Boom and Bust in Telecommunications

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The telecommunications sector has experienced a spectacular decline from mid-2000 until the present, after experiencing a spectacular rise from early 1997. Equity valuations and capital spending soared and then plummeted, and a flood of initial public offerings turned into a flood of bankruptcy filings. The boom and bust in telecommunications coincided with the boom and bust in the U.S. equity market as a whole and with the "dot-com bubble" of Internet stocks. The dot-coms received most of the publicity initially, but the telecommunications industry accounts for a much larger share of market capitalization gained and lost than do the dot-coms.[1] This article documents the telecom boom and bust, and contends that it was caused by a combination of major changes in the regulatory landscape and rapid technological progress. Both factors made it difficult for telecommunications firms and outside investors to accurately forecast supply and demand conditions in the industry.[2]

The single most important telecommunications regulatory change in recent years was the Telecommunications Act of 1996. This Act was meant to bring competition to the local exchange carrier level, that is local telephone service. By 1996, long-distance telephone service had a significant amount of competition, whereas local service was largely monopolized by the regional Bell

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[1] As will become clear, the two industries are closely related.

[2] We concentrate on the U.S. telecommunications sector. A similar telecom boom and bust occurred in other countries; this does not seem to be at odds with our explanation for the U.S. experience, but further study is warranted.

operating companies, such as Bell Atlantic and Southwestern Bell. On the technological side, passage of the 1996 Act coincided with advances in fiber-optic technology that dramatically increased the capacity for data transmission and with more efficient use of the spectrum available for wireless communication. This was also a time of rapidly increasing Internet use. Growth of the Internet alone meant greater demand for telecommunications services. The combination of improving technology for data transmission and the possibility of a deregulated market for telecommunications services held out the potential that providers would be able to compete for *all* of a household's or firm's telecom needs. The confluence of these factors led to the tremendous investment surge and high stock valuations that were the hallmark of the telecom boom.[3]

Within four years of its passage, however, the Act's initial promise had faded. A series of legal battles had ushered in tremendous uncertainty about the industry's future. By early 2001, it became apparent that massive overinvestment had taken place in the sector, particularly in the area of long-distance fiber-optic cable. Stock prices plunged and investment collapsed. These problems were exacerbated by the U.S. economy's swing into recession early in 2001, and the telecommunications sector remains in a slump to this day.

We do not subscribe to the view held by many, that the boom and bust in the telecommunications industry represented a bubble that burst.[4] According to this view, telecom equity prices were high because people believed they would be high in the future, though there was no expectation of high future dividends. In turn, high equity prices drove the high levels of investment in the industry. Then, when the belief collapsed, equity prices and investment collapsed (the bubble burst). With the benefit of hindsight, it is clear that telecom equity prices and levels of capital spending were "too high" in the late 1990s. However, high equity prices and high investment seem to have been based on beliefs about future fundamentals, not simply on the expectation that prices would rise in the future. We are also skeptical about the view that WorldCom can be blamed for the industry's fluctuations.

Already much has been written about the fluctuations in the telecommunications industry around the turn of the 21st century. We look forward to thorough analyses of this episode in the years to come. Our purpose in this article is to document some basic facts about what happened in the telecommunications industry, and to propose an explanation for those facts. The facts alone make for an impressive tale. In addition, we hope that a tentative

[3] Firms seem to have viewed the prospect of offering a broad range of telecommunications services (being a "single provider") as carrying with it high profit margins. This raises interesting questions: Are consumers willing to pay higher prices to a single provider? Are there production efficiencies in being a single provider?

[4] A Google search on "telecom bubble" yields 1,860 hits. One might think that any two-word phrase would yield hundreds of hits when typed into Google. This is not true: "textile bubble" yielded only five hits.

understanding of what drove the telecommunications boom and bust can help inform policymaking in the immediate future.

1. THE TELECOMMUNICATIONS INDUSTRY IN THE UNITED STATES

For our purposes, telecommunications services will refer to two-way transmission of information (to include voice, text, audio, and video) "between parties that are not in physical contact with each other" (Cave, Majumdar, and Vogelsang, 2002, 3). Consumers purchase these services from telephone companies, which include local, long-distance, wireless, and cable, and from Internet providers. The divisions between these categories are increasingly blurred, with many companies providing more than one of the services. The blurring of divisions between different telecommunications services is, like the boom and bust, related to technological and regulatory changes. As the provision of telecommunications services has become less monopolized in the years since the breakup of AT&T, firms producing intermediate service inputs also have begun to play an important role in the industry.[5]

Telephone services include local and long distance, wireless, and related services such as voice mail, caller ID, and directory assistance. Local telephone service was originally provided by a single firm in each area, a regional Bell, or GTE. These firms are referred to as incumbent local exchange carriers, or ILECs. Since the 1996 Act, long-distance companies and local entrants known as competitive local exchange carriers (CLECs) have begun to compete with the incumbents for the local market.[6] The technology for both the incumbents and the entrants consists of the copper local loop (the portion of the lines connecting directly to the house or business), a fiber network for longer-distance transmission, and switching facilities that route calls along the network. The technology also includes facilities for providing other services, such as voice mail, alongside basic local service. Recently, cable companies have used their existing networks to provide phone service.

