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 U.S. in 1983, mobile telephone subscriptions have grown at about 25 to 30 percent per year. By the end of 2000 about 110 million mobile telephones were in use in the U.S. (See Figure 1). More than 40 percent of Americans now use cellular, and there are about 80 percent as many cellular telephones in the U.S. as regular (wireline) 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 exceeds the number of wireline telephones. Thus, consumers and businesses have found mobile telephone to be one of the most significant innovations in the past twenty years.

When mobile telephone began operation in the U.S. in 1983-84, the Federal Communications Commission (FCC) licensed two analogue providers in each large MSA. This analogue service is now referred to as 1G, or “first generation,” service. Beginning in 1996 the next generation cellular technology, PCS, was introduced in the

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1 Macdonald Professor of Economics, MIT. Mr. Y.K. Kim provided helpful information on Korean telecommunications.
U.S. when the FCC auctioned a significant amount of additional spectrum. The carriers adopted digital technology, which is often called 2G technology or “second generation” cellular 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 U.S., it has been even more successful in other countries. In Finland, Sweden, and Japan mobile penetration has now surpassed regular telephone (wireline) penetration. The greater success of mobile services in Europe and Japan is explained in part by the higher monthly price for local wireline telephone service, particularly when one includes the charges for local calls. Thus, mobile is less expensive relative to wireline service in these countries than in the U.S.

In addition, in Europe and Australia a single 2G digital mobile standard (GSM) was adopted, while in the U.S. three different standards are in use, making the use of mobile telephones in non-local 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 U.S., the recipient pays, resulting in less usage and a much lower proportion of mobile calls.4

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3 Analogue service used radio transmission similar to that used on the traditional wireline network. Transmission voice quality improved markedly when 2G, or digital, technology began operation.

4 In the U.S. many mobile 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 mobile
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 for young people who need to control their budget. In Japan, NTT DoCoMo has introduced Internet-convenient mobile telephones that have a special appeal to young people. Indeed, mobile companies worldwide are attempting to develop technology that will allow convenient combine use of mobile telephone and the Internet.

Given that mobile telephones and the Internet are the two outstanding telecommunications developments of the past 25 years, one might question whether they will supplant wireline telephone service. Modern digital mobile telephone are convenient to use, have good voice quality, are moderately secure and the cost of using them is decreasing rapidly as Figure 2 shows. Cellular rates in the U.S. have demonstrated a rapid rate of decline, especially 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 10 to 15 cents per 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 per month and long distance calls priced at approximately 7-9 cents per minute, landline telephone is still less expensive than mobile for most callers but lacks the convenience of “anytime and anywhere” service through a subscriber use “bucket” plans of buying a large number of minutes per month of mobile usage. I discuss these bucket plans below.

5 In many European countries, e.g. Italy and the U.K., greater than 80% of new subscribers are using prepaid service. In the U.S. currently only about 6% of subscribers use prepaid service.

6 In the first 14 months after its introduction NTT DoCoMo’s I-mode telephone, which connects to the Internet, achieved approximately a 5% penetration among the Japanese population. Source: Wall Street Journal, April 17, 2000, p. A25.
single number.\(^7\) 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 wireline subscriptions.

...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 wireline subscriptions.

Long distance and local wireline usage is already declining in countries where consumers face charges for local calls. However, wireline telephone service offers broadband (high-speed) Internet service, which current mobile 2G technologies cannot currently offer. Current mobile technology has an upper range of about 19 kbs, which is considerably slower than current wireline narrowband connection speeds of 56 kbs.\(^8\)

Broadband wireline connections are typically at speeds above 300 kbs with top speeds in the range of about 1.5-2.5 Mbs. Thus, while at the current time mobile 2G technology provides a substitute for wireline voice services, 2G cellular does not provide a substitute for data services. In the next three to five years 3G wireless services may provide an adequate data substitute. If they do, the need for regulation for wireline service is likely to disappear along with the numerous economic distortions that such regulation creates.\(^9\)

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Broadband services for residential customers and for small businesses are currently provided by digital subscriber line (DSL) services over traditional incumbent local exchange carrier (ILEC) networks, by broadband by competitive local exchange carriers (CLECs), and by cable modems over hybrid fiber coaxial cable (HFC) networks

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\(^7\) A typical large user makes about 500-600 minutes of local calls a month so the charge is still significantly less than mobile.

\(^8\) Kbs is kilobits per second while Mbs is megabits per second.

operated primarily by cable TV operators.\textsuperscript{10} In a number of countries, ILECs have been required to share their networks with CLECs 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. As I discuss in Hausman (2001c, this volume), this regulatory approach has created significant economic distortions and helped cause the bankruptcy of a number of broadband CLECs.

