbent firms' telephone lines—the lines that the phone companies are using to provide ordinary voice service—and pay a fee only for the portion of the spectrum that they use. If those requirements were removed, competitive DSL providers would probably have to rent a second telephone line at the full price, even though they would only be using the high-frequency portion of it. The increase in their costs from the second-line rental would vary from state to state; however, according to one industry estimate, that change alone would boost the cost of competitive firms' DSL service in parts of California by roughly $20 per month (from $6 per month to $26 per month).[46] A more likely scenario is that two companies—a competitive voice service provider and a competitive DSL provider—will lease the entire line and split it into a low-frequency (voice) section and a high-frequency DSL portion.

46. See John Borland, "Feds Mull Broadband Market Shake-Up," *CNET News*, January 6, 2003, available at http://news.com.com/2100-1033-979356.html.

Figure 5.

Cable Telephone Subscribers

(Millions)



Source: Congressional Budget Office using data from the National Cable and Telecommunications Association, available at www.ncta.com/industry_overview/indStats.cfm?statID=13.

Note: Q = quarter.

In August 2003, the FCC issued an order to phase out the line-sharing requirement for residential broadband service over three years.[47] It is too early to tell what the result will be; competitive suppliers are still formulating their responses within the market and the legal system, and the decision is already under challenge in the courts. Should the decision stand, the overall market share (and possibly the number) of competitive suppliers of residential DSL service will probably decline. However, the supply of DSL is unlikely to be greatly affected because the FCC's most recent data show that the incumbent local telephone companies account for 95.1 percent of DSL lines nationwide.[48]

The FCC's order also established that the federal government would only impose sharing requirements on future fiber-optic or next-generation-technology networks that the local telephone companies built to serve homes if the local telephone company then elected to retire the existing copper network.[49] In that case, the incumbent company would have to offer competitive providers access to the low-frequency (voice) portion of the line.

47. Federal Communications Commission, *Report and Order*, paragraphs 255-269.

48. Federal Communications Commission, *High-Speed Services for Internet Access: Status as of December 31, 2002*, Table 5.

49. Federal Communications Commission, *Report and Order*, paragraphs 272-280.

Box 3.

Has Federal Regulation Hindered Local Telephone Companies' Investment in Broadband?

Federal regulations require certain local telephone companies—but not cable companies—to rent their phone lines as well as their switching equipment to their broadband competitors at wholesale prices determined by regulators. Advocates of relieving the local telephone companies of that line-sharing responsibility posit that the low prices that the regulators have set dampen those companies' incentives to invest in new facilities. Those advocates argue that the cable companies, which did not have similar requirements, rolled out their cable modem broadband service to households much more rapidly than the telephone companies rolled out their digital subscriber line (DSL) service and captured the lion's share of the market for residential broadband in the United States. Advocates also point to the broadband markets in some other countries to support their argument. There, DSL has played a much larger role than it has in the United States—further evidence, according to those advocates, that the line-sharing requirements have had a deleterious effect on the telephone companies' investments.

But proponents of eliminating the requirements have produced little evidence of the extent to which the local telephone companies' limited success thus far to compete in the residential broadband market can be explained by the facilities-sharing rules. Some analysts argue that the difference in when the telephone companies offered broadband service and when the cable companies did was largely due to the dynamics of each of their home markets. The cable companies had substantial motivation to develop and offer high-speed Internet access as part of the enhanced capabilities they were planning to provide to stave off competition from satellite television companies. By contrast, the telephone companies had conflicting incentives, including the cost of sharing facilities as the regulations required. Certainly, however, the telephone companies were in the best position of any participant in the market to see the overall demand for connectivity.[1] They knew the number of second telephone lines that were dedicated to Internet connections, and they could also see the millions of minutes during which residential consumers used the telephone network to connect, through their dial-up access, to Internet service providers. No other individual Internet service provider (or cable company) could see the total demand for Internet connections.

Some analysts further argue that the telephone companies deferred investing in broadband because it threatened to "cannibalize" some of their more profitable businesses. For example, many residential customers who bought broadband connections then canceled their second telephone lines, which they

1. Gerald R. Faulhaber, "Broadband Deployment: Is Policy in the Way?" 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, 2003), pp. 223-244.

