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6 From 2G to 3G: Wireless Competition for Internet-Related Services

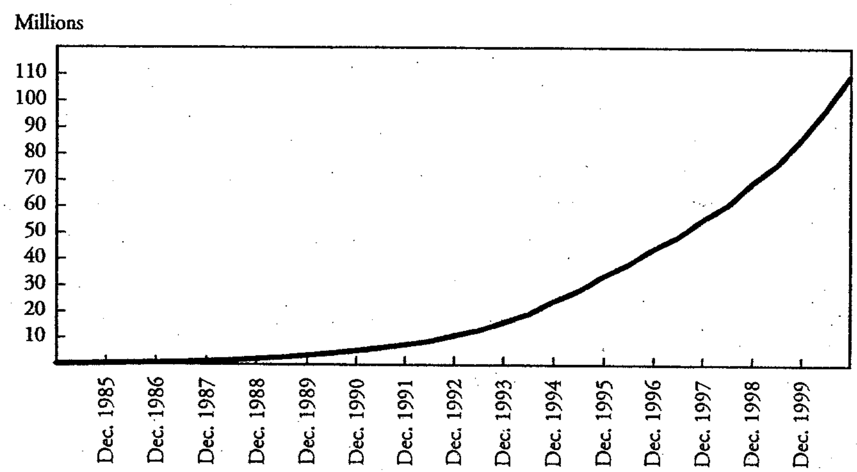
Mobile (cellular) telephone is a relatively new product that has significantly affected how people live. Since its introduction in Europe and Japan in the early 1980s and in the United States in 1983, mobile telephone subscriptions have grown at about 25 to 30 percent a year. By the end of 2000 about 110 million mobile telephones were in use in the United States (see figure 6-1). More than 40 percent of Americans now use cellular telephones, and there are about 80 percent as many cellular telephones in the United States as regular (wire-line) telephones. Cellular penetration rates in Europe are significantly higher, with the penetration in a number of countries exceeding 60 percent and the number of mobile telephone often exceeding the number of wire-line telephones. Thus consumers and businesses find the mobile telephone to be one of the most significant innovations since 1950.

When mobile telephone began operation in the United States in 1983–84, the Federal Communications Commission (FCC) licensed two analogue providers in each large metropolitan statistical area. This analogue service is now referred to as 1G, or first-generation, service.[1] Beginning in 1996 the next-generation cellular technology was introduced in the United

Y. K. Kim provided helpful information on Korean telecommunications.

1. Analogue service used radio transmission similar to that used on the traditional wire-line network. Transmission voice quality improved markedly when second-generation, or digital, technology began operation.

Figure 6-1. *Cellular Subscribers, 1985–2000*



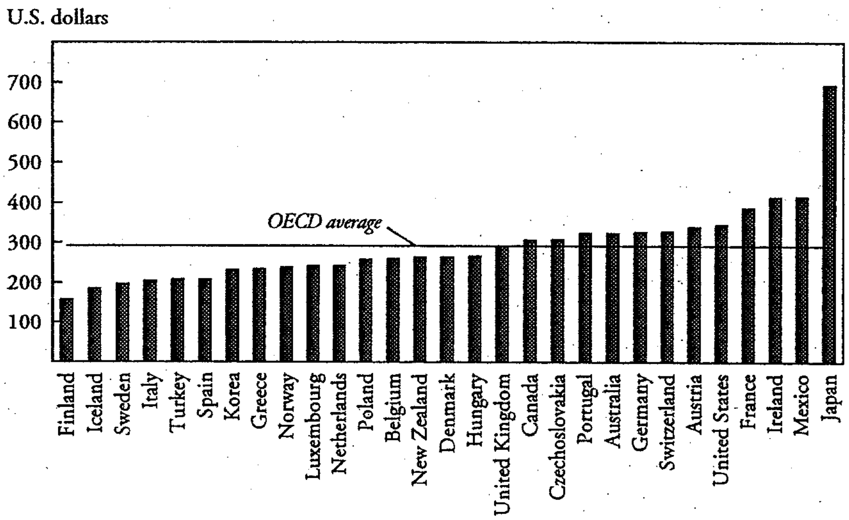
Source: CTIA (2001) (www.wow-com.com/2).

States when the FCC auctioned off a significant amount of additional spectrum. The carriers adopted digital technology, which is often called 2G, or second-generation, technology. As a result of the introduction of 2G, U.S. consumers have a choice among five or more mobile providers in most locations. Verizon Wireless (a joint venture between Verizon and Vodafone), AT&T Wireless, Sprint PCS, Cingular (a joint venture between SBC and Bell South), Voicestream, and Nextel all offer nationwide networks. Many other companies offer local or regional services.

Although mobile telephone has been a great success in the United States, it has been even more successful in other countries (figure 6-2). In Finland, Sweden, and Japan mobile penetration has now surpassed regular telephone (wire-line) penetration. The greater success of mobile services in Europe and Japan is explained in part by the higher monthly price for local wire-line telephone service, particularly when one includes the charges for local calls. Thus mobile is less expensive relative to wire-line service in these countries than in the United States.

In addition, in Europe and Australia a single 2G digital mobile standard was adopted, while in the United States three standards are in use, making the use of mobile telephones in nonlocal regions (called roaming) less convenient. Also, Europe and much of Asia have adopted a calling-party-pays framework, so that incoming calls to mobile telephones are not charged to the recipient of the calls. In the United States, the recipient

Figure 6-2. *Cost of Mobile Service for Consumers, Twenty-Nine Countries, August 2000*[a]



Source: OECD (2001a, 2001b).

a. The basket includes fifty minutes a month and excludes international calls. The OECD average is US$300.

pays, resulting in less usage and a much lower proportion of mobile calls.[2] Finally, European and Japanese mobile services have employed more innovative marketing than have U.S. carriers. For example, prepaid calling cards have been highly successful in Europe, especially among young people.[3] In Japan NTT DoCoMo has introduced Internet-convenient mobile telephones, which have a special appeal to young people.[4] Indeed, mobile companies worldwide are attempting to develop technology that will allow convenient combine use of mobile telephone and the Internet.