In this paper I analyze the potential of the next generation wireless 3G and consider whether future competition from 3G could be sufficient to make regulation of wireline unnecessary. But first I discuss the current extent of 2G wireless substitution for wireline voice service across different countries and contemplate the added features that 3G technology will offer.

I. Substitution of Cellular Voice (2G) Services for Wireline Voice Services

The voice quality of digital (2G) cellular is already very high—nearly equal to the quality of traditional wireline telephone service.\textsuperscript{11} For voice usage, cellular also has the advantage of mobility and a single number where a person can be reached anytime and anywhere. As a result, substitution of cellular for wireline is beginning to be evident in wireline usage data in countries such as Australia, which has current mobile penetration...
of about 53 percent. Australia, unlike the U.S., has a charge for local calls of about 20-22 cents per call. As a result, mobile companies have begun to offer special “local calling plans” that are competitive with this local calling fee. Hutchison, which markets under the Orange brand and has been highly successful in the UK and elsewhere, offers “Orange One” service, a combination mobile and local call service. Local calls made from a home zone are charged 15 cents and are untimed. Also, incoming calls from a fixed wireline number have no termination charges, thereby eliminating “calling party pays” for such calls.

A. Analysis of Australian Data

The following Australian data suggest that mobile services compete with fixed, wireline services:

- In Australia local calls per fixed access line are now decreasing by 1 percent per annum, from 95.5 per month to 94.1 per month.

- The mobile customer base has doubled over the last 3 years from 27 percent to 53 percent of the population as shown in Figure 4. Over the last three years’ growth in mobile lines has been 14.7 percent, 27 percent, and 34 percent, respectively, reflecting an average annual growth rate of 25 percent. By contrast, the growth in Telstra’s fixed access lines has been only 2.8 percent per annum over the same period. The total number of mobile services in operation, at 10.4 million, is approximately equal to, and beginning to surpass the total number of fixed lines.

- Growth in mobile originating call minutes is approximately 28 percent per annum, whereas the growth in fixed to fixed national long-distance

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12 Thus, the penetration of mobile and wireline phones in Australia is now approximately equal.
13 Local calls are untimed. All the dollar amounts in this section are A$ which currently stands at about US$0.50.
14 The calling party does pay the usual wireline amount for the call. Source: www.orange.net.au.
15 Based on traffic data in Telstra’s 1999/2000 annual reports.
minutes has declined from 4 percent to 1 percent over the last three financial years.\textsuperscript{16}

The slowdown in the growth of fixed wireline usage seems especially indicative of substitution from fixed to wireless in Australia.

1. \textit{Australian Long Distance Data}

Growth in wireline long distance traffic in Australia has decreased significantly over the past few years from 4 percent per year to 1 percent per year. Given the robust growth of the Australian economy over the past three years -- per capita GDP growth of 3.6 percent per year -- and the likely income elasticity of approximately 1.0,\textsuperscript{17} the decrease in the growth of fixed wireline long distance calls is especially noteworthy.\textsuperscript{18} Only if wireline long distance prices had increased or Internet telephony had increased substantially in the past year, could this decrease in growth be explained other than by significant mobile substitution. However, since long distance prices decreased by about 16.1 percent in 1997-1999, or 5.7 percent per year over this period, the evidence seems to point strongly towards mobile substitution for fixed long distance calls.\textsuperscript{19} Otherwise, given an estimated price elasticity of \(-0.55\), the expected growth rate of long distance

\begin{itemize}
\item\textsuperscript{16} Estimated from Telstra’s 1999/2000 annual reports.
\item\textsuperscript{17} Based on U.S. empirical studies.
\item\textsuperscript{19} ACCC, “Telecommunications charges in Australia”, April 2000, p.19.
\end{itemize}
would be 6.8 percent per year compared to the actual growth rate of 1 percent.\textsuperscript{20} Thus, the data point very strongly towards significant substitution of fixed to mobile for long distance calls.\textsuperscript{21}

2. \textit{Australian Local Traffic Data}

The Australian government sponsored Communications Research Unit (CRU) found similar evidence of mobile for fixed substitution for local calling in its recent report.\textsuperscript{22} The CRU study found that fixed line local calls per access line on Telstra’s fixed line network are now decreasing by 1 percent per annum, from 95.5 per month to 94.1 per month even though the price of local calls was decreasing.\textsuperscript{23} The CRU study found 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 1998/99 to 1999/2000 period, the CRU study found significant decreases in the number of local calls per access line for residential users (over 15 percent for capital (large) city residential users). The report also found large decreases in revenue per call (over 15%), and revenue per access line for residential users as detailed in the graphs shown in Figure 5, extracted from the report.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Changes consumption & expenditure - local calls}
\end{figure}

Source: CRU estimates using data supplied by carriers

\textsuperscript{20} Source of price elasticity estimate, Access Economics, "Review of Price Controls on Telstra", August 1998, p. 99. The corresponding elasticity estimated for the U.S. is -0.73, which would lead to an even higher expected growth rate.