Many observers maintain that the low rental rates for infrastructure and the line-sharing requirements have weakened the local telephone companies' incentive to invest. They further argue that the cable companies' much larger share of the residential broadband market results directly from those deterrents to investment.

The evidence indicates, however, that both the cable and the telephone companies have invested substantial amounts in the broadband portions of their business, although the telephone companies might have invested more had regulatory policy been different and less uncertain. As discussed below, the larger local telephone companies have probably invested more of their income in broadband since enactment of the 1996

Box 3. Continued

had used to dial up the Internet and lessen traffic on their main line. Similarly, many business customers of the telephone companies were leasing dedicated high-capacity private lines (referred to in the industry as T-1 lines) that were capable of carrying 1.5 million bits of data per second and that cost businesses between $500 and $800 per month (before figuring in ancillary distance-related charges). The telephone companies feared that their customers would substitute a business DSL line, which costs between $60 and $300 per month, depending on speed and other factors.[2]

Consequently, to avoid losing the profits from the additional residential and high-capacity business lines, the local telephone companies did not enter the broadband market as rapidly as the cable companies did, which risked no loss of other business. Some analysts point out that it was only after the cable companies began signing up large numbers of subscribers—many of whom presumably discontinued their second telephone lines—that the telephone companies began to enter the residential broadband market in a serious way.

Furthermore, some analysts believe that although the upgrading of the physical plant (both wires and equipment) required to carry high-speed data proved more difficult than either the cable operators or the local telephone companies had anticipated, it proved substantially more difficult for the local telephone companies. They had forecast that they would have upgraded 95 percent of their plant by 2003; according to some industry observers, they have upgraded only about 66 percent. (For example, Verizon indicated that as of spring 2003, it could not provide DSL service to roughly 40 percent of the households in the areas it serves.)[3] By comparison, cable companies have upgraded 90 percent of their infrastructure.

Despite such constraints, the number of DSL lines in service has grown rapidly, from 292,000 in December 1999 to 5.5 million by December 2002, an average annual rate of growth of 166 percent. During the same period, cable modem service enjoyed average annual growth of 100 percent. Nevertheless, with their head start relative to the telephone companies (as discussed above), cable operators continue to maintain their lead in the residential broadband market in the face of the increased financial commitment to DSL by the large local telephone companies over the past several years.

2. Many of those points come from Faulhaber, "Broadband Deployment." Lara Warner, Bryan Kraft, and Julia Belladonna, in their analysis *The Broadband Battle 2003: A Crossroads for High-Speed Data* (New York: Credit Suisse/First Boston Equity Research, April 3, 2003), raise some of the same issues.

3. Peter Howe, "Verizon Battling on Broadband," *Boston Globe*, May 15, 2003, p. A1.

telecommunications law. Furthermore, as Box 2 notes, the relative shares of the residential broadband market claimed by the cable companies and the local telephone companies may be due more to the dynamics of competition in their different home markets than to the regulations governing local phone companies.

In any event, the litigation over the FCC's regulations is not likely to end soon. The commission's recent order devolves much of the regulatory authority to the states. Disagreements and uncertainty are likely to follow that authority to the state level.

Supply and the Performance of the Market

It is not clear whether the local telephone and cable television companies' current dominance of the broadband market is slowing consumers' adoption of broadband service. Indicators of the industry's performance are mixed. Competition in pricing is tepid compared with that in the cellular telephone market, which at one time was also limited to two providers but now has four to six competitors in every major sales area in the country. Similarly, price competition is more vigorous in the market for dial-up Internet access, which has many more providers than the broadband market has. A further indicator of less competitive pressure is that the broadband market has seen few of the other tactics that are typically used in competition. For example, neither of the dominant parties has engaged in the kinds of negative advertising about products that they often employ on policy issues or that cable television and satellite providers regularly engage in in the multichannel video programming market. However, both the local telephone and cable television companies have rapidly invested to expand their networks—a positive aspect of performance.

Competition in Broadband Pricing. Changes in prices by the dominant broadband firms do not yet suggest that they are aggressively competing. But the lack of consistent, verified data on prices prevents rigorous analysis of the recent trends in residential broadband charges. Patterns of pricing are evolving, and suppliers are still exploring the nature of the demand they face, which is to be expected in such a rapidly growing market. Consequently, the movements of prices may have several competing explanations.

