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1 *Introduction*

The 1990s was the decade of the Internet and the stock market bubble, two phenomena that were likely related. After the bubble burst and the stock market settled down to more normal levels, economists began to measure the real effects of the information technology revolution on the economy—and were often pleasantly surprised. Productivity growth accelerated in the late 1990s, fed in large part by investments in information technology and the growth of the Internet. Some fear, however, that public policy may be impeding the development of the Internet into a high-speed communications network capable of delivering full video images, complicated games, and comprehensive audio entertainment. In the absence of a wide diffusion of high-speed Internet connections, the demand for information technology equipment and new Internet service applications has remained stagnant.

On October 4 and 5, 2001, the AEI-Brookings Joint Center for Regulatory Studies convened a conference of telecommunications scholars to address the public policy issues that arose over the dispersion of broadband telecommunications services to residential and small business customers. Subsequently, the Columbia Institute for Tele-Information (CITI) held a similar conference in New York, which included many of the same scholars. This volume includes papers from both conferences.

The Issues

Any discussion of telecommunications policy in the current era of market liberalization engenders enormous controversy. Public policy on broadband technology is among the most controversial, in large part because of the differences among regulatory regimes faced by various carriers. Cable television companies, incumbent local telephone companies, and new entrants into telecommunications services compete to provide households and small businesses with not only high-speed Internet connections but also satellite services. Cable television companies are now largely deregulated and therefore face neither retail price regulation of their cable modem services nor requirements to make their facilities available to competitors. (As part of the merger agreement, AOL Time Warner must offer its cable customers alternative Internet service providers.) The incumbent local exchange carriers, on the other hand, face both retail price regulation and a requirement, imposed by the 1996 Telecommunications Act, that they unbundle their network facilities and lease them to rivals. Finally, new entrants are largely unregulated, but many rely upon the incumbent telephone companies for the loop (the "last mile") to connect their customers to their high-speed Internet services.

The primary focus of the two conferences was on such asymmetric regulation. In addition, many papers addressed the issue of subsidies for the diffusion of broadband technology, the availability of technologies for its diffusion, likely consumer demand, and the network effects that might be created by the spread of such access.

Demand and Diffusion

Chapter 2, by Bruce Owen, raises the questions of why broadband Internet technology inspires heated policy debate and why many observers believe that there are barriers to the diffusion of such access. Owen concludes that residential access has spread as rapidly as most other "successful" new consumer services and durables, such as cable television, videocassette recorders, and personal computers. To Owen, barriers to broadband access are more likely to be related to demand than to supply, including regulatory policy. Until important new uses for broadband Internet access develop, many potential residential customers may believe that the service is not worth its current cost (a view of the demand side sup-

ported by Paul Rappoport, Donald Kridel, and Lester Taylor in chapter 4). Owen admits that there is little theoretical justification for the asymmetric regulation of digital subscriber line (DSL) and cable modem service but points out that such anomalies are common due to the political economy of regulation.

Demand for broadband Internet access is addressed in chapters 3 and 4. Hal Varian, in chapter 3, provides evidence from a marketlike controlled Internet demand experiment (INDEX) conducted at the University of California, Berkeley, in 1998–99. Participants in INDEX were given the choice of symmetric and asymmetric speeds of service, up to the now rather slow 128 kilobits a second, at prices that varied over time. The variation in prices across bandwidths and over time allowed Varian and his associates to estimate the price sensitivity of demand for speed in connecting to the Internet. He concludes that the demand for speed is quite sensitive to price; estimated own-price elasticities are in the range of –2.0 to –3.1 for the higher speeds. The most surprising result, however, is that most of the Berkeley participants were willing to pay no more than $0.02 a minute, or $1.20 an hour, for the time saved by high-speed connections to the Internet. Varian suggests that the delays encountered elsewhere on the Internet and the lack of applications that require high-speed connections are likely to explain this apparently low value of connection speed. It is also important to note that Varian's results are from several years ago, an ancient era in Internet time.

Rappoport, Kridel, and Taylor (chapter 4) provide more recent estimates of broadband demand. They compare a sample of narrowband and broadband subscribers' use of the Internet in mid-2001 and discover that broadband subscribers are heavier users of the Internet at all hours of the day, visit more Internet sites, but spend less time at each site than narrowband users. Their study finds that the price elasticity of demand for broadband is approximately –1.0, a much lower value than that indicated by Varian's INDEX project. Perhaps the proliferation of Internet applications is making high-speed service more attractive.