\textsuperscript{21} Preliminary evidence of substitution of mobile for fixed long distance in the U.S. has been found by G. Woroch, “Demand, Competition and Regulation of Fixed and Mobile Services”, mimeo. See his Table 6.

\textsuperscript{22} Report by the Communications Research Unit of the Department of Communications \textit{Benefits to Consumers of Telecommunications Services in Australia 1995-96 to 1999-2000}.

The CRU’s report suggests the decline in local calling per access line is 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.”

The CRU data also demonstrates 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.

B. Korean Wireline Usage Data

Mobile penetration has also grown rapidly in Korea to about 58 percent of the population. As a result, mobile penetration now exceeds wireline penetration. 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. Likewise long distance calls decreased from 13.5 billion to 12.2 billion, a decrease of 9.6%. Over the same period, mobile usage increased by 49.6 percent, and the price of mobile calls was falling relative to the price of wireline calls, which is consistent with a significant substitution from wireline to mobile calling.

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24 CRU report, p. 21.
C. Irish Wireline Usage Data

Similarly, in Ireland, wireline minutes decreased by 1 percent between June 2000 and June 2001, as only Internet (narrowband) use was growing. Non-Internet wireline 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 wireline penetration.

D. UK Survey Data

While survey data are not as good as actual usage data, they do tend to demonstrate significant and increasing substitution from wireline to mobile usage. The survey evidence published by the British regulator, Oftel shows the percentage of mobile subscribers that substitute mobile originating calling for fixed line calling in certain situations. It attributes this phenomenon to the convenience the lower price of mobile usage. The survey evidence discussed in the Oftel report finds:

- **Impact of mobiles on fixed phone usage**

  The survey finds significant use of mobiles amongst homes without a fixed phone. (6%) 7 in 10 consumers with both fixed and mobile phones claim to be actively choosing mobile rather than fixed phones (in situations, typically at home, where they could use either) for at least some of their calls.

- **Impact of mobile phones on use of fixed line home phones**

  About half of UK adults claimed to personally have both a fixed and mobile phone (dual-users). Only 3 in 10 dual-users said they were not substituting fixed phone usage with mobile in any of the listed circumstances. These tended to be lower spending fixed and mobile customers, and those over the age of 55.

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30 Oftel Report, ibid, pp. 18 and 19.
Almost 1 in 10 (8%) of these dual-users consider their mobile rather than their fixed line to be their main phone.

In addition to the obvious substitution of fixed phone usage with mobile amongst homes who do not have a fixed phone, these results indicate an increasing proportion of consumers and range of circumstances in which certain groups of consumers are actively choosing to use their mobile rather than fixed line phone. Apparent reasons for this substitution include greater convenience and perceived cost savings on a range of call types.

The report goes on to say:

- **Mobile usage**

Mobile ownership continues to rise. During August 54% of UK adults claimed to have a mobile, up from 50% in May. Furthermore, mobile penetration amongst the UK population (adults and children) has risen by 3 million since May, to approximately 31.8 million subscribers by August 2000.

6% of UK homes claimed to use mobiles instead of fixed phones, mainly a result of the flexibility and ability to control costs offered by pre-pay 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 monthly spend. Additionally, 8% of homes with both mobiles and fixed phones considered their mobile to be their main phone.

Furthermore:

- **Mobile-only homes**

74% of homes without a fixed phone (which equates to 6% of all UK homes) currently use mobiles instead of fixed phones. 4 in 5 of these mobile-only consumers use pre-pay packages, higher than the average 64%.

Preference for the flexibility and convenience that mobiles offer, particularly pre-pay in relation to managing costs, are the main drivers behind this trend. 27% of these mobile-only users said they used to have a fixed line.

E. **US Data on Wireline Growth**

The substitution of mobile for wireline in the U.S. is more difficult to analyze because most residential usage (apart from New York City) is untimed, i.e. local calls are “free” after payment of a monthly fee. Nevertheless, available data does tend to

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31 See OfTEL Report, ibid, p. 8, sections 4.6 and 4.7.
demonstrate that the growth rate of access lines has decreased significantly in the U.S. After a period of significant growth from 1988 to 1999 that averaged about 3.5 percent per year, the number of residential access lines decreased slightly in the U.S. between 1999 and 2000, by about 0.3%. Between 2000 and 2001, Verizon’s total access lines have remained approximately constant at 62.9 million between 2000 and 2001 while SBC’s total access lines have remained at 61.3 million. These carriers are by far the largest Incumbent Local Exchange Carriers (ILECs) in the U.S. with over three-fourths of all access lines served. SBC announced that total residential lines in service decreased by approximately 2.5%, due to both a slowing U.S. economy and competitive losses.