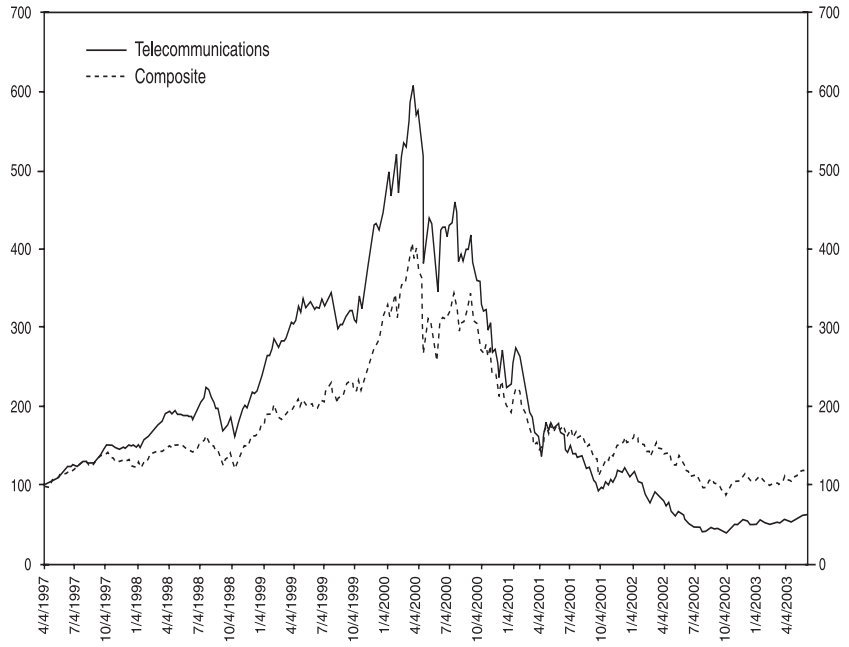
Since the breakup of AT&T in 1984, long-distance service has been provided primarily by a few large companies (such as AT&T, Sprint, or MCI) and many resellers. The 1996 Act conditionally opened the long-distance market to ILECs, and since then several of them have entered the market.

Wireless service was originally organized by the FCC as a duopoly. The FCC reserved one license for the incumbent local exchange carrier and auctioned the other. When the FCC auctioned rights to previously restricted parts

[5] On the industry's historical evolution in the United States, see Brock's chapter in Cave et al. (2002). Other chapters in that book also have been tremendously helpful to us in researching this article.

[6] Prior to 1996, four states had firms competing against the ILECs, but these accounted for only a small share of telecom revenues.

Figure 1 Nasdaq Telecommunications and Composite Indices



Note: End of week close. Normalized to April 4, 1997 = 100.

Source: Bloomberg

of the spectrum in 1995, many other firms entered the market; many areas now offer a choice of several wireless companies. Recently, wireless has become increasingly popular as a substitute for land lines (Noguchi 2002). Calls are transmitted from wireless phones to towers and then are connected to the local or long-distance networks.

Internet service is available from local phone companies, cable companies, and other providers such as AOL. Dial-up access, which still accounts for roughly 70 percent of the market (Noguchi 2003), allows users to connect to the Internet through the phone lines. Digital subscriber line (DSL) service also travels over the local loop, but is much faster than dial-up access. This service is most commonly offered by the ILEC, but any company can purchase capacity from the incumbents on a wholesale basis to resell to consumers. CLECs currently have a 20-percent market share in digital subscriber line service (Fitchard 2002). Cable companies also offer high-speed service over their own networks in some areas, and this has been more widely adopted than DSL. Both DSL and cable are commonly referred to as broadband connections.

Finally, wireless Internet services have recently gained popularity, offering access at home or at other locations with transmitters, such as coffee shops or airports.

A significant part of the telecommunications sector now consists of service wholesalers. These firms, such as Global Crossing and Level 3, constructed long-haul fiber networks in the 1990s in the hopes of selling capacity to telecom retailers and selling final services to large firms with high telecom demand.

2. QUANTIFYING THE BOOM AND BUST

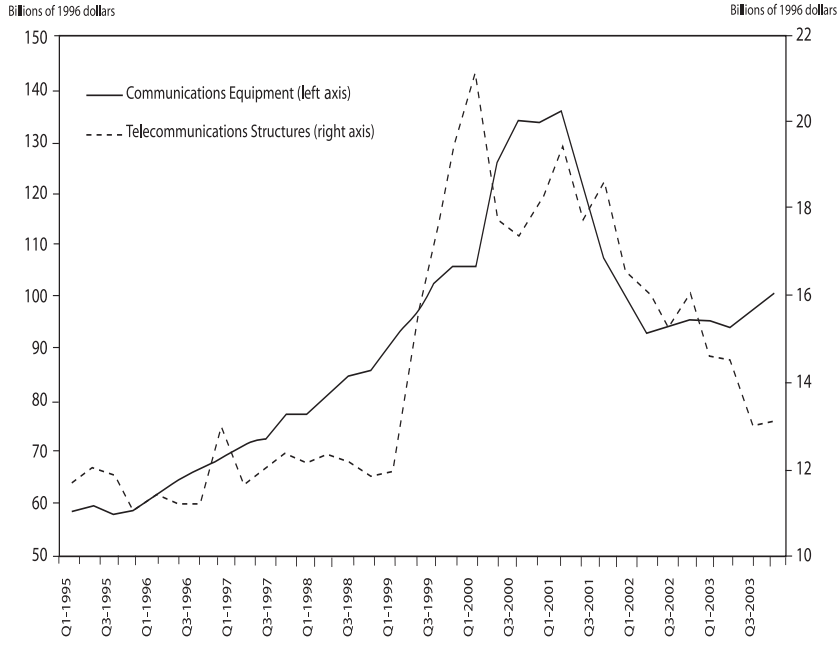
From April 1997 to March 2000, the Nasdaq index of telecommunications stocks rose spectacularly, from 198 to 1,230, an average annual increase of approximately 84 percent. As of May 16, 2003, the index stood at 136, an average annual decrease of approximately 50 percent since March 2000. To put these figures in perspective, the Nasdaq Composite Index rose and fell at respective annual rates of 61 percent and 32 percent over the same periods. Figure 1 displays a plot of the time series for the Nasdaq telecommunications and composite indices over this period, with both series normalized so that April 4, 1997, equals 100.

Equity price behavior illustrates the telecom boom and bust most vividly, but the evolution of the sector's investment spending, employment, and profitability is also dramatic. In contrast, increases in the consumption of telecommunications services and the price of local phone service, and decreases in the price of long-distance phone service have all been gradual.

From the first quarter of 1996 to the fourth quarter of 2000, investment in communications equipment grew from approximately $62 billion per year to over $135 billion per year in constant 1996 dollars (Figure 2). This represents average annual growth of nearly 18 percent. Since the final quarter of 2000, year-over-year communications investment growth was negative for seven straight quarters. In terms of investment levels, the low point came in quarter four of 2001, at under $93 billion—only 69 percent of the same figure one year earlier. As a percentage of total private investment, communications equipment fell from nearly 7 percent in 2000 to 4.8 percent at the end of 2002. Real investment in telecommunications structures was flat through most of the 1990s at approximately $12 billion. Enormous growth occurred in 1999 as investment in structures rose $9 billion in that year alone, to more than $21 billion in the fourth quarter. Such investment has fallen since then to about $13 billion at the end of 2002.