Given that the mobile telephone and the Internet are the two outstanding telecommunications developments since 1950, one might ques-

2. In the United States many mobile telephone subscribers do not give out their mobile telephone number because they have to pay for incoming calls. However, this policy seems to be changing as more mobile subscribers use so-called bucket plans—buying a large number of minutes per month of mobile usage.

3. In many European countries (for example, Italy and the United Kingdom) greater than 80 percent of new subscribers are using prepaid service. In the United States only about 6 percent of subscribers use prepaid service.

4. In the first fourteen months after its introduction NTT DoCoMo's I-mode telephone, which connects to the Internet, achieved approximately a 5 percent penetration among the Japanese population. See *Wall Street Journal,* April 17, 2000, p. A25.

tion whether they will supplant wire-line telephone service. Modern digital mobile telephones are convenient to use, have good voice quality, are moderately secure, and the cost of using them is decreasing rapidly (see figure 6-3). Cellular rates in the United States declined rapidly after the removal of regulation in 1995 and the entry of the new providers in 1996. For example, carriers now offer monthly packages that cost approximately $0.10 to $0.15 a minute for combined local and long-distance service when large bundles of minutes are purchased. With a monthly landline residential subscription price that averages $20 a month and long-distance calls priced at approximately $0.7 to $0.9 a minute, landline telephone is still less expensive than mobile for most callers but lacks the convenience of anytime-and-anywhere service through a single number.[5] However, mobile prices do not have to fall too much farther before they could begin to have a significant substitution effect on landline telephone usage. Indeed, in a number of countries mobile usage has begun to supplant wire-line subscriptions.

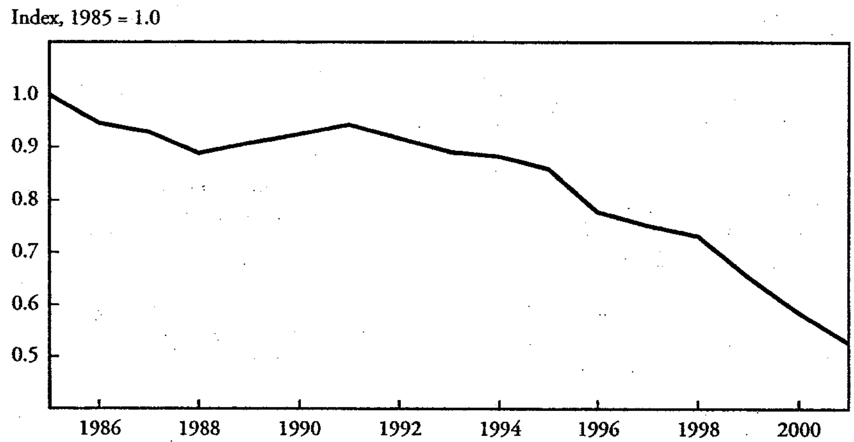
Long-distance and local wire-line usage is already declining in countries in which consumers face charges for local calls. However, wire-line telephone service offers broadband (high-speed) Internet service, which mobile 2G technologies cannot currently offer. Current mobile technology has an upper range of about 19 kilobits a second, which is considerably slower than current wire-line narrowband connection speeds of 56 kilobits a second. Broadband wire-line connections are typically at speeds above 300 kilobits a second, with top speeds in the range of about 1.5–2.5 megabits a second. Thus although current mobile 2G technology provides a substitute for wire-line voice services, 2G cellular does not provide a substitute for data services. In the next several years third-generation (3G) wireless services may provide an adequate data substitute. If they do, the need for regulation for wire-line service is likely to disappear, along with the numerous economic distortions that such regulation creates.[6]

Broadband services for residential customers and small businesses are currently provided by digital subscriber lines using traditional incumbent local exchange carriers, by broadband using competitive local exchange carriers, and by cable modems using hybrid fiber-coaxial cable networks operated primarily by cable television operators. In a number of countries, incumbent local exchange carriers are required to share their networks with

5. Each month a typical large user makes local calls totaling about 500 to 600 minutes, so the charge is still significantly less than mobile.

6. For research on these distortions, see Hausman (1998, 1999a, 1999b, 2000, forthcoming).

Figure 6-3. *Cellular Average Price Index, 1985–2001*[a]



Source: Survey of cellular prices in the top thirty metropolitan statistical areas, 1985–88, from Hausman (1999b); Bureau of Labor Statistics (2001).
a. 2001 data are year to date.

competitive local exchange carriers through unbundling rules at prices set by regulation. However, cable providers have not been required to share their networks. This is an example of asymmetric regulation, a regulatory approach that has created significant economic distortions and has helped cause the bankruptcy of a number of broadband competitive local exchange carriers.[7]

In this chapter I analyze the potential of the next-generation (3G) wireless and consider whether future competition from this innovation could make the regulation of wire line unnecessary. But first I discuss the extent of 2G wireless substitution for wire-line voice service across countries and contemplate the added features that 3G technology offers.