While 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 DSL or cable modems. Nevertheless, the data are consistent with some substitution to mobile.

F. Potential competition from Mobile usage on Wireline Prices

To determine if mobile service is a substitute for fixed wireline service, one needs to analyse whether fixed line operators could profitably increase the price of a local call. Assume that a local costs 20 cents in Australia. 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,

32 SBC 10-Q, Quarter 1
34 Sources: Source: 1999 and 2000 from company 10-Ks; 2001 from 10-Qs.
35 The price of wireline local calls has decreased in Australia from 25 cents to approximately 20 cents over the past two years. However, I cannot separate out the effects of mobile competition from regulation set resale prices in causing the price decrease.
which just makes the 5% price above competitive level unprofitable, follows from the equation:\footnote{\textsuperscript{36}}

$$Q_2 (1.05p-c) = Q_1 (p-c)$$ \hfill (1)

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

Using a US estimate for marginal costs and converting them to Australian currency, I estimate $c$ equals \$0.038 (Australian). Solving, $Q_2 / Q_1 = 0.941$. Thus, if 5.9% of consumers shift their local calls from fixed to cellular, an attempted price increase would not be profitable.\footnote{\textsuperscript{37}} 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 attempted price increase unprofitable.

Current usage levels in the UK for mobile for local calls that replace fixed line calls, according to the Oftel report, appear to be approaching this range. Thus one could conclude that mobile is currently constraining wireline prices, or very nearly is doing so. As mobile calls become relatively less expensive relative to wireline calls, this constraint should become even more important. Thus, the outcome of the critical share analysis demonstrates that only a relatively small share of wireline usage needs to shift to wireless usage to have a significant constraining effect on wireline pricing. Once a significant constraining effect exists, the need for wireline regulation begins to disappear.

\footnote{\textsuperscript{36} See Hausman, Leonard, and Vellturo, "Market Definition Under Price Discrimination," Antitrust Law Journal, 64, 1996 for a further discussion. Also, see Appendix 1 of this paper for a discussion of critical share analysis.}

\footnote{\textsuperscript{37} For slightly higher or lower values of marginal cost, the percentage does not change very much.}
However, as discussed in the introduction, current 2G mobile is not an adequate substitute for wireline Internet usage for either narrowband or broadband Internet content. Current advances in 2.5G mobile being implemented in 2001-2002 are likely to make mobile approximately equivalent to narrowband Internet access. But an important issue that remains is whether wireline will need to continue to be regulated because of its ability to provide broadband Internet access.

II. Evolution from 2G Cellular Technologies to 3G Cellular Technology

Broadband Internet access over 2G cellular (or 2.5G cellular) is not competitive with either DSL or cable modems. Will 3G potentially offer a competitive service?

A. Potential Effects of 3G Cellular

The first question is whether the expected technology for 3G cellular will deliver sufficient speed to offer broadband Internet access capability.

1. Description of 3G Technology

The mobile communications industry has evolved in three stages from analog (first generation or 1G) through digital (second generation or 2G) to broadband (third generation or 3G). Both 1G and the early implementations of 2G mobile systems were only designed for circuit switched services. Wireline voice calls use circuit switching technology, which establishes a link for the entire 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 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 that data can be sent or received at any time in a manner similar to that provided by DSL and cable modems. The transition from 2G to 3G has resulted in hybrid circuit and packet based services and this hybrid is often referred to as 2.5G.

The basic evolution has been:

(i) Analogue 1G could only be used to make voice calls.

(ii) Digital 2G mobile phone systems added fax, data and messaging services as well as voice telephone service. However data transfer speeds are at 9.6 kbs, significantly slower than current wireline narrowband data transfer speeds of 56kbs.

(iii) 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 2 Mbs or 200 times higher than 2G and similar to DSL and cable modems broadband data transfer speeds. Voice capacity also increases significantly with 3G technology for a given amount of spectrum.

Carriers are beginning to deploy 3G communications systems outside the United States. Indeed, NTT DoCoMo in Japan began service on October 1, 2001, a few days

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38 Short messaging services (SMS) have become extremely popular in Europe and Asia, but they have not gained wide usage in the U.S. Much of the European usage is among young people who purchase prepaid cards and are quite price sensitive. To date, this population segment has not used cellular to a similar extent as usage in Europe and much of Asia.