Telecommunications industry employment (services plus manufacturing) peaked at approximately 1.59 million workers in March 2001. Employment in telecom-related industries declined 22 percent—an average annual decrease of 8 percent—to about 1.30 million by July 2003 (Figure 3 shows services

Figure 2 Real Private Fixed Investment in Communications Equipment and Structures

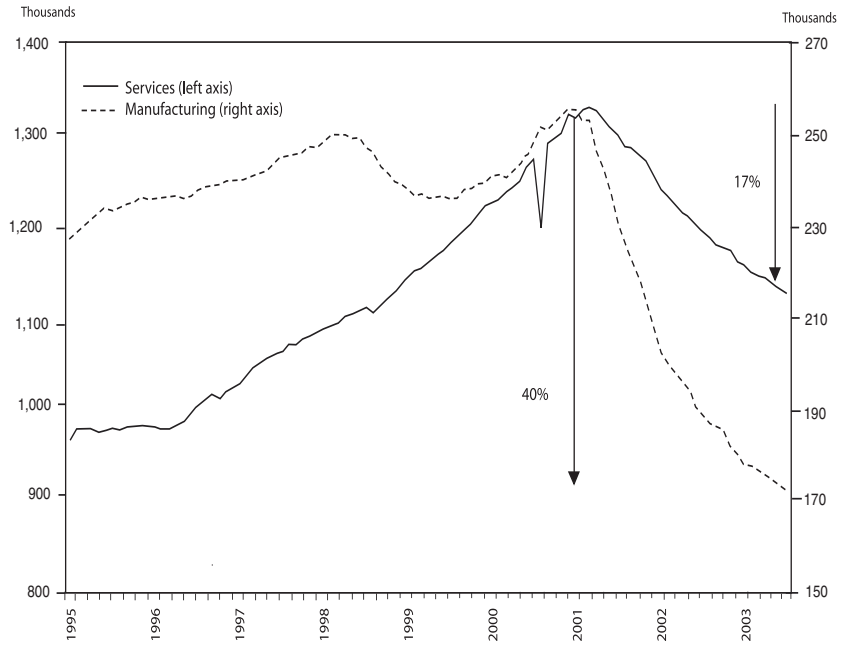


Source: BEA/Haver

and manufacturing employment separately). Announced figures for job cuts have been even more staggering, and media reports have cited numbers of over 500,000. That is nearly one-third of the sector's total employment at its peak. Observed declines in telecom employment have not been as large as the number of job cuts for two reasons. First, some new jobs were created even as others were being eliminated. Also, announced job-cut figures often include reductions in payroll through attrition, so there may be a significant lag between the announcement of cuts and observed employment declines. The boom and bust in employment is less dramatic than that in investment when measured relative to the U.S. economy. As a share of total employment, telecom employment fell only from 1.2 percent to 1.0 percent from March 2001 to July 2003.

Corporate profits for the communications industry started on a rapid downward trend after 1996. Current returns were negative for the year in which telecom stocks reached their highest market capitalization. Profits continued to be negative in 2001, the most recent year for which industry data is available:

Figure 3 Employment in Telecom Services and Manufacturing



Notes: Monthly observations. A strike at Verizon accounts for the downward spike in August 2000.

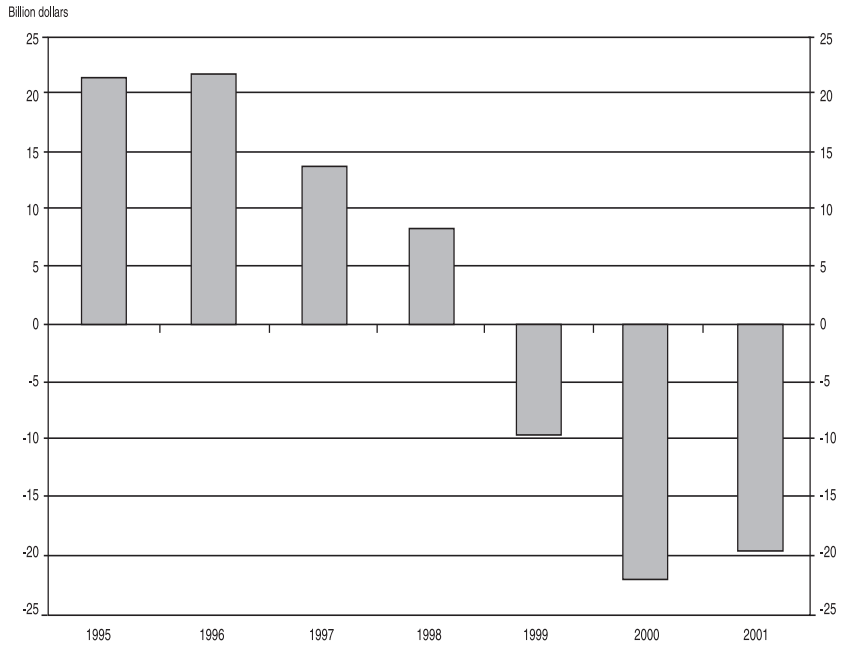
Source: BLS

the communications industry lost nearly $20 billion in 2001, as seen in Figure 4.

Consumption of telecommunications services grew steadily during the boom in investment and equity valuations, from approximately $88 billion in 1995 to $151 billion in 2001 in constant 1996 dollars. Telecom consumption's growth rate rose slightly during the boom—its average year-over-year growth was 6.7 percent from 1990 to 1995 and was 7.4 percent from 1996 to 2001. Consumption of telecom services grew faster than total consumption before, during, and after the boom. In 1995, consumption of telecom services amounted to approximately 1.7 percent of total personal consumption. By 2001, that number was 2.4 percent.