Substitution of Cellular Voice Services for Wire-Line Voice Services

The voice quality of digital cellular voice service is already high, nearly equal to the quality of traditional wire-line telephone service.[8] For voice

7. See Hausman, chapter 7, this volume.
8. First-generation (1G) cellular is the original analog technology, which had voice quality significantly below wire-line quality. Second-generation (2G)—digital—technology is provided by GSM, CDMA, and TDMA.

usage, cellular also has the advantage of mobility and a single number at which a person can be reached anytime and anywhere. As a result, substitution of cellular for wire line is beginning to be evident in wire-line usage data in countries such as Australia, which has current mobile penetration of about 53 percent.[9] Australia, unlike the United States, has a charge for local calls of about $0.20 a call.[10] As a result, mobile companies have begun to offer special local calling plans, which are competitive with this local calling fee. Hutchison, which markets under the Orange brand and has been highly successful in the United Kingdom and elsewhere, offers Orange One service, a combination of mobile and local service. Local calls made from a home zone are charged $0.15 and are untimed. Incoming calls from a fixed wire-line number have no termination charges, thereby eliminating the calling-party-pays framework.[11]

The Australian Data

The Australian data suggest that mobile services compete with fixed, wire-line services:

—Local calls using fixed access lines decreased by 1 percent a year between December 1997 and December 2000, from 95.5 a month to 94.1 a month.[12]

—The mobile customer base doubled over this period, from 27 percent to 53 percent of the population (see figure 6-4). Growth in mobile lines during these averaged 25 percent; that of Telstra's fixed-access lines was only 2.8 percent a year. The number of mobile services in operation, at 10.4 million, is approximately equal to—and beginning to surpass—the number of fixed lines.

—Growth in mobile, originating-call minutes was approximately 28 percent a year, whereas growth in fixed-to-fixed national long-distance minutes declined from 4 percent to 1 percent over those years.

Given the robust growth of the Australian economy over the same period (per capita gross domestic product growth of 3.6 percent a year) and a likely income elasticity of approximately 1, the decrease in the growth of fixed wire-line long-distance calls is especially noteworthy.[13] Only if wire-

9. The penetration of mobile and wire-line phones in Australia is now approximately equal.

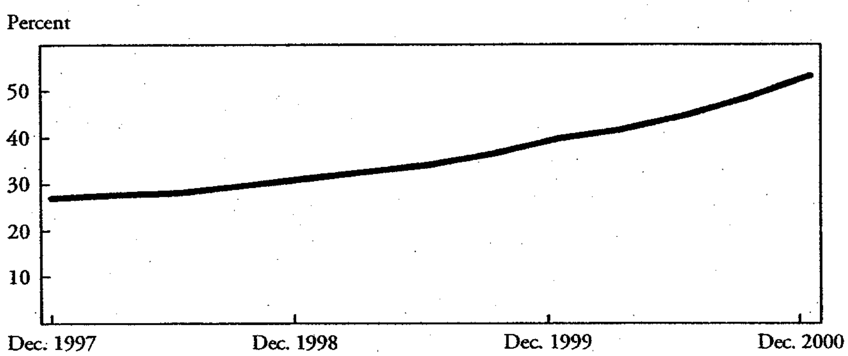
10. Local calls are untimed. Dollar amounts used are in A$ (about US$0.50).

11. The calling party does pay the usual wire-line amount for the call (www.orange.net.au).

12. Based on traffic data in Telstra (1999–2000).

13. Income elasticity is based on U.S. empirical studies. For an evaluation of income elasticities for long-distance service, see Taylor (1994, pp. 265–66). Also see (www.rba.gov.au).

Figure 6-4. *Mobile Penetration Rate, Australia, 1997–2000*



Source: Communications Research Unit, Department of Communications, Australia.

line long-distance prices increased or Internet telephony increased substantially could this decrease in growth be explained other than by significant mobile substitution. However, since long-distance prices decreased by about 16.1 percent between 1997 and 1999, or 5.7 percent a year, the evidence points toward mobile substitution for fixed long-distance calls.[14] Given an estimated price elasticity of –0.55, the expected growth rate of fixed long distance is 6.8 percent a year; the actual growth rate is 1 percent a year.[15]

The Communications Research Unit of Australia's Department of Communications finds similar evidence of mobile-for-fixed substitution for local calling (see figure 6-5).[16] Between 1997 and 2000 local calls for each access line on Telstra's fixed-line network decreased by 1 percent a year, from 95.5 a month to 94.1 a month, even though the price of local calls was decreasing.[17] The report finds that "local call prices declined by an average of 18 percent between 1999 and 2000, but the distribution of the declines was uneven." Over the 1998–2000 period, the number of local calls for each access line for residential users significantly decreased (more than 15 percent for capital city residential users). Revenue per call and revenue per access line for residential users also decreased by more than 15 percent.

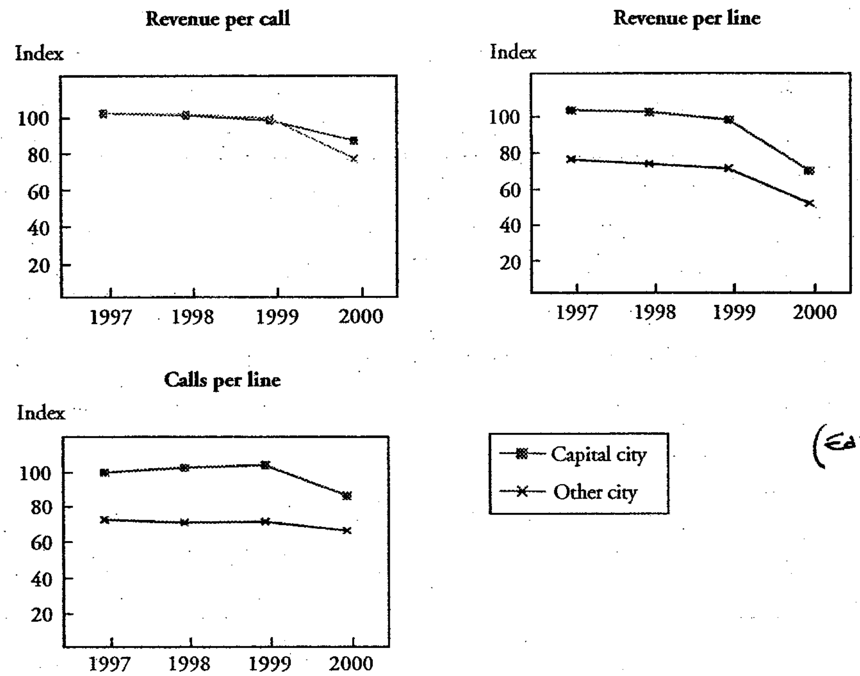
14. ACCC (2000, p. 19).