Throughout the late 1990s, the prices charged for broadband service declined, according to industry sources.[50] The technologies used to provide that service became less expensive, and at least part of those cost reductions appears to have been passed on to consumers. Alternatively, firms may have been cutting prices to gain a larger share of the market, a common strategy among technology firms at that time.

However, beginning in 2000, the price of cable modem service began to rise while that of DSL service remained constant or even declined, say reports by two groups of industry analysts that have tracked prices for broadband service since that year.[51] Both groups also found that the prices of cable service were on average initially much lower than those for DSL service, although the studies differ on exactly how much. Nationwide, monthly DSL subscription rates in 2000 averaged between $45 and $50, according to the studies. Monthly cable Internet subscriptions ranged from $8 to $17 less (depending on the study and date). The two groups agree that throughout 2000 and 2001, cable system operators raised their prices for broadband service while DSL providers lowered theirs or kept them constant. By the end of that period, prices for cable modem service were only 13 percent to 18 percent lower than prices for DSL service, or roughly $7 to $8 per month lower. Both studies indicate that in 2002, DSL subscription rates averaged $2 to $5 per month more than the $39 to $42 per month charged for cable Internet service.[52]

Recently, discounts and some outright cuts have signaled new competition in prices for broadband service. In 2003, Verizon, for example, decreased its DSL

50. Association for Local Telecommunication Services, *The State of Local Competition: 2001* (Washington, D.C.: Association for Local Telecommunication Services, February 2001), p. 31. Neither the Bureau of Labor Statistics nor the FCC has collected price statistics on broadband service over a long enough period to construct a price series. Consequently, for its analysis, CBO relied on data from market research firms and other industry observers.

51. The estimates of broadband prices are taken from ARS, Inc, a market research firm in La Jolla, California (available at www.ars1.com) and from Warner, Kraft, and Belladonna, *The Broadband Battle 2003*.

52. In 2002, the method for calculating prices in one of the studies changed, according to its authors, to include the initial discounts that broadband operators had widely begun to offer. (Such discounts might include an initial lower rate that then jumped after three or six months.) Because the other study analyzed revenue per subscriber, it had always included such discounts.

price from $45 to $50 a month to $35 per month.[53] The company also offers a lower price of $30 a month for DSL if the customer also takes certain other Verizon services. Other telephone companies have similar offers.[54] For the time being, the cable companies have not responded with price cuts of their own. But discounts for bundles of services offered by both the telephone and cable companies are an additional sign of competition on the basis of price. (The bundles also affect the prices that the companies charge for voice telephone and cable television services.)

Competition Through Investment and the Use of New Broadband Technologies. The fragmented data that are available on investment suggest that both local telephone and cable television providers have been investing to increase their broadband capabilities. CBO was unable to obtain specific data on the broadband investments of the two dominant providers, but the high overall rates of investment it found suggest that the companies are competing in building up their capacity to deliver broadband service.

The high rates of investment can be explained in several different ways. The cable and local telephone companies could be investing to deter new entrants to the market by establishing capacity in excess of demand in areas where they currently provide broadband service and foreclosing the easy sales that entrants might attempt to achieve in underserved areas. Alternatively, cable and telephone companies might be investing simply to keep up with demand. Whatever the explanation, it is unclear whether the rapid buildup in capacity will lead to more or less competitive price and service offerings in the future.[55]

Most important, the high rate of investment by the dominant firms means that even if they are beginning to acquire some durable power in the broadband market, that power is not preventing a very rapid rate of growth of supply and service. In other words, the negative consequences of such power, should it become established, have not been felt on the supply side of the market. Another implication, however, of the growth in investment is that the barriers to entry associated with high fixed and sunk costs will not be coming down soon. If anything, they are being reinforced.

Investment by Telephone Companies. The incumbent local telephone companies have been spending a great deal of money to upgrade their infrastructure. Over the past six years, the four largest local telephone companies (companies that were part of the old Bell system) have spent an average of 28 percent of their total annual operating revenues to purchase new structures and equipment (*see Table 3*).[56] That share rose through 2000 but fell with the general decline of investment in telecommunications structures and equipment that occurred in 2001 and 2002.[57] By way of perspective, for the economy as a whole over the same period, investment in structures, equipment, and software represented 12.3 percent of gross domestic product. Thus, on the dimension of physical investment, the tele-

53. In some locales, Verizon offered discounts from its price of $50 per month by giving promotional rates for the first three or six months and only then boosting the rate to $50. In other areas, it offered a rate of $40 per month as the standard fee.