39 Claims have been made that 2G networks can be upgraded to data speeds of 180 kbs. See e.g. WSJ.com, Feb. 21, 2001. Whether these speeds can be achieved outside a laboratory with reasonable economics is doubtful.
before this conference, offering voice, video, graphics, audio and other information.\textsuperscript{40}

A summary of the evolution in technology and services is shown in Table 5.1.

Table 5.1: Technology and Service Transition

<table>
<thead>
<tr>
<th>Generation</th>
<th>Type</th>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>First—1G</td>
<td>Analog</td>
<td>1980s</td>
<td>Voice centric, multiple standards (AMPS, NMT, TACS)</td>
</tr>
<tr>
<td>Second--2G</td>
<td>Digital</td>
<td>1990s</td>
<td>Voice centric, multiple standards (GSM, CDMA, TDMA) Data at 9.6 kbs, short message service, email</td>
</tr>
<tr>
<td>2.5G</td>
<td>Higher Rate Data Circuit Switched</td>
<td>2001</td>
<td>High Speed Circuit Switched Data (HSCDS) at 14.4 – 43.2 kbs Introduction of new higher speed packet data services including services such as General Packet Radio Service (GPRS) 10 – 115 kbs and Enhanced Data Rates for Global Evolution (EDGE) at 144 kbs (mobile) – 384 kbs (stationary).</td>
</tr>
</tbody>
</table>

Speeds of up to 2 Mbs are achievable with 3G. The data transmission rates will 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 kbs are expected to be available and this rate is about three times the speed of today’s wireline narrowband modems. Note that for stationary applications, a user can use a “universal appliance” such as an evolved laptop anywhere with access to broadband speeds with similar capabilities in the office (connected to a LAN), at home, in airports, hotels, or other destinations.\textsuperscript{41} The user will only have to turn on the appliance with no changes of protocols, networks, and other impediments that currently exist for a mobile user.

\textsuperscript{40} NTT DoCoMo expects to attract 150,000 mostly business customers in the first 6 months of 3G deployment. Source: Economist, Sept. 15, 2001, p. 55.

\textsuperscript{41} Currently broadband stationary wireless broadband networks are being deployed in airports and other locations using WiFi technology (i.e. 802.11b standard technology). However, WiFi technology does not offer mobile applications.
3G facilitates several new applications that have not previously been readily available over mobile networks due to the limitations in data transmission speeds. These applications range from Web Browsing to file transfer to Home Automation (the ability to remotely access and control in-house appliances and machines). Because of the bandwidth increase, these applications will be even more easily available with 3G than they are with interim technologies such as GPRS (2.5G).\textsuperscript{42} From an economic perspective, the key question is whether sufficiently compelling applications e.g. “compelling apps”, will arise to generate the revenue required to fund the development of 3G networks.\textsuperscript{43} To date, 2G applications that attempt to offer web-based services such as WAP (wireless applications protocol) have been unsuccessful, in part due to slow speed and small screen-size. 3G services will have to overcome these problems. Very little of current 2G networks can be re-used in 3G networks so that the cost of a 3G network is substantial.\textsuperscript{44} The major medium-term uncertainty regarding 3G in terms of competition with wireline is whether 3G will be able to achieve high enough speeds economically to offer broadband applications that will attract consumer demand.\textsuperscript{45}

\textsuperscript{42} BT introduced 2.5G service in May 2001. Data speed is 30 kbs, still only approximately ½ of the speed of narrowband wireline Internet access. Source: \url{http://www.iii.co.uk/isa/}, May 18, 2001.
\textsuperscript{43} “Compelling apps” formerly went by the name of “killer apps”.
\textsuperscript{44} In Norway one of the recipients of 3G spectrum has returned the spectrum to the government. See \url{http://www.iii.co.uk/isa/}, August 13, 2001. A number of European countries are considering allowing facilities sharing among 3G service providers to decrease required network construction costs. British Telecom (BT) and Deutsche Telecom (DT) that they will share 3G network facilities in the UK and Germany. They expect a 30% savings in investment costs. \url{http://news.ft.com/ft/gx.cgi/ftc?}, September 21, 2001. The UK and German regulators have given preliminary approval to the network sharing plans.
\textsuperscript{45} Initial broadband deployment will be at speeds significantly below 2 Mbs. See e.g. See \url{http://www.iii.co.uk/isa/}, September 6, 2001. Reports have suggested initial rollout speeds for 3G data of between 64 kbs to 384kbs. Speed appears to be a significant issue regarding 3G performance. Vodafone has stated that the slower speed of 64 kbs will only occur on the edge of coverage areas, while 384 kbs will be the common speed at rollout.
B. Access Requirements

To use 3G, users will need:

- A mobile phone or terminal that supports 3G. To date 3G terminals have become a problem in 3G implementation as equipment manufacturers have encountered difficulties in producing terminals in sufficient amounts.\(^\text{46}\)

- A subscription to a mobile telephone network that supports 3G. Automatic access to the 3G may be allowed by some mobile network operators, others will charge a monthly subscription and require a specific opt-in to use the service as they do with other non-voice mobile services.