15. Price elasticity estimate from "Review of Price Controls" (1998, p. 99). The corresponding elasticity estimated for the United States is –0.73, which would lead to an even higher expected growth rate.

16. Report by Collins, McCutcheon, and Osiowy (2001).

17. Based on data comparing local calls for each access line in fiscal year 1998–99 and in fiscal year 1999–2000. See Telstra (1999–2000).

Figure 6-5. *Consumption and Expenditure, Residential Local Calls, Australia, 1997–2000*



Source: Author's calculations based on data from the Communications Research Unit, Department of Communications, Australia.

The report suggests that the decline in local calling per access line was due to substitution of mobile for fixed services. "Residential users made fewer local calls per line in 2000 than 1999. The decline in the average number of local calls per line is most likely to have been partly due to the substitution of mobile telephony for local calls."[18] The data also demonstrate that fixed-line local calls are decreasing faster in large cities, a pattern that is consistent with the greater penetration of mobile telephones in these areas.

The Korean Data

Mobile penetration has also grown rapidly in Korea, to about 58 percent of the population. As a result, mobile penetration now exceeds

18. Collins, McCutcheon, and Osiowy (2001, p. 21).

wire-line penetration.[19] Between 1999 and 2000 (the last year for which data are available) fixed local calls, which are charged for in Korea, decreased by 16.1 percent, from 78.1 billion to 65.5 billion, and long-distance calls decreased from 13.5 billion to 12.2 billion, a decrease of 9.6 percent. Over the same period, mobile usage increased by 49.6 percent, and the price of mobile calls fell relative to the price of wire-line calls, which is consistent with a significant substitution from wire-line to mobile calling.

Data for the United Kingdom and the Republic of Ireland

Although survey data are not as good as usage data, they demonstrate significant and increasing substitution of mobile usage for wire line usage. Survey evidence published by the British regulator Oftel, shows the percentage of mobile subscribers who substitute mobile originating calling for fixed-line calling in certain situations and attributes this phenomenon to the convenience and lower price of mobile usage.

> About half of U.K. adults . . . have both a fixed and mobile phone (dual-users). Only three in ten dual-users . . . were not substituting fixed phone usage with mobile. . . . Almost one in ten (8 percent) of these dual-users considered their mobile rather than their fixed line to be their main phone. . . .
>
> Six percent of U.K. homes . . . use mobiles instead of fixed phones, mainly a result of the flexibility and ability to control costs offered by prepay mobiles. These homes are spending as much each month on their mobile usage as other mobile owners and almost as much as the average fixed-phone owners spend. . . . Four in five of these mobile-only consumers use prepay packages, higher than the average 64 percent. Preference for the flexibility and convenience that mobiles offer, particularly prepay in relation to managing costs, are the main drivers behind this trend.[20]

In the Republic of Ireland wire-line minutes decreased by 1 percent between June 2000 and June 2001, as only Internet (narrowband) use was growing.[21] Non-Internet wire-line minutes, including international long distance, declined by about 18 percent. Over the same period, mobile penetration grew significantly, to 70 percent of the population, well in excess of wire-line penetration.

19. Data as of November 2000. See Korea Ministry of Information and Communication (www.mic.go.kr). Other Korean data from (www.rapa.or.kr).
20. Office of Telecommunications (2000).
21. Office of the Director of Telecommunications Regulation (2001).

The U.S. Data

Data on substitution of mobile for wire line in the United States is more difficult to analyze, because most residential usage (apart from New York City) is untimed (local calls being "free" after payment of a monthly fee). Nevertheless, data does demonstrate that the growth rate of wire lines has decreased significantly. After a period of growth from 1988 to 1999 (about 3.5 percent a year), the number of residential lines decreased slightly between 1999 and 2000 (by about 0.3 percent).[22] Between 2000 and 2001 the number remained approximately constant (Verizon at 62.9 million and SBC at 61.3 million).[23]

Although the growth in mobile telephone usage is likely one cause of this decrease in residential access lines growth followed by an absolute decline, there are other causes, such as a reduction of second residential lines previously used for Internet access as consumers shift to digital subscriber lines or cable modems.

Mobile Use and Wire-Line Prices

To determine if mobile service is a substitute for fixed wire-line service, one needs to analyze whether fixed-line operators could profitably increase the price of a local call. To measure the potential competitive effect of the growth of mobile usage on wire-line prices, assume that the price of a fixed wire-line local call is \$0.20. Suppose one wants to determine if price is as much as 5 percent above the competitive level. What percentage of subscribers would need to shift to make the current price uneconomic? The critical share loss, which just makes the 5 percent price above competitive level unprofitable, follows from the equation:[24]

$$Q_2\,(1.05p - c) = Q_1\,(p - c)$$

where Q_1 is the quantity sold before the price increase, Q_2 is the quantity sold after the price increase, p is the price before the price increase, and c is marginal cost.

Using a U.S. estimate for marginal costs and converting these costs to Australian currency, c would equal \$A0.038. Solving, find $Q_2/Q_1 = 0.941$.

22. FCC (1999–2001).

23. These carriers are by far the largest incumbent local exchange carriers in the United States, with more than 75 percent of all access lines. 1999 and 2000 data from company 10-Ks; 2001 data from 10-Qs.