Technology

Chapters 5 and 6 deal with the technology of broadband delivery through fixed wires and by wireless connections. Charles Jackson, in chapter 5, describes the two rival wire-line technologies: digital subscriber lines and cable modems. Jackson demonstrates that these technologies are sim-

ilar in structure and in cost. Digital subscriber lines use part of the spectrum on copper telephone wires to provide high-speed service, while cable modems use part of the spectrum on the coaxial cable that distributes cable television. Because both services are offered over networks designed for other services, the carriers offering the services must make substantial investments in electronics and plants. The sharp decline in the cost of electronics has allowed both services to become more affordable in recent years.

Jackson points out that much of the cost of delivering broadband service is in the conversion of optical signals to electrical signals. Digital subscriber line and cable modem services are both delivered over a fiber backbone to an optical network interface, which converts the signal to an electrical signal for distribution over wires. The length of the wires in local telephone networks serves as a barrier to digital subscriber lines, while the number of subscribers sharing the fiber to the node, where it is converted from an optical signal to an electric signal, limits the capacity of cable modems. In the future, extremely high-speed service could be obtained through either system by extending optical fiber all the way to the subscriber, but each subscriber would then have to convert the optical signal to an electrical signal compatible with the equipment in his or her home.

Jerry Hausman, in chapter 6, provides a review of the current wireless broadband technology, often described as third-generation technology. Hausman begins with a review of the evidence on the substitutability of wireless (cellular) telephony for ordinary voice services delivered over the traditional wired telephone network. He concludes that wireless is rapidly becoming a full-fledged substitute for these narrowband services in many countries but that the wire-line networks do not yet face meaningful competition from third-generation wireless for broadband services due to its lack of market penetration. Hausman identifies spectrum availability as one of the major obstacles to the deployment of third-generation technology. In the United States the federal government has not yet released and auctioned sufficient spectrum for the deployment of third-generation services. As a result, there is no evidence on the cost of building these networks, on the ability of consumers to cope with the hand-held devices, on the interfaces required to access wireless broadband service, or on the likely price of this service. Once the spectrum problem is solved, Hausman foresees the evolution to a world in which numerous wireless carriers compete with existing telephone and cable television networks, obviating the need for regulation.

Regulation

A major issue in current discussions of broadband Internet service is the role of regulation in encouraging or inhibiting its diffusion. Jerry Hausman, chapter 7, provides a critical assessment of the current regulatory regime, which mandates wholesale unbundling of telephone company networks and retail price controls while largely exempting cable from retail or wholesale regulation. Hausman shows that Korea now leads the world in broadband deployment by a wide margin and that far more Korean households have digital-line connections than have cable modems. In the United States, by contrast, cable modems outnumber digital subscriber lines by more than two to one. Hausman asserts that one reason for this disparity is that the Korean telephone company is not required to unbundle its local lines to allow other companies to use its facilities to deliver digital service. On the other hand, cable modem providers can use Korea Electric's infrastructure to offer cable modem service without regulation. Other reasons for the success of broadband Internet service are lack of government regulation, the service's low price, and the built-in access to the service in Korea's numerous modern high-rise apartment buildings. Hausman provides an economic analysis (based on the Hausman-Sidak test) of the need to unbundle the facilities used for delivering broadband in Korea and the United States. Because in both countries there is competition in providing the service and rivals are able to duplicate the incumbents' facilities, Hausman concludes that unbundling is not required in either country. Finally, Hausman shows that the incentives for telephone company deployment of broadband are particularly attenuated in the United States by the low total-element, long-run incremental cost of unbundled elements leased to rivals. At these low rates, entrants are provided a free option, and facilities-based entrants are unfairly penalized.

In chapter 8, Howard Shelanski shows that the case for unbundling depends on setting the correct wholesale prices, including an option price for avoiding the risk of stranded sunk facilities. He cites SBC's experience in unbundling: providing co-location at remote terminals when it deployed Project Pronto, its version of digital subscriber line service. Shelanski concludes that there is at best a tenuous case for unbundling anything more than the conventional loops. Similarly, he finds the case for open-access regulation of cable modem services unpersuasive, because such regulation would provide disincentives for investment by cable operators.

Thomas Hazlett, chapter 9, provides an analysis of the effects of regulating the vertical integration of carriers delivering innovative services. Mandatory unbundling or access rules discourage investment in these risky activities by encouraging firms to wait and simply lease others' sunk investments at regulated rates. Hazlett attributes the cable television companies' reluctance to dedicate more than six megahertz of their systems' capacity to cable modem service to a fear that opportunistic would-be entrants without their own facilities would petition regulatory authorities for mandated access to this additional capacity. Hazlett concludes that there is already sufficient competition in the delivery of broadband to allow regulators to refrain altogether from regulating the service. Proponents of regulating cable or telephone companies' delivery of broadband are competitors seeking to raise their rivals' costs. A firm that would benefit from greater output of broadband services, such as Intel, is opposed to regulation of either service.