54. James Hu, "Endless Summer of DSL Discounts," *CNET News,* July 7, 2003, available at http://news.com.com/2100-1034_3-1023465.html?tag=fd_lede1_hed.

55. Jean Tirole, *The Theory of Industrial Organization* (Cambridge, Mass.: MIT Press, 2001), Chapter 8.

56. CBO used the data series for total plant added rather than the more customary one for total plant in service (TPIS). The difference between the two series is that the former includes all new construction (jobs that are already in service as well as those not yet completed). However, the difference in the two measures is not substantial. Under the TPIS measure, the incumbent telephone companies have invested an average of 24 percent of their total annual operating revenues in new structures and equipment. Both sets of figures exclude investments by the companies' cellular telephone subsidiaries. See Federal Communications Commission, *Statistics of Communications Common Carriers* (various years).

57. The decline in investment by the regional Bell operating companies has been less dramatic than the drop in investment in communications equipment and structures for the U.S. economy as a whole. Economywide, such investment rose by 75 percent between 1996 and 2000 and then fell by 20 percent, in nominal terms, in 2001. By contrast, the investment by Bell companies rose by 81 percent but fell by only 9 percent.

Table 3.

Investment by Regional Bell Operating Companies

(Billions of dollars)

	1996	1997	1998	1999	2000	2001
Investment						
Structures and equipment	19.7	20.0	20.2	27.5	35.7	32.4
Research and development	0.2	0.2	0.1	0	n.a.	n.a.
Total	**19.9**	**20.2**	**20.3**	**27.5**	**35.7**	**32.4**
Memorandum:						
Operating Revenues	78.7	80.4	86.0	90.4	109.2	108.7
Total Investment as a Percentage of Operating Revenues	25.3	25.1	23.6	30.4	32.7	29.9

Source: Congressional Budget Office using data from Federal Communications Commission, *Statistics of Communications Common Carriers* (various years).

Note: n.a. = not available.

phone companies have been rapidly introducing new capacity (and presumably services) in their market.

The data are not available to determine how much of the companies' total investment was intended for the voice telephone market (to convert from an analog to a digital system) rather than the broadband market. But the limited information that can be assembled indicates that investment by the former Bell telephone companies that is most closely related to residential broadband service rose even more rapidly than did total investment by those companies.[58] Improving voice service requires investment in both circuit and digital switching equipment. Both types of equipment are also required to provide DSL service, but increasing the availability of that service requires more intensive investment in circuit equipment. The share of their investment dollar that the regional Bell operating companies spend on circuit equipment has increased steadily since 1995, while the share devoted to digital switching equipment has decreased (*see Figure 6*). The growing share of spending for capital goods likely to be used in providing DSL service is even more impressive in the context of the upward trend in overall investment spending by the former Bell companies. Those data are also consistent with the previously noted growth of both DSL availability and of the number of customers buying the service.

Each of the above indicators is imperfect on its own. Taken together, however, they suggest that the major telephone companies have been expanding their broadband capabilities at a rapid rate.

Investment by Cable Companies. Cable system operators have a similarly aggressive pattern of large capital investment. In 1999, the industry's revenues totaled $36.8 billion, and capital investment totaled $10.6 billion, or 29 percent of revenues.[59] In 2000, cable companies spent $15.5 billion on such investment. And in 2001, the FCC estimates, the industry invested $17.8 billion to build new facilities or upgrade old ones—or, to put it another way, in two years, the industry increased its capital spending by 68 percent.

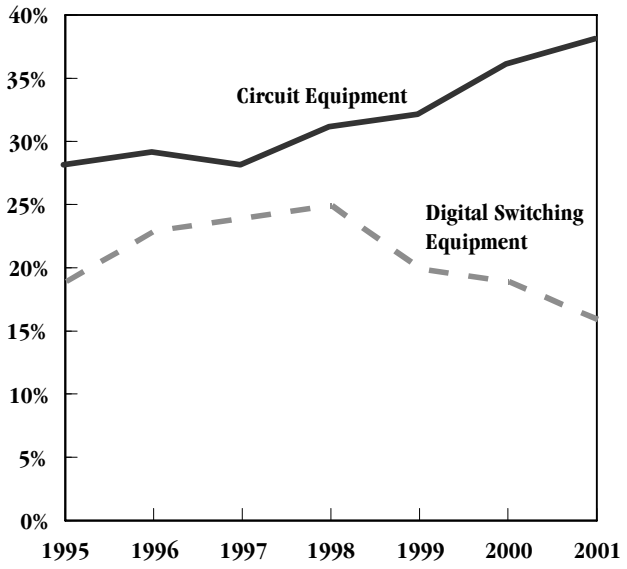
58. In the case of two of the Bell companies, Qwest and SBC, some or all of their investments in broadband were made by subsidiaries that are not required to report them to the FCC. Thus, a significant fraction of investment in DSL service is not reflected in the federal statistics.