24. Also see Hausman, Leonard, and Vellturo (1996); appendix to this chapter.

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Thus if 5.9 percent of Australian consumers shifted their local calls from fixed to cellular service, an attempted price increase would not be profitable.[25] For long-distance calls the marginal cost is well below the price of the calls; therefore, for an attempted 5 percent price increase, only a relatively small amount of usage would need to shift to make the increase unprofitable.

In the United Kingdom, mobile use for local calls that replace fixed-line calls appear to be approaching this range. Thus one could conclude that mobile is currently constraining wire-line prices, or nearly so. As mobile calls become relatively less expensive relative to wire-line calls, this constraint should become even more important. Thus only a relatively small share of wire-line usage needs to shift to wireless usage to have a significant constraining effect on wire-line pricing. Once a significant constraining effect exists, the need for wire-line regulation begins to disappear.

However, current 2G mobile service is not an adequate substitute for wire-line Internet usage for either narrowband or broadband Internet content. Advances in 2.5G mobile service are likely to make mobile service approximately equivalent to narrowband Internet access. An important issue remains: whether wire-line service will need to continue to be regulated because of its ability to provide broadband Internet access.

From 2G to 3G

Broadband Internet access over 2G (or 2.5G) cellular service is not competitive with either digital subscriber lines or cable modems. Will 3G cellular service be competitive? That is, will it deliver sufficient speed to provide broadband Internet access? A summary of the several generations of the technology is presented in table 6-1.

The mobile communications industry has evolved in three stages, from analog (1G) through digital (2G) to broadband (3G). Both 1G and the early implementations of 2G mobile systems were designed for circuit-switched services. Wire-line voice calls use circuit-switching technology, which establishes a link for the duration of the call. By contrast, 3G systems use packet-switching technology, through which the information is split into separate but related packets before being transmitted and reassembled at the receiving end. Packet-switched data formats are much more common than their circuit-switched counterparts, the best example

25. For slightly higher or lower values of marginal cost, the percentage changes little.

Table 6-1. *Generations of Technology and Service*

Generation	*Type*	*Year*	*Description*
1G	Analog	1980s	Voice centric, multiple standards
2G	Digital	1990s	Voice centric, multiple standards; data at 9.6 kilobits a second; short message service; e-mail
2.5G	Higher-rate digital	2001	High- speed circuit-switched data, 14.4–43.2 kilobits a second; general packet radio service; 10–115 kilobits a second and enhanced data rates for global evolution; 144 kilobits a second for mobile; 384 kilobits a second for stationary
3G	Digital broadband	2001–03	Voice- and data-centric, single standard, with multiple modes; maximum data rates from 144 kilobits a second (high-speed mobile) to 2 megabits a second (stationary)

being the Internet Protocol. The Internet is packet based, and it is expected that most 3G applications will be Internet based. Packet- switched systems also have an always-on characteristic, so data can be sent or received at any time in a manner similar to that provided by digital subscriber lines and cable modems. The transition from 2G to 3G has resulted in hybrid circuit- and packet-based services; this hybrid is often referred to as 2.5G. The basic evolution has been

—Analogue 1G could be used only for voice calls.

—Digital 2G mobile phone systems added fax, data, and messaging services.[26] However data transfer speeds are at 9.6 kilobits a second, significantly slower than current wire-line, narrowband, data-transfer speeds of 56 kilobits a second.[27]

26. Short messaging services have become extremely popular in Europe and Asia, but they have not gained wide usage in the United States. Much of European usage is among young people, who purchase prepaid cards and who are quite price sensitive. This U.S. population has not used cellular to the extent that its European and Asian counterparts have.

27. Claims have been made that 2G networks can be upgraded to data speeds of 180 kilobits a second. See (WSJ.com [February 21, 2001]). Whether these speeds can be achieved outside a laboratory with reasonable economics is doubtful.

—Broadband 3G services add high-speed data transfer to mobile devices, allowing new video, audio, and other applications through mobile phones. Data transfer speeds are available up to two megabits a second, or 200 times higher than 2G and similar to the broadband data-transfer speeds of digital subscriber lines and cable modems. Voice capacity also increases significantly with 3G technology for a given amount of spectrum.[28]

Carriers are beginning to deploy 3G communications systems outside the United States. Indeed, NTT DoCoMo in Japan began service on October 1, 2001, offering voice, video, graphics, audio, and other information. Speeds of up to 2 megabits a second are achievable with 3G. Data transmission rates depend upon the environment in which the call is being made. Only in stationary environments will the highest data rates be available. For high mobility, data rates of 144 kilobits a second are expected to be available, a rate about three times the speed of today's wire-line narrowband modems. For stationary applications, a subscriber can use a universal appliance, such as an evolved laptop computer, in any place that has access to broadband.[29]

Next-generation wireless, or 3G, facilitates applications not previously available.[30] These applications range from web browsing to file transfer to home automation (remote access of, and control of, home appliances and machines). Because of bandwidth increase, these applications will be even more easily accessed with 3G than they are with interim technologies such as GPRS (2.5G). From an economic perspective, the question is whether sufficiently compelling applications will arise to generate the revenue required to fund the development of 3G networks. To date, 2G applications that attempt to offer web-based services such as wireless applications protocol have been unsuccessful, in part due to slow speed and small screen size. 3G services will have to overcome these problems. Little of 2G networks can be reused in 3G networks, so the cost of a 3G network is substantial.[31] The major uncertainty regarding 3G is whether it will achieve

28. In Japan the 3G communications system NTT DoCoMo began service on October 1, 2001. It offers voice, video, graphics, and audio. The firm expected to attract 150,000 customers (mostly business) in the first six months of 3G deployment. See "Joy of Text" (2001, p. 55).

29. Broadband stationary wireless networks are being deployed in airports and other locations using WiFi technology (802.11b standard technology). However, WiFi technology does not offer mobile applications.