Figure 5 displays price indices for telephone service. Prices for long-distance telephone service fell 18.5 percent from December 1997 (the earliest date available) to March 2003, as measured by the consumer price index. Over the same period, prices for local service rose 21.7 percent. The rise in local

Figure 4 Corporate Profits after Tax in the Communications Industry



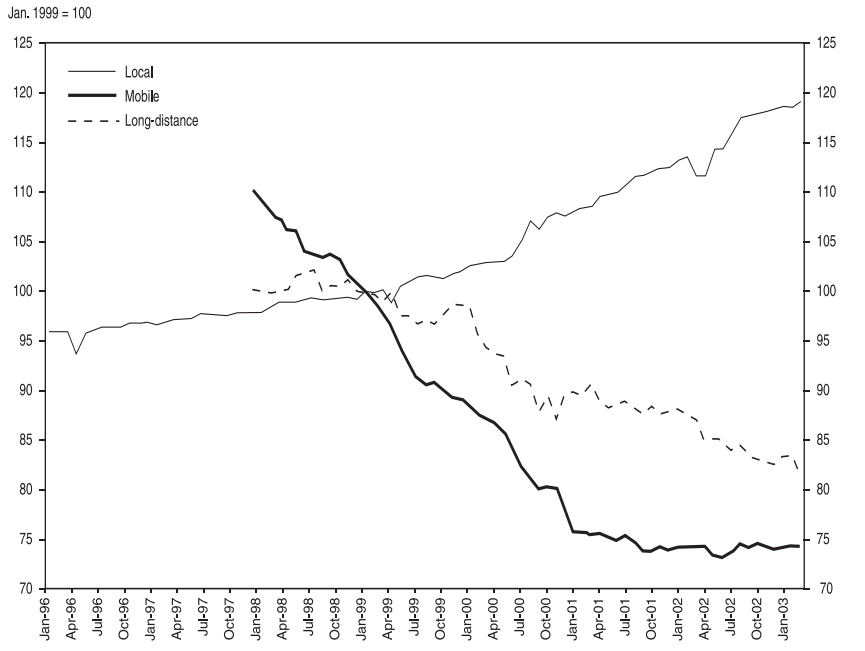
Source: BEA

service prices is particularly striking when compared with data from earlier in the 1990s. From January 1990 to January 1997, prices for local service increased only 8.9 percent. The price index for wireless service fell roughly 32 percent from July 1997 to early 2003, with most of the decline occurring before 2001.

3. UNDERSTANDING THE BOOM AND BUST

The interaction of technological and regulatory changes goes a long way toward explaining the behavior of the telecommunications industry at the turn of the 21st century. Technologies involved in producing telecommunications services advanced dramatically in the late 1990s, opening the door both to lower prices for existing services and to the introduction of a plethora of new services. At the same time, the regulatory environment appeared to be on the verge of transformation. The telecommunications boom was predicated on

Figure 5 Price Indices for Telephone Service



Source: BLS/DRI

technology and regulatory changes interacting propitiously.[7] In the event, the regulatory environment became clouded with uncertainty, undercutting the virtuous circle scenario on which the telecom boom was based.

With the benefit of hindsight, most people would say that telecommunications stocks were overvalued at their peak, and that too much investment took place in the telecommunications sector in the late 1990s. However, any time there is great uncertainty or rapid change in a market environment, one should not be surprised, *ex post*, to observe large forecast errors. Thus, our explanation for the telecommunications boom and bust does not involve fraud, irrationality, or a bubble. To be sure, as the bust became apparent, fraud did occur. But it is not clear that fraud played an important role in the boom and the early stages of the bust.

[7] Of course, technological progress was not entirely exogenous. Firms undertook research and development projects with the expectation of generating future profits.

Technology-Related Changes

While the period of the telecommunications boom saw significant improvements in technology, many of the basic elements forming the infrastructure remained the same. Switches and routers form a connection between the originator of the communication and its destination. Copper wire continues to connect most consumers to the nearest local switching center. For voice communication, an analog signal travels to a local switching center, where the signal is converted to a digital format.[8] Switches also direct the signal toward its destination. Fiber cables known as trunks carry the digital signal between switches. At some point sufficiently near the destination, the signal is converted back to analog format and directed to its destination in the local loop via copper wire.[9]

Fiber has proven to be far superior to copper in its ability to transmit data. However, the existing infrastructure running into homes and businesses primarily is made up of copper wire. Consequently, technology that increases the amount of data that can be carried over copper wire (in particular, digital subscriber line, or DSL) has been an important part of the development of telecommunications.

Technologies that increase the capacity of glass fiber also have been important. These arguably have been the most impressive advances in telecommunications in recent years. In 1996, a strand of fiber transmitted data at approximately 2.5 gigabits per second (Gbps). By 2000, the capacity of the same fiber could reach 100 Gbps.[10] This increase in capacity resulted from developments in "multiplexing," the transmission of more than one channel of information over a single medium (Freeman 1999). Instead of 2.5 Gbps over one wavelength, companies could replicate this flow over 40 wavelengths on the same fiber. Fiber capacity has since increased further, with equipment maker Cisco in July, 2002, claiming a maximum capacity of 320 Gbps over relatively short distances.[11]

A similar change took place in wireless communications. First-generation wireless was analog. Digital "second-generation" wireless networks, introduced in 1993, transmitted data at a much faster rate.[12] The shift from first- to

[8] Analog signalling uses variations in some physical property such as frequency or amplitude to transmit information. Digital signals are composed of discrete "on" or "off" units.

[9] For further explanation along these lines, see Sharkey's chapter in the *Handbook of Telecommunications* (2002).

[10] As a benchmark, a 56-kilobits-per-second (Kbps) dial-up connection is the same as a 0.000056 Gbps connection! To put the fiber capacity increase in perspective, compare the increase in capacity to the growth in the speed of integrated circuits, also considered quite rapid. Whereas the number of transistors per square inch on integrated circuits has doubled roughly every 18 months (Moore's law), fiber's capacity to transmit data doubled approximately every nine months between 1996 and 2000 (Doms Forthcoming).