- Knowledge of how to send and/or receive 3G information using their specific model of mobile phone, including software and hardware configuration (this creates a customer service requirement).

- A destination to send or receive information through 3G. 3G users can access any web page or other Internet applications, providing an immediate critical mass of users.\(^\text{47}\)

C. Service Features

3G mobile Internet technology represents a significant departure from 1G and 2G mobile technology. Some of the changes include:

- People will look at their mobile phone as much as they hold it to their ear;

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\(^\text{47}\) A similar equipment manufacturing problem has arisen for GPRS (2.5G). Thus, web pages need not be altered as in current WAP applications. See http://www.iii.co.uk/isa/, May 18, 2001.
• Data (non-voice) uses of 3G will be as important as and very 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 current 2G networks.

• Mobile communications will be similar in its capability to 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.

To the extent that 3G is successful, it will offer voice and data services of similar (or better) quality to wireline services. 3G is packet switch technology with the “always on” capability. However, 3G mobile will have advantages over wireline networks because it will offer a single number with high speed data capabilities. Thus, a 3G user will not have to suffer the agony of navigating multiple networks when shifting from the workplace, to home, to traveling with a mixture of airports and hotels. Security problems should decrease as well, and 3G technology will offer many attractive attributes that will attract users. However, cost and spectrum availability will be important factors in its adoption.

II. Spectrum Availability for 3G Technology

A number of European and Asian countries have already auctioned spectrum for 3G. The April 2000 auction in the U.K. for 3G technology spectrum raised approximately $35 billion for the government.48 In August 2000, Germany completed its

48 The U.K. government reserved one of five frequency bands for a new entrant.
auction for 3G spectrum that raised approximately $46 billion.\textsuperscript{49} A number of other European countries, such as the Netherlands and Italy, have also completed 3G auctions, as have Australia and Hong Kong. While recent spectrum prices have decreased from their earlier high levels, companies continue to bid for the spectrum and will begin to roll-out the service in 2002-03.

The U.S. is the only country that seems to be encountering difficulty in arranging to auction spectrum for 3G, in part because of insufficient spectrum availability. This problem has been created by regulation. The U.S. authorities, the FCC and the Department of Commerce, have given away spectrum “for free” and 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 governmental agencies have no incentive to use the spectrum in an economically efficient manner. Indeed, most local government usage is extremely spectrum inefficient because it employs analogue technology.\textsuperscript{50} 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 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.\textsuperscript{51} The

\textsuperscript{49} An interesting outcome is the per capita auction amounts for the UK and Germany are extremely close, with the UK slightly higher.

\textsuperscript{50} The shift from analogue (1G) to digital (2G) technology in cellular led to an efficiency improvement of approximately 3-10 times. Astoundingly, in its recent plan to shift 10 channels of UHF television spectrum to other uses the FCC reserved 40% of the spectrum for further local government usage.

\textsuperscript{51} The proportion returned to the government entities would be significantly less than one.
government entities could use the excess revenue (after buying considerably less spectrum than they currently use) to implement current digital technology that is much more spectrum efficient than the technology currently in use. This market approach to solving the spectrum problem is likely to lead to a much 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 U.S. involves “earmarking” the PCS (2G) spectrum for small companies 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, but subsequently to try to keep the spectrum when they emerged from bankruptcy. The most notorious of these examples is Nextwave, which five years after the auction is still tied up in litigation.

The FCC auction rules, as interpreted by the bankruptcy court and subsequent appeals courts, have given Nextwave a “free option”. An option 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 achieve a profit with little or no risk. If the price of the spectrum had decreased, 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. Thus, the outcome of the political favor by Congress is a

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52 Current negotiations between Nextwave and the FCC may lead to Nextwave keeping about $5 billion, after taxes.
huge windfall gain and enormous delays in deploying facilities to use the spectrum. 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 significantly before the U.S. as the result of FCC inaction. As with the original 1G cellular, delaying 3G in the U.S. will entail a welfare cost that will be in the billions of dollar per year and may cause U.S. suppliers of broadband content to suffer significant delays compared to European and Asian providers.