59. Federal Communications Commission, *Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming: Eighth Annual Report*, Table B-4, and *Annual Assessment of the Status of Competition in the Market for the Delivery of Video Programming: Ninth Annual Report*, paragraph 35.

Figure 6.

Equipment Investment by Regional Bell Operating Companies

(As a percentage of all investment)



Source: Congressional Budget Office using data from Federal Communications Commission, *Statistics of Communications Common Carriers* (various years).

To a large extent, the cable companies upgraded their facilities in response to a strategic threat from satellite companies to their core multichannel video programming business, not because of a greater commitment to compete in the market for broadband. Yet once the cable companies had upgraded their networks to provide digital television service and added channels to match the satellite offerings, providing cable modem service was much less expensive.

The Demand Side: Public Goods and Constraints on Content

The claims of a failure on the demand side of the residential broadband market rest on arguments about public goods and the observation that removing constraints on the content that can be transmitted over the Internet might make broadband more attractive to consumers. If the issues related to public goods were significant, the market could be judged as providing too few broadband subscribers compared with the number that would maximize society's economic welfare. And if any and all content, copyright protections notwithstanding, was made available for downloading over the Internet, more people would probably subscribe to high-speed access (because the files for such material in many cases are very large). That latter policy, however, could pose substantial costs for economic efficiency because it would reduce the incentives to produce such content.

Claims About Public Goods

Public goods are goods that, once provided, can be consumed by an additional person at no cost and for which it is costly (or at least inefficient) to exclude any one consumer from receiving them. National defense is an example and is sometimes called a pure public good. Other goods—for example, communications networks, education, and public health—to a greater or lesser extent have attributes of a public good. Private markets, left to their own workings, are likely to supply too small an amount of a public good.

Network Effects. If network effects are present, a good's (or service's) value to a person rises as the number of other people who consume the same kind of good rises.[60] For example, a phone system increases in value as the number of people who can be reached through it grows.[61] In that case, an additional subscriber to a network provides a benefit to the existing subscribers—in the form of an additional person with whom to communicate.

Communications networks have some of the attributes of a public good because the additional subscriber to a network provides a benefit to the existing subscribers that is available to all subscribers at little or no addi-

60. S.J. Liebowitz and Stephen E. Margolis, "Network Effects and Externalities," in Peter Newman, ed., *The New Palgraves Dictionary of Economics and the Law* (New York: MacMillan, 1998), pp. 671-675, available at wwwpub.utdallas.edu/~liebowit/palgrave/network.html.

61. That increase in value is one rationale for federal subsidies for universal telephone service, although the centrality of telephone communications to modern economic and social life is the more commonly used justification.

tional cost and from which it is difficult to exclude an existing subscriber.[62] Because a would-be subscriber fails to account for the value of the network's expansion in calculating the benefits of subscribing, too few people will subscribe compared with the number that will enhance economic well-being to the greatest degree.

The Internet itself is a creation of such network effects. The protocols that regulate traffic on the Internet are voluntary. Other computer networks and their conventions predated the widespread popularization of the Internet, but in many cases they could not interconnect. Yet as more people, data, and organizations became available over the Internet, those other networks, such as CompuServe, found that they, too, had to connect to it and comply with its protocols —which for many networks meant losing their independent identity—or risk losing their subscribers.

Network effects are certainly present in the current market for residential broadband services, but they are probably small. Within the narrow category of Internet-based residential communications, dial-up access is likely to account for most of the network gains from connecting to the Internet because most people can already use that kind of service to send and receive e-mail, retrieve files, and perform most other Internet-related tasks. Another factor that is likely to reduce any network gains specifically attributable to residential broadband is the multiplicity of communications and broadcast networks. (For example, many people have high-speed Internet access through work or at school.)