[11] http://newsroom.cisco.com/dlls/prod_062402d.html

[12] Time division multiple access, the first second-generation technology, was introduced in 1993. The global system for mobile communication, based on time division multiple access tech-

second-generation technology increased the quality and security of the wireless network, and consequently increased the substitutability of wireless for wireline voice communication. Third generation digital wireless, defined by the International Telecommunications Union to be technologies with rates of 114 Kbps to 2 megabits per second (Mbps), is now widely available in South Korea. There, the maximum rate of transmission is 153 Kbps, nearly three times the top capacity of a typical dial-up connection. Tests have shown that rates as high as 1.8 Mbps are possible, but the technology has not been deployed to consumers.[13] Besides the improvements in data capacity, third-generation technology makes more efficient use of the spectrum, easing the constraints on areas with dense demand for mobile voice wireless service. However, third-generation technology is still unavailable in most areas in the United States, and its prospects for deployment are hampered by its incompatibility with earlier systems.

Another technological change affecting the telecommunications industry has been the shift from circuit to packet switching. Historically, voice calls have been circuit switched, meaning that an entire circuit—and therefore all the bandwidth on that circuit—is devoted to a single call end-to-end. Much of the capacity of the circuit goes unused. Over the past few years, as voice communication has moved to digital transmission and switching, telecommunications providers are gradually shifting to packet switching. With packet switching, the voice signal, which is analog by nature, is converted to digital packets of data. These packets can be transmitted separately to their destination, over whatever bandwidth is available. There, the data is reassembled and converted to sound again. This is the same basic process used for transmission of data over the Internet. Because bandwidth is distributed as needed, packet switching leads to more efficient use of available capacity. However, packets can be delayed or lost. Such losses are usually insignificant for data transmission, but they interfere with the quality of voice calls. Note that voice communication is transmitted and switched mainly in digital form even when circuit-based switching is used. Packet-based and circuit-based switching differ in how the network allocates bandwidth, but neither type handles information in an analog format—except at the level of the local loop.

If widely disseminated, these advances in basic technology for providing telecommunications services would have two implications. First, because the capacity of existing networks would increase dramatically, the price of existing services would be expected to fall. Second, the increase in capacity, and in speed, would lead to the development of new applications which

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nology, is standard in Europe and most of the world. Some major U.S. carriers such as Cingular use it as well. Code division multiple access, which followed in 1995, is standard in South Korea and for U.S. carriers such as Verizon.

[13] QUALCOMM press release, Nov. 8, 1999. http://www.qualcomm.com/press/pr/releases1999/press378.html.

benefited from high-speed, high-capacity transmission. To cite one example that has already been observed, the World Wide Web is a telecommunications application which relied on relatively high-speed modems for its practicality. Looking ahead, high-quality streaming video is an application that relies on data transfer speeds greater than are currently available. The interaction between basic technology (speed and capacity) and new applications represents a virtuous circle in which new applications lead to demand for bandwidth, and demand for bandwidth provides the impetus for new supply of bandwidth, which in turn makes new, bandwidth-hungry applications feasible. To a large extent, belief in the relevance of this interaction fueled the telecommunications boom.

Changes in the Regulatory Environment

The Telecommunications Act of 1996 was designed to open up local phone service to competition. Similar liberalization of long distance in the previous decade had produced significant entry, and hopes were high that the 1996 Act would be equally successful. Prior to the 1996 Act, the telecommunications sector consisted of highly regulated monopolies in local service, competitive producers (and resellers) of long-distance services, and a large number of relatively small-scale Internet service providers. The distinctions between these sectors and between others such as cable were strictly preserved. As of September 1, 1995, a majority of states allowed competition in switched local service, but only four states (Illinois, Michigan, New York, and Washington) had any firms actively competing with the incumbent (Federal Communications Commission [Fall 1995]). And while the competitive access providers nearly doubled in size each year in the early 1990s, they accounted for less than 1 percent of revenues in 1993 (Federal Communications Commission [Spring 1995]). Meanwhile, the long-distance market had become increasingly competitive. AT&T's share of long-distance revenues had fallen to 55 percent in 1994; MCI, Sprint, and LDDS (WorldCom) together had 31 percent, and a fringe of smaller companies, 14 percent (Federal Communications Commission [Fall 1995]). By 1995, interstate toll call prices had fallen to roughly half their inflation-adjusted 1984 level (Federal Communications Commission [Spring 1995]).

The authors of the 1996 Act hoped to promote competition specifically in local phone services while maintaining universal service subsidies for residential users.[14] Economides (1999) identifies four crucial regulatory changes in the 1996 Act that were designed to encourage entry.

[14] Rural phone customers are more expensive to serve than their counterparts in more densely populated areas. In the interest of providing phone service to all at the same low prices, "universal service charges" average the cost over the two groups; the subsidy to rural customers comes at the expense of urban customers.

- All incumbents were required to sell unbundled network elements (such as rights to use the copper local loop or access to central office equipment) to entrants; the FCC and state utilities commissions would set the pricing methodology for unbundled network elements.

- Entrants were permitted to purchase at wholesale prices any ILEC service for resale.

- Incumbents and entrants were required to set reciprocal termination charges on their networks.

- Regional Bells that faced significant competition according to a list of criteria (the "competitive checklist") were permitted to enter the long-distance market.

Other rules pertained to cable, Internet, and long-distance service, but were not as sweeping (Economides 1999).

While the Act clearly aimed to bring competition to local telephone service, the specific means of implementation were ambiguous and difficult to interpret. The Act endowed the FCC with considerable discretion in implementing the Act's provisions; the telecoms used a variety of legal tactics to shape the FCC's interpretation of the Act. When the FCC's choices favored entrants, the incumbents challenged provisions in court, and vice versa when the FCC's choices favored incumbents. Of course, challenges were typically met with counter challenges (either by the FCC, state regulators or one segment of industry), further complicating implementation.

Incumbents challenged the FCC's rules concerning (1) whether the FCC had the authority to institute unbundled network element schemes, (2) which network elements must be unbundled, and (3) what conditions entrants must satisfy in order to gain access to those elements. A series of court cases ending with a January 1999 Supreme Court decision established the FCC's jurisdiction. In February 2003 the FCC completed revised rules for unbundling exempting upgraded systems from resale and allowing states to grant further exemptions, but leaving the unbundled network element platform largely intact.