IV. Will 3G Solve the Regulatory Problem?

Significant regulatory problems have existed in the U.S. since the AT&T divestiture in 1984. First, a Federal District Court judge “ruled” 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 has cost consumers billions of dollars per year. In 1996, Congress passed the Telecommunications Act of 1996, legislation that 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 the local carriers and the

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53 See J. Hausman (1997) for a description of this delay and the subsequent welfare loss to U.S. consumers of billions of dollar per year.
long distance companies, a policy that every other country world wide has adopted and that leads to lower prices for consumers.\textsuperscript{55} Furthermore, most of the companies which entered local telecommunications to provide voice services, traditional data services, or competitive broadband services are in extremely financial difficulty, with a number of the largest now bankrupt or liquidated.\textsuperscript{56}

The FCC policy of asymmetric regulation of broadband, including the establishment of ILEC wholesale rates for unbundled elements at levels that are below cost has created severe regulatory distortions.\textsuperscript{57} This latter policy has been a principal cause of the economic disaster that has befallen the U.S. telecommunications industry and the U.S. failure to construct a more modern telecommunications infrastructure, as called for in the Telecommunications Act of 1996. This deficiency in infrastructure investment in the U.S. is an outcome of government regulation, a fact that FCC Chairman Michael Powell recently recognized.\textsuperscript{58}

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 in the U.S. As the price of cellular continues to decrease and the younger generation matures, voice usage of mobile will become increasingly important. However, the wireline network currently also provides Internet access, both narrowband and broadband, which 2G cellular cannot provide. Once 3G technology proves

\textsuperscript{56} See J. Hausman (2001, this volume) for an analysis of these outcomes.
\textsuperscript{57} For a demonstration that ILEC wholesale rates have been set below cost by regulators see J. Hausman, (1997 and 1999a).
successful, it may provide sufficient competition to constrain wireline providers and eliminate the “regulatory problem” of government induced distortions through its regulatory practices.

A. **Potential Effects on Telecommunications 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 per year and may be in the hundreds of billions of dollars per year. Economists generally agree that the purpose of regulation is to correct market failure (in this case the potential ability of a wireline local exchange carrier (ILEC) to distort competition because of potential market power), not to favor competitors, the recent practice at the FCC. Thus, regulation is only needed to prevent the exploitation of market power. A sufficient increase in competition from 3G mobile would likely remove the economic rationale for regulation of the ILECs, the incumbent local exchange carriers.

As current and new mobile users become increasingly comfortable with forgoing wireline telephone service, ILECs will not have the potential ability to distort competition. Substitution of 3G for wireline service will depend on features and price. However, substitution with 2G technology is already occurring in countries that do not subsidize local wireline service to the same extent as in the U.S. As prices for mobile continue to decrease, the substitution from wireline to mobile will increase because of the change in relative prices and changing demographics.

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59 See J. Hausman (1997), (1998) and (2000); Hausman and Shelanski (1999), and Hausman, Leonard and Sidak (2001) for quantitative estimates of consumer harm. This latter paper estimates that long distance prices for residential customers and small businesses would be 15-20% less if the regulatory restriction on BOC provision of long distance service were eliminated.
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 wireline providers. The amount is perhaps as little as 10 percent. to provide a constraint on the pricing behavior of wireline carriers. However, given the experience in eliminating regulation of cellular in the U.S. in 1994, it is quite unlikely that regulators will remove themselves from a job. Despite evidence that state cellular regulation led to higher prices for consumers, it took an act of Congress to eliminate cellular regulation.\textsuperscript{61} 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.

B. Will the 3G Competitive Outcome Occur?

The recent past of telecommunications is replete with new technology predictions that never succeeded. 3G mobile could be another example. In 2000-2001 cellular providers paid hundreds of billions of dollars in auctions to purchase 3G spectrum.\textsuperscript{62} In Europe, mobile operators paid over $125 billion for 3G spectrum. Successful spectrum auctions for 3G spectrum have taken place in 2001 in Australia and other countries, although at reduced spectrum prices. Thus, market actions expect that 3G technology will succeed. Numerous technological problems have occurred in 2001 that have delayed deployment of 3G, such as a lack of availability of handsets and a variety of software

\textsuperscript{60} Regulation might still be needed for universal service reasons. However, a tax system could solve this need. See J. Hausman (1998).
\textsuperscript{61} See J. Hausman, “Mobile Telecommunications” (2001b) for a further discussion.
\textsuperscript{62} J. Hausman (2001b) op. cit. discusses the auctions results
problems. BT cancelled a 3G rollout in the summer of 2001 because of these problems.\textsuperscript{63} These problems are likely to be transitory events with little effect on the likely long-term 3G outcomes.