Nor does the presence of network effects necessarily mean that the market will fail to develop appropriately without government action. The market for fax machines, which are subject to network effects, offers an example. A single fax machine is useless. But if most of the vendors and clients with which a firm does business have fax machines, then it becomes a useful business tool. Initially, fax machines were very expensive and not widely used, but once technological advances drove down their price, they quickly became much more widespread. The federal government had little involvement in the market for fax machines because they were largely considered the province of businesses. Consequently, popular pressure for federal intervention was limited.[63]

The fax machine market would probably have developed differently if the federal government had subsidized it, but in that event, the economy might also be worse off today. The point that is most relevant for this analysis is that no one can say whether the market for fax machines would have developed any more rapidly with federal subsidies than it did without them, especially once the distortions and inefficiencies that a federal subsidy program would inevitably entail were factored in. For example, federal subsidy programs could have mandated a specific technology that subsequently became obsolete or favored particular firms rather than technological innovators.

Broadband's Role in Providing Public Goods. High-speed data transmission has become an input in the production of several key services that have a public good component—for example, education and public health. Claims have been made that those services are not produced in sufficient quantity and that wider adoption of broadband would help compensate for their underproduction. This analysis does not address the question of whether certain public goods are adequately provided. Analysts would agree, however, that subsidizing vehicles for the delivery of a public good is less effective than directly subsidizing the provision of the public good itself. Furthermore, the federal government typically does not subsidize other inputs to the production of public goods—for example, pencils, electricity, or natural gas—that are usually considered more important to schools and health centers than are advanced telecommunications.

62. People can be excluded from a network, but once they are part of it, they typically have access to all other individuals in it.

63. For a discussion of network effects and the fax market, see Nicholas Economides and Charles Himmelberg, *Critical Mass and Network Size with Application to the U.S. Fax Market*, Discussion Paper No. EC-95-11 (New York: Stern School of Business, New York University, 1995), available at www.stern.nyu.edu/networks/referenc.html.

In any case, the federal government already subsidizes public health services and education and, more specifically, broadband access for some rural health care providers and for educational institutions. It also has other programs that attempt to bring broadband to rural areas. Those efforts have been justified less on the basis of providing public goods and more on the basis of equity. Most prominently, the Telecommunications Act of 1996 established a program of subsidies to provide advanced telecommunications for schools and public libraries. The program is technology neutral —it does not mandate that the subsidies be used for high-speed Internet access—but many if not most of the schools who receive the subsidies are using them for that and for related services. The subsidies are more generous for schools and libraries in less affluent communities in which broadband and Internet access in general are likely to be less common than they are in higher-income areas. The most recent farm bill also provided loans and loan guarantees for the development of rural broadband infrastructure. (*Box 4* discusses those programs.)

Entertainment-Oriented Content on the Internet

A final claim of failure on the demand side of the broadband market is not related to the market itself but to the content that is available over the Internet. Ultimately, the demand for broadband is a derived demand: consumers buy the connection so they can communicate with others, retrieve information, or download entertainment-oriented content. Technical or legal limits on a consumer's ability to access, download, and share such materials decrease the value associated with the monthly cost of a broadband connection and, some analysts argue, in turn reduce the demand for residential high-speed Internet access.[64]

The core of the argument is that the ability to directly download movies, music, and other entertainment-oriented content will for many consumers justify the additional money that a broadband connection entails. Ordering a CD from an online store does not require a high-speed connection. But downloading a movie or a quantity of music directly is time-consuming with a dial-up link. Much of the Internet's content at present is not geared to traditional popular entertainment—aside from material that might be infringing on the entertainment companies' intellectual property rights. Adding that type of content to the material currently available, those analysts implicitly argue, might bring a whole new audience to broadband, an audience that so far has resisted its allure.

That analysis has several shortcomings, the most important being that most residential consumers already have access to a broadband conduit for entertainment-oriented content through cable and satellite television and radio. In addition, the analysis raises technological, business, and legal issues.

- *Technological Issues*. Most domestic high-speed Internet service is not fast enough to download some types of content—for example, movies in real time. Consequently, some method would have to be developed to allow subscribers to download large amounts of digital content in advance to be played back later—for example, on a television set. Those arrangements would take time and resources to set up and coordinate, although many of the elements currently exist.