Incumbents and state utilities commissions fought against entrants and the FCC over the FCC's choice of total element long-run incremental cost as the pricing methodology for unbundled network elements. This pricing scheme is based upon the forward-looking cost faced by a hypothetical efficient network, including "reasonable" profits for the incumbents. Believing that the pricing methodology would not allow them to recapture the costs of their network, the incumbents challenged the FCC's pricing order in court. Arguments that the methodology was contrary to the intent of the 1996 Act or was unconstitutional were rejected by the Supreme Court in May 2002.

The FCC's 1999 Collocation Order allowed entrants to place necessary equipment in incumbents' central offices and set a cost-recovery methodology for collocation. Incumbents who felt the entrants were given too much access challenged the order, and the Washington, D.C. Circuit Court of Appeals issued a mixed decision in March of 2000. The court agreed with the incumbents that the definitions of "necessary" and "physical collocation" were too broad; however, it approved other features of the Collocation Order, including the FCC's cost recovery methodology and a broad definition of the premises to which entrants had access (Ryan 2000).

Since 1978, the FCC has set rates for cable and telephone companies that were able to establish that electric utilities were charging monopoly rents for the right to string wires from utility poles; the 1996 Act gave the FCC authority to set pole attachment rates for *all* telecommunications providers. In 1998, the FCC added cable Internet and wireless attachments to the list of regulated attachments. The power companies challenged that policy in court, arguing that because "telecommunications services" did not include cable Internet, an "information service," the FCC could not set rates. The Supreme Court agreed with the FCC that the 1996 Act had in fact granted that authority, and the rules were upheld. Internet access charges, universal service subsidies, and the competitive checklist, among other things, have also been the cause of controversy.

The Industry Responds with Boom and Bust

With dramatic changes in basic technology, new products, and the regulatory environment, it is not surprising that during the period from 1996 to 2002 the telecommunications sector experienced significant volatility. The magnitude of the volatility, and the fact that it involved a sharp ascent followed immediately by a sharp descent, is nonetheless striking. Some observers have blamed fraud and irrationality for the boom and bust, and others have described the episode as a bubble. We see the boom and bust as—in large part—a rational response to the changing fundamentals of technology and regulatory environment.

Boom

In the wake of the 1996 Telecommunications Act, there was tremendous optimism about the eventual opening up of local telephony to competition. With the local exchange open to competition, all manner of firms would be free to compete to be the single provider of a household's or business's telecommunications services (that is, local, long distance, data, and wireless). It was expected that the 1996 Act would encourage the competition and innovation seen in the long-distance market after the breakup of AT&T in 1984. Services

would become cheaper for business users especially, and new services would become available. Writing in May 1996, Dennis R. Patrick, FCC chairman from 1987 to 1989, expounded the early optimistic view: "The Telecommunications Act of 1996 represents a significant milestone. It announces that the federal government is finally, largely, out of the way, or at least headed in that direction. It will usher in an era of radical transformation in the industry the scope and import of which will make divestiture [of AT&T] look like a footnote in history" (Patrick 1996).

Early optimism was mitigated somewhat by questions about exactly how the Act would be implemented, but these questions were expected to be resolved relatively quickly. Thus, the regulatory uncertainty that existed in the immediate aftermath of the Act's passage was a secondary factor; it may have affected where telecommunications investment was channeled, but did little to discourage investment in the industry as a whole.

Questions about the Act's implementation were most pressing in the short-run for new entrants, but early FCC rulings and court decisions seemed to bear out optimistic assessments of the entrants' prospects. The pricing methodology that the FCC had chosen for unbundled elements was favorable for entrants, making it appealing for those firms to compete by leasing at least some unbundled elements rather than by building entirely separate facilities. The Supreme Court's January 1999 decision in *AT&T vs. Iowa Utilities Board* supported the FCC's authority over pricing, and this was widely interpreted as a victory for entrants (CLECs). Robert Taylor, chief executive officer of Focal Communications, a Chicago competitive local exchange carrier, called the decision "great news for CLECs,"[15] and William Kennard, FCC chairman at the time, said that the ruling would create certainty in the industry.[16]

The competitive local exchange carriers—while relatively small—experienced a tremendous boom after the Act was passed. From 1996 to 2000 the number of CLECs rose from 30 to 711, and their revenue increased from less than $5 billion to $43 billion over the same period. From 1996 to 1999 CLECs' market capitalization rose from about $3 billion to $86 billion.[17] Over this same period, however, S&P 500 telecommunications services companies grew in market capitalization by about $500 billion. Thus, while the growth rate of the entrants was high by any measure, the increase in their market capitalization did not account for a large part of the telecom boom.

Investment from 1996 to 2000 was channeled primarily into long-haul fiber optic networks. There were few regulatory barriers to building such networks, and the value of these networks was expected to rise for two reasons. First, as mentioned above, eventual opening of local exchanges to competition

[15] Quoted in Schmelling (1999).

[16] Quoted in Mills (1999).

[17] Sources: FCC, Association for Local Telecommunications Services, and Progress and Freedom Foundation. Cited in Lenard (2002).

would allow owners of such networks to compete to be a single provider; this was viewed as a prize, particularly if a firm could attract a large number of customers.[18] Second, Internet use was growing rapidly, and with it the demand for bandwidth was increasing. From 1994 to 1996, traffic on Internet backbones in the United States is estimated to have grown from 16.3 to 1,500 terabits per month [19](Odlyzko 2002). Rapid growth in demand for bandwidth was widely forecast to continue as part of the virtuous circle, with new applications being developed to take advantage of bandwidth as it came online.[20] A May 1998 article about Qwest in *Wired* typified this view:

> Qwest is operating under an if-you-build-it-they-will-come vision. Bandwidth restrictions, the company believes, have held back development of all manner of innovation. Now the prospect of virtually endless throughput will free up the planet for a host of new applications in such areas as high-speed video and multimedia. (Diamond 1998)