30. Data speed for 2.5G is thirty kilobits a second (www.iii.co.uk/isa [May 18, 2001]).

31. In Norway one of the recipients of a 3G spectrum has returned the spectrum to the government (www.iii.co.uk/isa/ [August 13, 2001]). A number of European countries are considering allowing

speeds high enough and cheap enough to attract consumer demand.[32] To use 3G, users will need

—A mobile phone or terminal that supports 3G. To date, equipment manufacturers have encountered difficulties in producing terminals in sufficient numbers.[33]

—A subscription to a mobile telephone network that supports 3G. Automatic access may be allowed by some mobile network operators; others will charge a monthly fee and require a specific opt-in to use the service (as is done with other nonvoice mobile services).

—Knowledge of how to send and receive information using their model of mobile phone, including software and hardware configuration. This creates a customer service requirement.

—A destination to send or receive information.[34]

Third-generation mobile Internet technology represents a significant departure from earlier generations of mobile technology:

—People will look at their mobile phone as much as they hold it to their ear.

—Data (nonvoice) uses of 3G will be as important as, but different from, the traditional voice business. Indeed, data uses of 3G are crucial for the economic success of 3G because it offers only limited voice quality improvement over 2G networks.

—3G will be similar to 2G in its capability for fixed communications. Thus many people will likely have *only* a mobile phone or appliance. This last point is crucial for the evolution of competition in telecommunications.

Third generation technology will offer voice and data services of similar (or better) quality than wire-line services. It is packet-switched

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facilities to be shared among 3G service providers to lower required network construction costs. British Telecom and Deutsche Telecom plan to institute a policy of sharing 3G network facilities with the expectation of a 30 percent savings in investment costs (//news.ft.com/ft/gx.cgi/ftc? [September 21, 2001]).

32. Initial broadband deployment will be at speeds significantly below 2 megabits a second. (www.iii.co.uk/isa/ [September 6, 2001]). Reports suggest initial rollout speeds for 3G data of between 64 to 384 kilobits a second. Speed appears to be a significant issue regarding 3G performance. Vodafone has stated that the slower speed of 64 kilobits a second will occur only on the edge of coverage areas, while 384 kilobits a second will be the common speed at rollout. NTT DoCoMo's 3G service, introduced on October 1, 2001, has data speeds of 384 kilobits a second. (Data can be obtained from author.)

33. A similar equipment manufacturing problem has arisen for GPRS (2.5G).

34. Web pages need not be altered, as in current protocol applications (www.iii.co.uk/isa/ [May 18, 2001]).

technology with always-on capability. However, 3G mobile will have advantages over wire-line networks because it will offer a single number with high-speed data capabilities. Thus a 3G user will not have to navigate multiple networks when shifting from the workplace, to home, to traveling through and to airports and hotels. Security problems should decrease as well. However, cost and spectrum availability will be important factors in its adoption.

Spectrum Availability for 3G Technology

A number of European and Asian countries have already auctioned spectrum for 3G. The April 2000 auction in the United Kingdom raised approximately $35 billion for the government.[35] In August 2000 Germany completed its auction, raising approximately $46 billion.[36] A number of other European countries, such as the Netherlands and Italy, have also completed 3G auctions, as have Australia and Hong Kong. While spectrum prices have decreased from their earlier high levels, companies continue to bid for the spectrum and will begin the service in 2002–03.

The United States, on the other hand, is encountering difficulty in arranging an auction of spectrum for 3G, in part because of insufficient available spectrum. This problem has been created by regulation. The U.S. authorities (the FCC and the Department of Commerce) have given away spectrum and have specified its usage. As a result, large amounts of spectrum suitable for 3G are currently used by local governments and by the Defense Department. These government agencies have no incentive to use the spectrum in an economically efficient manner. Indeed, most local government use is extremely inefficient because it employs analog technology.[37] These government entities refuse to surrender some of their spectrum and claim they cannot afford to switch to more spectrum-efficient technology.

A market solution exists for this problem of contrived scarcity. An auction could be held for much of this spectrum. Local governments (and the

35. The United Kingdom reserved one of five frequency bands for a new entrant.

36. Per capita auction amounts for the United Kingdom and Germany are extremely close, with the United Kingdom slightly higher.

37. The shift from analog (1G) to digital (2G) technology in cellular led to an efficiency improvement of approximately 300–1,000 percent. Astoundingly, in its recent plan to shift ten channels of ultrahigh frequency television spectrum to other uses, the FCC reserved 40 percent of the spectrum for further local government use.

Defense Department) could compete in the auction as bidders, and a portion of the resulting auction proceeds could be returned to those government entities that currently use the spectrum.[38] The government entities could use the excess revenue (after buying considerably less spectrum than they currently use) to implement digital technology, which is much more spectrum efficient than the technology they currently use. This market approach to solving the spectrum problem is likely to lead to a more efficient outcome than that achieved by regulators. It is doubtful that the FCC can implement this economically efficient policy on its own. Therefore congressional action is likely to be necessary.

Another problem unique to the United States involves earmarking the spectrum for small companies' personnel communications systems (PCS) (2G) and allowing the winning bidders to defer their payments for a number of years. This political favor has allowed a number of winning bidders to default on their payments to the U.S. government when it appeared that they had overbid for the spectrum and to try to keep the spectrum when they emerged from bankruptcy. The most notorious example is Nextwave.

The FCC auction rules, as interpreted by the bankruptcy court and subsequent appeals courts, gave Nextwave a free option, that is, the right but not the obligation to purchase the spectrum. Nextwave bid for the spectrum and then declared bankruptcy when it was unable to raise the necessary capital. If the price of the spectrum increases, as it has, Nextwave can sell the spectrum and realize a profit with little or no risk. If the price of the spectrum decreases, Nextwave could liquidate (chapter 7 bankruptcy), with no financial obligation to pay. It now appears that Nextwave may sell the spectrum for approximately $10 billion more than its winning bid if congressional approval can be obtained.[39] Thus the outcomes of the political favor by Congress are a huge windfall gain and enormous delays in using the spectrum. So even the auction process can be distorted by political interference.