Two major 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 usage of 2G mobile and wireline narrowband or DSL (or cable) broadband Internet access. Second, 3G technology must provide broadband speeds. I expect the market to solve the potential applications problem, while the broadband data speed uncertainty remains.

In addition, two necessary conditions for 3G to provide sufficient competition to the wireline 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.\textsuperscript{64} With sufficient spectrum and full rollout of facilities their would be no need for the continuation of wireline regulation.

C. The End of Regulation?

Regulation has been a persistent feature of U.S. telecommunications for the past 50 years. Despite the technological changes over this period, regulators have failed in the economic goal of promoting the introduction of new technology in a timely manner to consumers and causing telecommunications prices to reflect the underlying costs. In addition, regulatory induced distortions in the U.S. economy have been extremely large. The one successful deregulatory episode in telecommunications has been the deregulation

\textsuperscript{63} See http://www.iii.co.uk/isa/\textellipsis May 14, 2001.

\textsuperscript{64} Potential problems of decreased competition in rural areas might be handled by requiring uniform prices for residential customers for a transitory period.
of cellular created by Congressional action in 1995. Cellular prices have decreased significantly since deregulation occurred.\textsuperscript{65}

A similar outcome could occur in wireline telecommunications if 3G is successful. The barriers to entry created by the significant sunk costs in constructing a competing wireline network would not matter in a rapid growth industry such as cellular telephony. Only a relatively small share of wireline users, on the order of 10 percent, needs to shift away to alternative technologies such as 3G (or cable networks) to provide a competitive constraint on wireline providers that will make regulation unnecessary. The process could be lengthy and contentious, as the lawyers will need to collect their tolls, but the “end of regulation” may a glimmer on the horizon with gains to the economy in the tens of billion of dollars per year.

V. Conclusions

Widespread substitution of 2G mobile services for wireline voice services is beginning in a number of countries. However, for Internet access, wireline-based DSL or cable modem access currently 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 for sufficient customers to shift to 3G to provide a competitive constraint to wireline. This competitive constraint would make regulation redundant. Regulation would then disappear along with the market distorting and

\textsuperscript{65} In the UK regulation of cellular continues by Oftel with significantly higher prices than in non-regulated countries such as the U.S. and Australia. See Figure 4 for a comparison of cellular
consumer welfare harming regulatory outcomes that we have seen in the U.S. over the past 17 years since the AT&T breakup. This outcome would create a large gain in economic efficiency and consumer welfare.
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APPENDIX 1: The Relevant Product Market and Critical Share

The 1992 U.S. Merger Guidelines specify 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. According to the Merger Guidelines, 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 five percent) above the competitive level for a “nontransitory” period of time (normally assumed to be two years). Thus, under the Merger Guidelines, a potential market definition is too narrow if, in the face of a five percent price increase, the number of customers who would switch to products outside the “market” is sufficiently large 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 would imply a high own-price elasticity of demand. Following the same logic as the market definition
criteria, the Merger 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.\(^6_7\) This test is the basis for the econometric investigation and conclusion that I discussed in the previous section.

Because competition takes place at the margin, only a small proportion of the ILEC’s customers need to defect to defeat its attempted price increase. In a simple example, it is possible to calculate that necessary proportion. Suppose that an ILEC attempted to increase prices on end-user access by five percent. How much traffic would that ILEC need to lose before the increase would be unprofitable? The formula to calculate that “critical share” is:

\[
(1 - \frac{MC}{P}) Q_1 < (1.05 - \frac{MC}{P}) Q_2.
\]

An important empirical fact for network elements is that fixed costs are a very large component of the overall cost, so that 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 0.94\(Q_1\), so that the critical share is six percent. Thus, if the ILEC were to attempt to raise its price by five percent, and if, as a result, it were to lose more than six

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\(^6_6\) See 1992 DOJ and FTC Horizontal Merger Guidelines.

\(^6_7\) See the 1992 Merger Guidelines. The Merger Guidelines emphasize the own-price elasticity of demand, while other analyses focus on the cross-price elasticity of demand. But the two elasticity measures are closely related.
percent of its traffic, the attempted price increase would be unprofitable and thus unilaterally rescinded.  

Figure 1
Cellular Subscribers

Source: CTIA Semi-Annual Wireless Industry Survey
Figure 3
Mobile Penetration Rate (AMPS/GSM/CDMA)

Note: The basket includes 50 minutes per month and excludes international calls.

Source: OECD Communications Outlook 2001: OECD Basket of Consumer Mobile Telephone Charges
Figure 5: Changes consumption & expenditure - local calls

a. Revenue per call

b. Revenue per line

c. Calls per line

Source: CRU estimates using data supplied by carriers