Gerald Faulhaber, in chapter 10, questions whether regulatory policy is indeed "in the way" of broadband development and, like Bruce Owen, finds little in residential broadband use to lead him to conclude that regulation is impeding the deployment of the service. Instead, the telephone companies' own internal problems in provisioning digital subscriber lines, he claims, are retarding growth in residential digital service. Moreover, he feels that DSL is only a stopgap technology, which will eventually be replaced by fiber. But even if regulation is not the cause of the incumbent carriers' lagging behind cable television systems in the broadband race, Faulhaber finds no reason to impose wholesale unbundling on the telephone companies' investment in new facilities, such as digital subscriber line access multiplexers or other equipment at remote terminals deployed in the architecture of the new generation digital loop carrier described in chapter 5.

An empirical analysis of the financial effects of broadband regulation by George Bittlingmayer and Thomas Hazlett, chapter 11, finds that the threat of new or continued regulation in three areas—open-access regulation of cable television, regulation of incumbent telephone companies' digital-line services, and bans on the participation of regional Bell operating companies in inter-LATA (local area transport and access) services—reduces the returns to major competitors' securities. The threat of open-access requirements on cable systems has adverse effects on Internet-related companies. On days when positive news appeared about the

Tauzin-Dingell legislation (which would reduce regulation of incumbent local exchange carriers' broadband services and facilities), competitive local exchange carriers' stocks enjoyed positive returns. Finally, positive news on the lifting of the restrictions of section 271 of the 1996 Telecommunications Act was not negatively associated with the stock returns on Internet, semiconductor, or Internet equipment. However, setbacks for the lifting of these restrictions had negative effects on the values of Cisco, Sun Microsystems, and Level 3 (a large competitive supplier of transmission capacity). Bittlingmayer and Hazlett conclude, therefore, that neither new regulation of cable systems nor continued regulation of incumbent telephone companies provides a benefit to new entrants into telecommunications.

Subsidies and Broadband Deployment

Chapter 12, by Austan Goolsbee, addresses the question of whether and how to subsidize the deployment of broadband services to residential subscribers. Using 1999 consumer survey data on willingness to pay for broadband service, Goolsbee constructs a demand function for broadband services. This demand function is then used to estimate the value of encouraging broadband deployment through public subsidies. Goolsbee shows that the most cost-effective (and welfare-enhancing) subsidy is one that funds the start-up costs for the deployment of broadband in unserved markets. Subsidies focused on attracting additional subscribers in markets in which broadband services are already deployed necessarily attract new subscribers who do not value the service at its current price. On the other hand, subsidies that induce firms to expand services to new markets facilitate the enrollment of subscribers who value the service highly but have not had the opportunity to signal their preferences through the market.

In the concluding chapter, Robert Crandall, Robert Hahn, and Timothy Tardiff show that any estimate of the likely benefits of broadband deployment to consumers depends crucially on the assumed form of the demand function. Nevertheless, any of several potential functional forms provides very large estimates of the value of broadband when it achieves universality, that is, when 94 percent or more of all households subscribe. The danger is that regulation may postpone the achievement of universal broadband service, much as earlier regulatory policies postponed or otherwise reduced the value of cable television, cellular telephony, voice messaging, and network television programming.

Conclusion

Broadband Internet services have been available to dispersed residences and small businesses for only a few years. As a result, there is little accumulated evidence on the likely uses for such services, their potential value to consumers, or even the best technologies for bringing them to households and small businesses. The leading players in the broadband game have been companies with networks not designed for the delivery of such services: cable television and telephone companies. These companies have deployed these services in differing regulatory environments. Cable companies were virtually deregulated by the 1996 Telecommunications Act, but incumbent telephone company regulation was substantially expanded by the act. Because regulated telephone companies have had less market success than the unregulated cable companies, they blame regulation for a large share of their problems. The chapters in this volume do not provide much empirical support for the theory that regulation is inhibiting the growth of digital subscriber lines, but neither is there a compelling case made for continuing this asymmetric regulatory policy. Jerry Hausman provides an a priori argument that asymmetric regulation is impeding digital service in the United States, and George Bittlingmayer and Thomas Hazlett show that such regulation is not apparently enhancing the prospects of new entrants into the market. Bruce Owen and Gerald Faulhaber comment on the lack of evidence linking regulation to the slow deployment of digital service, but neither concludes that regulation of new investment in broadband facilities is a good idea. In summary, the papers in this conference volume provide little support for the asymmetric regulatory policy that now governs broadband.