Whether Congress and the FCC can solve the spectrum problem in the near term is problematical. Powerful vested interests, such as the Defense Department and local governments, are loath to give up their free spectrum. However, if 3G proves successful in other countries, this demonstration effect is likely to force a political solution, as happened with the original cellular technology, which began operation in Europe signifi-

38. The proportion returned to the government entities would be significantly less than one.

39. Current negotiations between Nextwave and the FCC may lead to Nextwave keeping about $5 billion, after taxes.

cantly earlier than in the United States as the result of FCC inaction.[40] As with 1G cellular, delaying 3G in the United States will entail a welfare cost of billions of dollar a year and may cause U.S. suppliers of broadband content to suffer significant delays compared to European and Asian providers.

3G and the Regulatory Problem

Significant regulatory problems have existed in the United States since the AT&T divestiture in 1984. First, a federal district court judge controlled U.S. telecommunications for a decade. This experiment in judicial regulation was far from a success, as regulatory delays and the absence of residential long-distance competition cost consumers billions of dollars a year.[41] In 1996 Congress passed the Telecommunications Act of 1996, which was supposed to modernize the regulation of telecommunications. This objective has not been achieved, given that all but seven states are still lacking long-distance competition between local carriers and long-distance companies, a policy that every other country worldwide has adopted and that leads to lower prices for consumers.[42] Furthermore, most of the companies that entered local telecommunications to provide voice services, traditional data services, or competitive broadband services are in extreme financial difficulty, with a number of the largest now bankrupt or liquidated.[43]

The FCC's policy of asymmetric regulation of broadband, including incumbent local exchange carriers' wholesale rates for unbundled elements at levels that are below cost, has created severe regulatory distortions.[44] This latter policy is a principal cause of the economic disaster that has befallen the U.S. telecommunications industry—this and the failure to construct a more modern telecommunications infrastructure, as called for in the Telecommunications Act of 1996. This deficiency in infrastructure investment is an outcome of government regulation, a fact that FCC Chairman Michael Powell recognizes.[45]

40. See Hausman (1997) for a description of this delay and the subsequent welfare loss to U.S. consumers of billions of dollar a year.

41. See Hausman (1995, 1997); Hausman, Leonard, and Sidak (2001) for estimates of consumer welfare losses.

42. See Crandall and Hausman (2000) for an analysis of the Telecommunications Act of 1996.

43. See Hausman, chapter 7, this volume, for an analysis of these outcomes.

44. For a demonstration that such wholesale rates have been set below cost by regulators, see Hausman, (1997, 1999a).

45. Michael K. Powell, chairman of FCC, "Digital Broadband Migration," pt. 2, October 23, 2001 (www.fcc.gov/speeches/powell/2001).

3G cellular, which will be largely unregulated by the government, has the potential to solve the regulatory problem, the severe economic distortions, and the billions of dollars of annual losses in consumer welfare caused by telecommunications regulation. As the price of cellular continues to decrease and the younger generation matures, voice usage of mobile will become increasingly important. However, the wire-line network currently also provides Internet access, both narrowband and broadband, which 2G cellular cannot provide. Once 3G technology proves successful, it may provide sufficient competition to constrain wire-line providers and to eliminate government-induced distortions through its regulatory practices.

Competition and Regulation

Regulators attempt to direct a framework of regulated competition (an oxymoron), but the harm to consumers is easily in the tens of billions of dollars—if not hundreds of billions of dollars—a year.[46] Economists generally agree that the purpose of regulation is to correct market failure (in this case, the potential ability of a wire-line local exchange carrier to distort competition because of potential market power), not to favor competitors. Thus regulation is needed only to prevent the exploitation of market power.[47] A sufficient increase in competition from 3G mobile would likely remove the economic rationale for regulation of incumbent local exchange carriers.

As current and new mobile users become increasingly comfortable with forgoing wire-line telephone service, incumbent local exchange carriers will not have the potential to distort competition. Substitution of 3G for wire-line service will depend on features and price. However, substitution with 2G technology is already occurring in countries that do not subsidize local wire-line service to the same extent as in the United States. As prices for mobile continue to decrease, the substitution of wire line by mobile will increase because of the change in relative prices and demographics.

46. See Hausman (1997, 1998, 2000); Hausman and Shelanski (1999); Hausman, Leonard, and Sidak (2001) for quantitative estimates of consumer harm. Long-distance prices for residential customers and small businesses are estimated at 15–20 percent less if the regulatory restriction on the Bell operating companies' provision of long-distance service were eliminated.

47. Regulation might still be needed for universal service reasons. However, a tax system could solve this need. See Hausman (1998).

Note that, according to the critical share analysis discussed above, only a relatively small group of marginal customers needs to shift to mobile to create a competitive constraint on wire-line providers. A shift of perhaps as little as 10 percent would constrain the pricing behavior of wire-line carriers. However, given the experience of eliminating regulation of cellular in 1994, it is unlikely that regulators will eliminate their jobs. Despite evidence that state cellular regulation led to higher prices for consumers, it took an act of Congress to eliminate cellular regulation.[48] The self-interest of regulators seemingly takes precedence over the interests of consumers, as public choice theory suggests. However, it is still possible that a competitive outcome, absent regulation, is likely to occur, albeit with a longer lag than necessary.