- *Business Issues*. The business models in this market are in their infancy and untested. A few of the large media companies have just begun to sell their content over the Internet; they had delayed in part because of concerns about copyright infringement. Although the services that permit free downloading of music are very popular, it is unclear how that popularity might be turned into a stream of revenue on which a business could be built. Recent attempts to create commercial sites for downloading music for a fee have proved attractive to the public but are too new to be declared financially successful.[65]

- *Legal Issues*. Entertainment copyright policy and law are in a state of flux. With the advent of each

64. Lawrence Lessig, "Who's Holding Back Broadband?" *Washington Post*, January 8, 2002, p. A17.

65. Nick Wingfield and Ethan Smith, "With the Web Shaking Up Music, A Free-for-All in Online Songs," *Wall Street Journal*, November 19, 2003, pp. A1 and A6.

Box 4.

Existing Federal Programs to Promote Adoption of High-Speed Internet Access

The federal government currently subsidizes high-speed Internet access and other forms of advanced telecommunications in many of the uses from which public benefits are most likely to result. In a number of instances, that translates into subsidies for broadband access to the Internet. The targets of those subsidies are schools and libraries, rural health care providers, and rural broadband providers.

Schools and Libraries

The Telecommunications Act of 1996 (Public Law 104-104) established a program of subsidies for advanced telecommunications at schools and public libraries.[1] The cost of the program is capped at $2.25 billion per year, but annual expenditures have been running below that level. The program is "technology neutral": it does not mandate broadband connectivity, but many if not most of the schools that receive the subsidies use them for that purpose and for related services. The subsidies are larger for less affluent schools and communities in which the use of broadband and the Internet in general are less common than in higher-income areas.

The portion of the subsidy program directed toward schools continues to receive more attention from policymakers than does the funding for libraries. Recent evidence suggests that the schools' component is indeed providing lower-income children with access to computers and the Internet. According to recent Department of Education figures, 99 percent of all public schools have Internet access; among schools in the bottommost category (75 percent or more of a school's students qualify for a reduced-price lunch), 97 percent are connected to the Internet.[2] Similarly, in 2001, 87 percent of classrooms in all public schools were connected, up from 51 percent in 1998.[3]

1. Congressional Budget Office, *Federal Subsidies of Advanced Telecommunications for Schools, Libraries, and Health Care Providers* (January 1998).

2. Department of Education, National Center for Education Statistics, *Internet Access in U.S. Public Schools and Classrooms: 1994-2001* (September 2002), p. 14.

3. Ibid., p. 16.

new technology, the rights and responsibilities of both producers and consumers of intellectual property must be redefined. That process is under way. Notably, the federal agency with the lead responsibility for broadband deployment, the FCC, has only a marginal role in copyright policy.

The market for video cassette recorders (VCRs) offers an instructive historical precedent as federal intervention in the residential broadband market is being considered. The VCR developed as an entertainment-oriented consumer product without a need for federal subsidies. Entertainment copyright owners fought against consumers being allowed to use VCRs, but the federal government did nothing to promote the technology other than by its adjudicating the balance of rights between copyright holders and consumers.[66] Yet once the limits to the copyright holders' rights were delineated, new consumer services—for example, video sales and rentals—developed rapidly without further federal intervention. Movie studios made more of their material available and lowered prices. And revenues in the movie industry rose dramatically.

66. James Lardner, *Fast Forward: Hollywood, The Japanese, and the VCR Wars* (New York: W.W. Norton & Company, 1987).

Box 4.
Continued

Rural Health Care Providers

The portion of the federal subsidy program directed toward nonprofit rural health care providers cannot claim as much success as the schools' component. Rural health care providers are not making full use of the subsidies that are currently available. In 2001, the program provided telecommunications subsidies to fewer than 800 nonprofit health care providers. (In the first three years of the program, it distributed only $13 million in subsidies.)[4] The low level of utilization of the program has spurred the Federal Communications Commission (FCC) to begin regulatory proceedings to change it and make it more responsive to the rural providers' needs.