Spurred by expected increases in demand for bandwidth from the Internet and by the promise of future access to local exchanges, construction of long-haul fiber networks exploded after 1996. Much of this investment was undertaken by new firms such as Qwest, Level 3, and IXC. In 1996, the "old guard" of AT&T, MCI, WorldCom, and Sprint together accounted for 72 percent of long-haul fiber in the United States, but by 1999 they accounted for only 30 percent of the total. Over this same period, annual fiber deployment increased more than four-fold (Dunay 2000). One of the major producers of fiber was Lucent Technologies. Early in 2000, Lucent was expanding its facilities to enable it to increase fiber output by 60 percent. A Lucent executive said, "We've seen fiber growth at 17 percent forever. Now we think the growth rate will be 30 percent this year. There's an enormous amount of fiber required to have the penetration needed by long-hauls, cable, and others."[21]

One of the mantras of the telecom boom was that Internet use doubles every three to four months. Many people attribute the origins of the statement to WorldCom (now called MCI) (Dreazen 2002). WorldCom carried the plurality of Internet traffic for a time, so their reports may have carried substantial weight (Sidak 2003).[22] Even so, the real effects of such a claim and the extent to which WorldCom should be faulted are hard to establish. According to research by Kerry Coffman and Andrew Odlyzko (2002), such growth did in fact occur for a time in 1995 and 1996. They estimate that the amount of data sent over the Internet has approximately doubled every year

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[18] This reasoning relies on some form of increasing returns to scale.

[19] "A terabit is one trillion bits."

[20] The "virtuous circle" involves complementarity between applications and network capacity.

[21] Kuhl (2000). The executive quoted is Tim Cahall.

[22] Prior to 1995, the National Science Foundation administered the backbone for the Internet and kept accurate records of its growth. However, private backbones replaced the government's during 1995, hence public data was no longer available.

since then. However, throughout the boom major players outside WorldCom, such as Duane Ackerman, CEO of BellSouth, continued to assert that Internet traffic was doubling every 100 days (Calicchio 1999). In addition, although WorldCom was the biggest carrier, Sprint also carried a large portion of Internet traffic (16 percent to WorldCom's 37 percent, according to the U.S. Department of Justice's announcement that it was suing to block WorldCom from acquiring Sprint [2000]).

During the boom period, contrarian forecasts of Internet use and the resulting demand for fiber could be heard. Odlyzko has pointed out that growth rates of 100 percent every three months would have implied that between 1994 and 2000 Internet use grew by a factor of 17 million (Odlyzko 2002). Forecasts based upon those growth rates and 1994 Internet usage data have every Internet user in the year 2000 constantly downloading streaming video. Even admitting that in 1998 no one knew what applications would be available in 2000, it is difficult not to view this growth rate estimate as excessively optimistic. In the contrarian view, fiber deployment based on such optimistic forecasts would also be excessive: a May 7, 1999, opinion piece from the *Industry Standard* referred to "an unprecedented network overbuild and a looming glut of bandwidth and connectivity. Precious capital has been funneled into too much connectivity, and too few smart applications that could put all this bandwidth to use" (Aguirre and Bruneau 1999).

Pessimistic views regarding the progress in implementing the Act could also be heard. For example, the view that the Supreme Court's 1999 decision would create certainty was not held by all. Writing in the *Business Communications Review*, March 1999, Michael Weingarten argued that in the wake of the January 1999 decision, "matters may be as uncertain as ever" (Weingarten 1999). As Weingarten noted, the decision settled neither the precise set of unbundled elements which incumbents were required to provide, nor the precise pricing scheme to be used.

In the presence of rapidly changing technologies and market conditions it is not surprising that there was heterogeneity in forecasts. During the telecommunications boom, market outcomes evidently reflected the optimists more than the pessimists. Recent research in finance has suggested that when there are heterogeneous forecasts associated with new or rapidly changing technologies, pessimistic voices will have "too small" an effect on the market. These theories rely on restrictions on taking short positions in stocks. If the distribution of forecasts has a mean at the true expected value, it may nonetheless be the case that equity prices reflect a higher value.[23]

[23] See Ofek and Richardson (2003) and Scheinkman and Xiong (Forthcoming).

Bust

Even in 1996, industry observers did not believe that competition would arrive overnight in local telecommunications. By late 2000, however, four years had passed, meaningful competition had not arrived, and implementation of the 1996 Act was bogged down in the courts. In addition, the macroeconomy was weakening, and it was becoming clear that there was significant overcapacity in the long-haul fiber market. Together these factors spelled gloom for the telecommunications sector.

While the competitive local exchange carriers grew extremely fast from 1996 to 2000, their share of the local telephone market was still small, less than 8 percent in 2000.[24] Furthermore, only about 40 percent of that share comprised so-called facilities-based competition, that is, local service provided by competitors using their own lines rather than by reselling ILEC service or by purchasing some unbundled elements from incumbents. This strategy left them particularly exposed to the adverse ruling on the FCC's pricing methodology by the Eighth Circuit Court of Appeals in *Iowa Utilities Board vs. FCC*, which in July 2000 moved in the opposite direction from the 1999 decision. The market capitalization of CLECs fell 63 percent from $86.4 billion in 1999 to $32.1 billion in February of 2001 and then 88 percent to just $3.77 billion in February of 2002.[25] In contrast, the respective market values of two major ILECs, BellSouth and Qwest, each fell less than 15 percent from March to December 2000.[26] Relative equity valuations, together with the bankruptcy of many CLECs, suggests that the ILECs' market power increased after the Eighth Circuit's decision. This assessment is supported by the price indices displayed in Figure 5; the price of local telephone service relative to long-distance and wireless rose noticeably after July 2000.

On March 10, 2000, the Nasdaq telecom index peaked at 1,230.06; by the end of 2000 it had fallen by 62 percent. With hindsight, it is clear that 2000 was the year in which the telecommunications industry began its sharp decline. If anything, this decline was especially pronounced in the long-haul fiber segment. However, industry observers did not generally catch this development before late 2000. Early in 2000, we saw that Lucent was optimistic about demand for fiber, and even as share prices had begun to fall, in September of 2000 *Broadband Week* published an article with the headline, "Future Looks Bright for Fiber Optic Manufacturers." It soon became apparent, though, that there was massive overcapacity in long-haul fiber. Media reports of the glut in long-haul fiber became widespread early in 2001. In an article titled "The

[24] FCC, cited in Crandall (2002).

[25] Association for Local Telecommunications Services, and Progress and Freedom Foundation. Cited in Lenard (2002).