The recent past of telecommunications is replete with new technology predictions that never succeeded. 3G mobile could be another example. In 2000–01 cellular providers paid hundreds of billions of dollars in auctions to purchase 3G spectrum.[49] In Europe mobile operators paid over $125 billion for 3G spectrums. Successful auctions for 3G spectrums took place in 2001 in Australia and other countries, although at lower prices. Thus market activity predicts that 3G technology will succeed. Numerous technological problems occurring in 2001—such as a lack of handsets and a variety of software problems—delayed deployment of 3G. British Telecom canceled a 3G rollout in the summer of 2001 because of these problems.[50] These problems are likely to be transitory events with little effect on the long-term outcomes.

Two developments are required for the widespread adoption of 3G mobile technology. First, sufficiently attractive applications need to be developed to cause people to shift from their current combined use of 2G mobile and wire-line narrowband (or digital subscriber lines or cable modems) to broadband Internet access. Second, 3G technology must provide broadband speeds. The market may solve the potential applications problem, even though uncertainty about broadband data speed remains. In addition, two conditions necessary for 3G to provide sufficient competition to the wire-line network to allow regulation to wither away are widespread deployment of 3G networks with broadband capabilities and sufficient spectrum to permit the deployment to occur.[51] With sufficient

48. See Hausman (forthcoming) for further discussion.

49. Hausman (forthcoming) discusses the auction results.

50. See (www.iii.co.uk/isa/ [May 14, 2001]).

51. Potential problems of decreased competition in rural areas might be handled by requiring uniform prices for residential customers for a transitory period.

spectrum and a full rollout of facilities, there would be no need for the continuation of wire-line regulation.

The End of Regulation?

Regulation has been a feature of U.S. telecommunications since the 1960s. Despite the technological changes over this period, regulators have failed both to promote a timely introduction to consumers of new technology and to allow telecommunications prices to reflect underlying costs. In addition, regulatory-induced distortions in the U.S. economy have been extremely large. The one successful deregulatory episode in telecommunications is the deregulation of cellular created by congressional action in 1995. Cellular pries have decreased significantly since then.[52]

A similar outcome could occur in wire-line telecommunications if 3G is successful. The barriers to entry created by the significant sunk costs in constructing a competing wire-line network would not matter in a rapid-growth industry such as cellular telephony. Only a relatively small share of wire-line users, on the order of 10 percent, needs to shift to alternative technologies such as 3G (or cable networks) to provide a competitive constraint on wire-line providers such that regulation becomes unnecessary. The process could be lengthy and contentious, but the end of regulation made a glimmer on the horizon, with gains to the economy in the tens of billions of dollars a year.

Conclusion

Widespread substitution of 2G mobile services for wire-line voice services is beginning in a number of countries. However, for Internet access, wire-line-based digital subscriber lines or cable modem access are the only technologies available.

The potential outcome from the adoption of 3G technology could be to create conditions that would allow an end to telecommunications regulation. A combination of voice and data applications with mobility, broadband access, and always-on features is likely to be sufficiently attractive to a sufficient number of customers to provide a competitive constraint to wire line. This competitive constraint would make regulation redundant. Regulation

52. In the United Kingdom regulation of cellular continues, with significantly higher prices than in nonregulated countries such as the United States and Australia.

would then disappear, along with market distortion. This outcome would create a large gain in economic efficiency and consumer welfare.

Appendix 5A. The Relevant Product Market and Critical Share

The 1992 U.S. *Merger Guidelines* specifies that relevant markets for merger analysis may be defined for classes of customers on whom a hypothetical monopolist of the merging firms' products would likely impose a discriminatory price increase.[53] The task of defining the relevant product market when price discrimination is not feasible involves identifying the smallest set of products for which a hypothetical monopolist could profitably raise price a "significant" amount (typically 5 percent) above the competitive level for a "nontransitory" period of time (normally assumed to be two years). Thus a potential market definition is too narrow if, in the face of a 5 percent price increase, the number of customers who would switch to products outside the market is large enough to make the price increase unprofitable.

Customers who decide not to purchase the product (or to purchase less of the product) at the increased price are "marginal" consumers. For small price increases, they switch from the products inside the putative market. Not all customers, however, are marginal customers. Indeed, in the typical case most customers would continue to purchase the product despite the higher price because their willingness to pay for the product exceeds the raised price. These customers are "inframarginal" consumers.

In the presence of high demand elasticity and high supply elasticity, a firm cannot exercise unilateral monopoly power by attempting to decrease its supply. Demand elasticity is captured by a customer's willingness to switch to competing suppliers as relative prices change. Thus a broad range of available substitutes implies a high own-price elasticity of demand. Following the same logic as the market definition criteria, the guidelines provide a concrete test for evaluating the competitiveness of a market as captured in the idea of market power, which is the ability of a single firm unilaterally to increase price above the competitive level for a nontransitory period of time.[54]

53. FCC (1992).

54. The *Merger Guidelines* emphasize own-price elasticity of demand, while other analyses focus on the cross-price elasticity of demand. But the two elasticity measures are closely related.

Because competition takes place at the margin, only a small proportion of the customers of the incumbent local exchange carrier need to defect to defeat its attempted price increase. It is possible to calculate that necessary proportion. Suppose that the local exchange carrier attempts to increase prices for end-user access by 5 percent. How much traffic would that carrier need to lose before the increase would be unprofitable? The formula to calculate that critical share is

$$1 - MC/P)\ Q_1 < (1.05 - MC/P)\ Q_2.$$

An important empirical fact for network elements is that fixed costs are a large component of the overall cost, so tat marginal cost is a relatively small component. Assume, for example, that the ratio of marginal cost to price, MC/P, is 0.2. Then Q_2 would be $0.94Q_1$, so that the critical share is 6 percent. Thus if the carrier were to attempt to raise its price by 5 percent, and if as a result it were to lose more than 6 percent of its traffic, the attempted price increase would be unprofitable and thus unilaterally rescinded.[55]

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55. For a more extensive discussion of critical share, see Hausman, Leonard, and Vellturo (1996).

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