Rural Broadband Providers

Title VI of the Farm Security and Rural Investment Act of 2002 (Public Law 107-171) authorized $20 million a year for four years to provide loans and loan guarantees to rural telecommunications companies to encourage them to offer broadband service in rural areas. However, to date, subsequent appropriation laws have prevented the Rural Utilities Service (the federal agency in charge of the Department of Agriculture's rural telecommunications subsidies) from making any loans or providing loan guarantees to build, acquire, or improve broadband facilities in eligible communities.

Yet even without that program, rural telecommunications companies have been rapidly increasing their broadband offerings. In a 2001 survey, the National Exchange Carriers Association (an association, mandated by the FCC, of 1,100 mainly small and rural local telephone companies) found that more and more of their members were providing digital subscriber line (DSL) service. In 1999, only 151 of the member companies surveyed offered DSL service. But by 2001, 557 companies offered it, and another 66 planned to do so soon, an increase of 269 percent in two years.[5]

4. See the 2001 annual report of the Universal Service Administrative Company (the organization that administers the universal service programs), available at www.universalservice.org/reports/2001/.

5. National Exchange Carriers Association, *Paving the Digital Highway: NECA 2001 Access Market Survey* (Whippany, N.J.: NECA, 2001), available at www.neca.org.

Conclusions

Rapid diffusion of high-speed access to the Internet for households and small businesses will unleash a whole series of benefits for consumers and for the national economy, proponents often argue. A recent study tried to quantify some of the more palpable benefits and found that by 2025, universal broadband deployment could provide the nation with roughly $300 billion to $500 billion of new consumer benefits annually.[67] The central issue for this analysis is not the magnitude of those benefits but whether there is reason to believe that the market will be unable to realize them without the federal government's intervention.

Over the next 25 years, consumers are likely to be better off not only because of the spread of residential broadband but also because of advances in a wide range of products, including automobiles and computers, and in old as well as new technologies. If the

67. See Robert Crandall and Charles Jackson, *The $500 Billion Opportunity: The Potential Economic Benefit of Widespread Diffusion of Broadband Internet Access* (Washington, D.C.: Criterion Economics, July 2001), available at www.criterioneconomics.com/documents/Crandall_Jackson_500_ Billion_Opportunity_July_2001.pdf. Many of the benefits would be reflected in increases in gross domestic product (GDP), but in other instances, the increases in consumer welfare (through, for example, reduced shopping time) would not trigger a parallel increase in GDP.

government subsidized broadband service to increase consumers' welfare, it would encourage households and small businesses to buy more high-speed Internet access than they would otherwise have purchased, substituting the benefits of broadband for those that might be enjoyed by consuming other goods or services. Yet if the market for broadband is working tolerably well, as CBO's analysis concludes, it is likely that consumer demand and market developments —uninfluenced by subsidies—will draw resources toward the production of a bundle of goods and services that will grant an even higher level of well-being. The losses of welfare that are likely to result if the government intervenes are a real cost of broadband subsidies as are the direct spending or tax benefits that some advocates of intervention claim are justified by failures in the broadband market.

The personal computer (PC) has provided the type of benefits to the economy that proponents of residential broadband hope it will provide in the future. PCs have diffused throughout the economy over the past 25 years, fundamentally changing the way business is conducted (as well as other aspects of economic life) and creating broad new benefits for consumers. Yet outside of funds for public schools and other areas of clearly defined public interest, the federal government has provided no subsidies for the technology's diffusion.[68] Indeed, in circumstances similar to those facing the broadband market today, PC technology changed so rapidly that it might have been difficult for any federal subsidy program to keep up with new developments. As a result, such a program could easily have distorted the incentives prevailing in the marketplace and ultimately slowed the pace of technological advances.

The market for high-speed Internet access for households and small businesses has only a small number of competitors and a tendency toward duopoly, yet it does not currently appear to need "fixing." Consumers' preferences and income and the economic cost of providing the service largely hold sway and determine the number of broadband subscribers and the amount that they pay for service. The number of broadband customers is growing at a rapid pace, and current providers face the prospect of new broadband market entrants and other competitive pressures from converging telecommunications markets. Many of the problems that remain, such as uneven distribution and availability of broadband, are a function of the market's immaturity and not necessarily permanent features.

68. The federal government has provided some subsidies for the research and development underlying the personal computer, both through the tax code and through grants to computer scientists at universities. Those existing federal subsidies fund research for the development of broadband as well. See National Research Council, *Funding a Revolution: Government Support for Computing Research* (Washington, D.C.: National Academy Press, 1999).

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