[26] Large mergers completed in 2000 greatly increased the market value of the other two ILECs, SBC and Verizon (formed from Bell Atlantic and GTE).

Coming Bandwidth Bubble Burst," Grahame Lynch wrote in *America's Network*, February 1, 2001, "It's the pain phase for America's fiber barons. Nearly 600,000 miles of new inter-city fiber is on the way. Capacity prices are dropping and major dot.com and CLEC customers are failing." And by June 2001, when Canadian equipment producer Nortel announced a $19 billion quarterly loss, the bust was clear to all. Compounding the problems that were specific to the telecommunications sector, the U.S. economy weakened over the course of 2000, with the National Bureau of Economic Research eventually declaring that a recession had begun in March 2001. This broad decline in economic activity coincided with the regulatory turmoil to send the industry into a sharp decline in 2000 and 2001, from which it still may not have emerged.

Overcapacity in long-haul fiber had three sources. First, the long-haul fiber industry was in its early stages, and it is typical in the evolution of an industry to see an initial overshooting of investment, followed by a shakeout period (Klepper 2002). Second, the dramatic increase in the capacity of a given strand of fiber may have been greater than anticipated when construction on various networks was begun (Sidak 2003, 216). Third, and perhaps most importantly, demand for long-haul fiber capacity had not grown as fast as many had forecast: the pessimists turned out to be right.

Above we explained the forecasts of high growth in demand for bandwidth as being based on the positive interaction between increases in bandwidth and the development of new applications to soak up that bandwidth. This interaction did occur; as average bandwidth to households has increased (mainly through digital subscriber line and cable broadband), it has become increasingly common for music to be disseminated over the Internet. However, the magnitude of increases in demand for bandwidth has been small compared to the forecasts embedded in equity valuations and investment numbers. The optimistic forecasts seem to have been based on a much wider adoption of fiber-to-the-home than actually occurred. Because the 1996 Act's implementation has been bogged down in the courts, neither ILECs or CLECs have undertaken large-scale investments in fiber-to-the-home, and thus bottlenecks at the level of the local loop remain (this is often referred to as the last-mile problem).

4. CONCLUSION

At any given time, some sectors of the U.S. economy are expanding and others are contracting. The behavior of the telecommunications sector since 1996 is particularly interesting because the magnitudes are so great. The decrease in market capitalization of S&P telecommunications firms alone from 2000 to 2002 was roughly $700 billion, more than 3.5 percent of the entire value of U.S. corporate equities at the stock market peak in 2000.

According to our analysis, the 1996 Telecommunications Act was an important factor in both the boom and the bust. High hopes for a new world of competition in telecommunications followed passage of the Act, and played a major role in the dramatic rise in equity valuations. Even as the boom was effectively over, in February 2000, then FCC Chairman William Kennard spoke of "the miracle of the American model for unleashing competition in telecommunications," competition that was "creating unprecedented investment and job growth in every sector of the communications industry."[27] Two years later, with the bust apparent to all, Kennard's successor Michael Powell described it in a speech as "an unbelievable disaster," and did not hesitate to assign some of the blame to "legal instability in the court system." Referring to the Telecommunications Act of 1996, Powell said

> I have rarely seen a 750,000-word document come out of the United States Congress with clarity, and I have rarely seen one that long and complex that isn't going to trigger years of uncertainty and litigation about the parameters of that statute. I was always sort of amazed by the degree to which people didn't have that expectation built into the way things would go.[28]

Of course, some people did have that expectation built into their forecasts, but market valuations were more optimistic. We do not have a definitive explanation for the market's valuations. However, theories of asset pricing in the presence of heterogeneous beliefs and restrictions on short sales imply that asset valuations will be driven by the market's optimists. Optimism about the fundamentals of the telecom sector was widespread during the boom years, leading us to be skeptical about claims that there was a bubble in telecom stocks.

In addition to the 1996 Act, technological advances in telecommunications also played important roles in both the boom and the bust. Investment in long-haul fiber was predicated on the idea that as-yet-unknown applications would be developed to take advantage of the new bandwidth. Failure of those applications to materialize at the rate that had been predicted translated into a capacity glut, and the glut was exacerbated by the dramatic advances in technology for increasing the capacity of each strand of fiber.

While our analysis of the telecommunications boom and bust has merely touched the surface of this issue, we do come away with two recommendations for policymakers. First, they should take seriously the idea that lack of clarity in the regulatory framework under which an industry operates can lead to substantial volatility in that industry. Our second recommendation is related

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[27] Speech to National Press Club, February 8, 2000.

[28] Remarks of Michael K. Powell, Chairman, Federal Communications Commission, at the Thomas Weisel Partners Growth Forum 4.0, Santa Barbara, California, June 17, 2002.

to the mantra or myth of Internet traffic doubling every three months. While we are skeptical of the extent to which irrational belief in such growth rates drove the telecom boom, it is clear that good aggregate data on Internet use was difficult, if not impossible, to acquire after 1994. The federal government is involved in many data collection efforts, and the data it collects are viewed as a public good. With the benefit of hindsight, collection and dissemination of data on Internet use would have been a productive activity for the U.S. government to be involved in during this period, and will be in the future.[29]

There is much room for future work on the telecom boom and bust. Here we mention just two areas of interest. First, while telecommunications experienced particularly extreme fluctuations from 1996 to 2002, other sectors also rose and fell, as did the U.S. economy as a whole. Biotechnology, in particular, experienced fluctuations of nearly the same magnitude as telecom, though the spike in biotech was very brief and came toward the end of the telecom boom. A comparative study of biotech and telecom might be revealing about the causes of the fluctuations in both sectors. Second, there have been other episodes of sectoral booms and busts in the history of the United States, and one that immediately invites comparison with telecom is the railroad boom and bust of the 1870s. Like telecommunications, railroads consist of networks, and a comparative study of these episodes would shed light on the question of whether network industries are particularly prone to large fluctuations.[30]

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[29] Sidak (2003) cited FCC Commissioner Michael Copps as making this argument in testimony before a Senate Committee.

[30] The analogy between telecom and railroads has been made by many. The first reference we have found is the August 31, 2001, episode of PBS's *NewsHour with Jim Lehrer* (PBS, 2001).

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